Tucannon River Project Area 27/28 Floodplain Restoration Project

Tucannon River Basin, SE Washington

Basis of Design Report
Phase 0.5 to 1
80% Design

Project Area 27/28 Tucannon River 2-4-2021, A. Dysart

PREPARED FOR:

Confederated Tribes of the Umatilla Indian Reservation

46411 Timine Way
Pendleton, OR 97801

PREPARED BY:

Wolf Water Resources, Inc.

1001 SE Water Avenue, Suite 180
Portland, OR 97214

July 2021

TABLE OF CONTENTS

1.0 PROJECT BACKGROUND

The Confederated Tribes of the Umatilla Indian Reservation (CTUIR) is leading the restoration of project areas 27/28 on the Tucannon River (River Miles 22.2-23.1). CTUIR is pursuing restoration throughout the Tucannon River with a focus on addressing ecological concerns and restoration of First Foods as guided by the Umatilla River Vision (Jones, et al, 2008). Kris Fischer (CTUIR) is the project manager. Wolf Water Resources (W2r) has been contracted by CTUIR to design channel and floodplain improvements to this project area. The Tucannon River is a tributary of the Snake River entering below Little Goose Dam. The project site is located approximately 11.5 miles northeast of Dayton, Washington. CTUIR has entered into a Tucannon River Access, Implementation and Maintenance Agreement with the landowner, Ty Haberling that allows access to the private property on the Tucannon River. This agreement allows CTUIR to plan, implement and maintain habitat restoration efforts in support of threatened Snake River steelhead and spring Chinook salmon in the Tucannon River Basin. CTUIR seeks to improve natural floodplain connectivity and enhance fish habitat complexity for native species on this property. The current land use is a combination of rural residential and agricultural development. The project reach is approximately one mile long (22.2-23.1) and is identified as Project Area 27/28 (PA 27/28) in the Conceptual Restoration Plan, Reaches 6 to 10 Tucannon River Phase II (Anchor QEA, 2011b). The Project is planned in a series of phases based on funding and construction considerations. The first part of Phase I (0.0-0.5) was completed in 2020 and is described in the Phase 1 Basis of Design Report dated June, 2020. That BDR includes Project-wide Project Background, Resource Inventory and Evaluation, Technical Data.

This 30% Design report provides updates or additions to the Phase 0 to 0.5 BDR as needed, including evaluation, technical data, design and modelling for the remaining portion of the project (Phase 0.5-1.0), but does not repeat the June 2020 Phase 0 to 0.5 report in its entirety.

Phase 0.5 to 1.0 covers riparian and channel treatments from approximately RM 22.525 downstream to RM 22.18, and upstream from RM 22.9 to RM 23.1.

PROJECT GOAL AND OBJECTIVES.

1.0.1 GOAL

The goal of the project is to address the Primary Limiting Factors identified for the Tucannon River in the 2008 Fish Accords (Three Treaty Tribes-Action Agencies 2008), incorporating the primary touchstones described in the Umatilla River Vision (Jones, et al, 2008), and be consistent with the Snake River Salmon Recovery Plan for Southeast Washington (SRSRB 2006), Draft Columbia River Bull Trout Recovery Plan (USFWS 2010) and the Tucannon Sub basin Plan (CCD 2004).

The project will address the effects of historic grazing, agricultural, and timber harvest and wood removal practices and associated ecologic concerns such that they improve and restore the system's ability to support the 'First Foods' using guidance provided by the Umatilla River Vision (Jones et al. 2008). The corresponding ecologic concerns affecting the River Vision touchstones that can be addressed specifically by this project include: High water temperatures; insufficient pools; shortage of LWD; loss of riparian vegetation; uncharacteristic vegetation; lack of trees in riparian zone for shade, cover, and large wood recruitment; stream-valley floor hydrologic connection; channel form, stability, sinuosity, pool/riffle ratios and aquatic fish habitat complexity; substrate embeddedness; wetland state; and beaver habitat. An overarching goal is to address these ecologic concerns in a manner that acknowledges their interconnectedness and positive feedbacks. The types of actions and ways these ecologic concerns can be addressed so they restore the five touchstones are laid out more specifically as project objectives in the next section.
CTUIR seeks to return the Tucannon River corridor to historic functioning capabilities to not only provide improved habitat for native fish species, but also to provide suitable habitat to promote the return of wildlife and native plants.

1.0.2 OBJECTIVES

Objectives specific to this design effort were developed as part of the Request for Proposal and address site specific constraints and opportunities. These will be used to guide development of the design. They include:

- Increase floodplain connectivity and frequency of inundation to a condition closer to historical and natural form. Re-engagement of the floodplain will result in flows that are less confined, decreased stream power, increased and more variable gravel deposition, raised groundwater tables, and increased base flows and decreased water temperatures. Hyporheic flow and native riparian species will thrive.
- Increase channel complexity with channel morphology (channel form, sinuosity, complexity, geomorphic and hydrograph stability) closer to historical and functional form especially wood, pools, and a diversity of bed material sizes.
- Increase stream velocity diversity at both low and high flows.
- Increase quantity and quality of habitat diversity, especially large wood and pools.
- Reestablish geomorphically-appropriate sediment sorting and routing.
- Improve and reestablish in-stream thermal diversity throughout the year.
- Improve quality and diversity of in-stream and off-channel habitat for resident and anadromous fish in the Tucannon River by increasing locations suitable for adult spawning and increasing area available for juvenile rearing.
- Restore natural channel forming processes through the addition of large wood to increase channel complexity, and restoration of sediment routing processes through the removal of levees and other floodplain impediments.
- Reestablish native floodplain plant communities and riparian function with site-appropriate native vegetation and off-channel habitat. Realistic, cost-effective planting plans will maximize plant survival and minimize labor and maintenance; the planting plan will reflect CTUIR First Food values.
- Work closely with the CTUIR and their project partners (restoration team) at each stage of design and obtain consensus on the design before proceeding to the next design stage.

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

Project Sponsor – Confederated Tribes of the Umatilla Indian Reservation (CTUIR);
Design Engineer – Wolf Water Resources (W2r);
Land Owner/Manager – Ty Haberling/Rick Turner.

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

The proposed project elements have been designed by a licensed engineer and are summarized below:

- Place large wood structures and individual large logs throughout the project area to increase channel and habitat complexity, and increase floodplain connectivity;
- Grade/excavate existing push-up levee, high ground terrace in lower project reach, and swales to increase floodplain connectivity;
- Place excavated materials in the lower reach of the mainstem to expand floodplain connectivity;
- Selectively grade portions of irrigation supply ditch to best fit large wood;
- Complete project flood risk assessment; and
- Evaluate the upstream irrigation ditch hydraulics to determine the next steps for floodplain connectivity upstream of Phase 0.5 to 1.0.

The outcomes expected from the preferred alternative include:

- Improved connectivity of the floodplain and adjacent wetland complexes;

- Improved access and suitability of off-channel networks and shallow-water habitat for juvenile salmonids;
- Expanded edge habitat which will benefit multiple species by increasing primary production and prey availability within the food web;
- Increased ponding; and
- Increased water quality due to improved hydrologic conditions and increased channel and floodplain complexity.

1.3 EXPLANATION AND BACKGROUND ON FISHERIES USE (BY LIFE STAGE - PERIOD) AND LIMITING FACTORS ADDRESSED BY PROJECT.

Included in Phase 1 BDR dated June 2020 (Appendix A).

1.4 LIST OF PRIMARY PROJECT FEATURES INCLUDING CONSTRUCTED OR NATURAL ELEMENTS.

- Improve Secondary Channels – strategically place wood throughout the reach to increase channel complexity.
- Grading and excavation – removal of a levee, high ground terrace, swale excavation (reach downstream of King Grade Road), and select, field fit grading in irrigation supply ditch (reach upstream of King Grade Road).
- Channel Reconstruction – strategically place material in the downstream incised reach to increase floodplain connectivity and spread flow to the excavated swales and secondary channels.
- Install Habitat-Forming Natural Structures – large wood and individual logs (throughout reach)
- Riparian Planting and invasive vegetation control (throughout reach).

1.5 DESCRIPTION OF PERFORMANCE / SUSTAINABILITY CRITERIA FOR PROJECT ELEMENTS AND ASSESSMENT OF RISK OF FAILURE TO PERFORM, RISK TO INFRASTRUCTURE, POTENTIAL CONSEQUENCES AND COMPENSATING ANALYSIS TO REDUCE UNCERTAINTY.

The design and construction of the project incorporate the following to reduce or eliminate potential risk and consequences:

- The project is designed and constructed to result in no rise of 100-year floodplain upstream or downstream of the project.
- The design will incorporate both stability and roughness elements (structures) to prevent headcutting from downstream into the project.
- Wetlands will be preserved with very little alteration. No fill will be added to wetlands. Wetlands will be improved by adding wood only.
- Stream power will be distributed and floodplain connectivity increased by scraping down a high ground terrace and levee, excavating two swales, and placing that material in degraded portions of the mainstem channel.
- The project monitoring and adaptive management plan will be developed in collaboration with CTUIR. CTUIR will implement the adaptive management plan at the site following the project actions as they continue to manage the property.
- The project will meet NMFS fish passage criteria immediately post construction.
- No damage to infrastructure is anticipated as a result of this project. Evaluation of all project elements will ensure the existing road and bridge will not be affected as a result of this project (Phase 2).

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

Phase 0.5-1.0 will include work in two distinct project areas:

Project area upstream of King Grade Road (RM 22.9-23.1):

- Laying back the banks in the existing irrigation ditch to facilitate wood placement and floodplain engagement. Grading to be determined in field at appropriate locations so that it does not interfere with irrigation needs;
- Placement of log jams/large wood in and around ditch;
- Placement of individual logs and small log structure in adjacent floodplain; and
- Invasive vegetation species treatment and revegetation.

Project area downstream of King Grade Road (RM 22.525-22.18):

- Removal of small levee at approximately RM 22.4. Cut material will be placed in the channel adjacent to levee;
- Grading of high ground terrace in floodplain at the downstream end of the reach;
- Excavation of two swales to promote floodplain engagement at the downstream end of the reach;
- Selective placement on mainstem channel fill from downstream grading areas/excavation between approximate river miles 22.2 – 22.34.
- Placement of log jams/large wood in and associated with channels;
- Placement of individual logs and small log structures on floodplain; and
- Invasive vegetation species treatment and revegetation.

Equipment will be tracked to individual installation sites primarily through invasive vegetation (Reed canarygrass and Himalayan blackberry) with no scraping or grading. Disturbance to existing native vegetation will be minimized. Construction of project elements below Ordinary High Water (OHW) will be carried out during the summer in-water work window for the Tucannon River, July 15th through August 30th. Timing of excavation at the site will coincide with site hydrology.

No in-stream or floodplain project activity is planned directly upstream or downstream of the King Grade Road and Bridge. Large wood will be placed upstream from the King Grade Road Bridge, however, these areas are located more than 500 feet or greater upstream from the bridge and the structures will be anchored with wood, boulders, and other native material. Project work will include minor modifications to the irrigation supply ditch including grading as needed for the installation of large wood and large wood installations. These elements are intended to be minimal at this phase in the project so that the irrigation supply remains unchanged. Phase 0.5-1.0 areal extents include the riparian area upstream and downstream of the bridge and the channel more than 500 feet upstream and over 1700 feet downstream from the bridge.

2.0 RESOURCE INVENTORY AND EVALUATION

The resources inventory and data evaluation for Phase 1 is included in Phase 0 to 0.5 BDR dated June 2020 (Appendix A), and the wetland assessment for Phase 1 is included as Appendix B.

Post Phase 0 to 0.5 LiDAR was flown in the fall of 2020 and was used for the Phase 0.5 to 1 design. Additional supplemental survey post construction of the Phase 0 to 0.5 was taken throughout the project reach by W2r in February 2021.

3.0 TECHNICAL DATA

3.0.1 ALTERNATIVE DEVELOPMENT AND PREFERRED ALTERNATIVE SELECTION AND INITIAL REVIEW AND PRELIMINARY DESIGN

Alternative development and selection were the major focus during the 15% design phase completed in 2020 and included the entire project area (Phase 0 to 0.5 and 0.5 to 1). These are described in the Phase 1 BDR dated June 2020. Alternatives were based on conditions and features identified in the Conceptual Restoration Plan (Anchor QEA 2011b) and from the goals and objectives identified in the Project RFP (CTUIR). These are described in detail in the June 2020 Phase 1 BDR.

During early alternative development efforts the project was divided into at least two phases. Phase 1 included floodplain restoration elements in the existing floodplain/riparian area in the reach, with exception of those connected with the King Grade Road and bridge and the existing irrigation diversion near the road/bridge crossing.

During Phase 1 project development, the floodplain restoration elements were further split into a segment from RM 22.5 to RM 22.95 (Phase 0.0 to 0.5), and a segment downstream from RM 22.5 and upstream from RM 22.9 to RM 23.1 (Phase 0.5 to 1.0) based on availability of funding and construction season constraints. Phase 0.5 to 1.0 addresses floodplain and channel restoration from RM 22.525 downstream to RM 22.18, and upstream from RM 22.9 to RM 23.1. Phase 0.0 to 0.5 was completed in 2020. **Phase 0.5 to 1.0 is planned for construction in 2021 and is the focus of this 30% BDR.** Additional Project Phases may be developed as needed.

3.0.2 RESTORATION ALTERNATIVES AND SELECTION

The following general restoration alternatives were considered to address project goals and objectives at the beginning of Phase 0.0-0.5 design:

- Alternative 1 -
    - Combined instream and floodplain grading (remove existing berms and levees and selectively use as fill in incised channel areas) in concert with instream medium-to-large wood placements (primarily apex log jam type structures) to maximize floodplain engagement, reduce effects of past incision, and increase instream and floodplain habitat complexity;
    - Small wood and single log placements throughout the floodplain and wetlands to increase split-flow and maximize floodplain complexity and habitat;
    - Installation of BDAs to accelerate floodplain and wetland recovery (removed at 80% Design for Phase 0.0-0.5);
    - Invasive vegetation management and revegetation; and
    - Replacement of culvert under King Grade Road to reroute tributary drainage likely altered as a result of historic construction of the road and restore water source to wetlands likely altered as a result of historic construction of King Grade Road (removed at 80% Design for Phase 0.0-0.5).
- Alternative 2 –
    - Removal of existing levees in concert with placement of large-scale channel spanning jams (typically between 15-25 logs per jam). These jams would be intended to create major obstructions to main channel flows to increase floodplain connectivity;
    - Invasive vegetation management and revegetation; and
    - Replacement of culvert under King Grade Road to reroute side drainage likely altered as a result of historic construction of the road and restore water source to wetlands likely altered as a result of historic construction of King Grade Road (removed at 80% Design for Phase 0.0-0.5).

Table 1 provides more specificity on the types of restoration treatments included under each alternative. Phase 1 would not include improvements to King Grade Road and bridge, or relief culverts as these need to be coordinated with the riparian area expansion and alternative irrigation delivery to be done in Phase 2.

Table 1 Generalized restoration treatments by alternatives for Phase 1 as considered in the 15% design phase.

Obstruction removal (remove artificial berms and bank protection where infrastructure allows)	X	X
Channel grading/fill in selected incised areas to increase floodplain connection and side channel development	X	
Small-medium sized LWM jams to encourage overbank flows, provide cover and instream complexity, and promote sediment deposition (typically between 1-8 pieces).	X	
Floodplain log placement to enhance off-channel habitat	X	
Beaver Dam Analogues to increase complexity and elevate water levels in side channels. (Removed)	X	
Medium-to-large scale channel-spanning jams to obstruct the mainstem and promote floodplain engagement	X	X
Invasive vegetation management and revegetation	X	X
Install culvert under King Grade Rd at edge of floodplain and valley edge. (Removed)	X	X

The 2020 design process selected a preferred alternative based on landowner input and a qualitative alternative selection tied to simplified project objectives and general rationale about the expectations for the different suites of restoration treatments. This selection focused on biophysical benefits of the restoration alternatives as categorized by CTUIR's River Vision Touchstones.
Alternative 1 was accordingly selected as the Preferred Alternative.
The preferred alternative (Alternative 1) involves the following strategies and restoration actions:

- Achieve maximum connectivity using a combination of floodplain connectivity, channel reconstruction, and increased complexity (including berm/levee obliteration, fill of incised channel areas) in concert with wood placements of all sizes both in-stream and adjacent to the main channel, and in existing side channels and flowpaths and wetlands.

3.0.3 CONCEPTUAL DESIGN

Aside from project goals and objectives outlined in Sections 1.0 and 1.5, the Phase 0.5 to 1.0 design has the following feasibility and constructability objectives:

- Relative balance in cut and fill to avoid the need for material on- or off-haul. This emphasis relates to the assumed material deficit in the reach created by historic channel incision. The restoration actions ideally would avoid contributing to this deficit.
- Construct or maintain pools and habitat features that provide refuge for fish immediately post construction activities.
- Minimal disturbance to existing floodplain wetlands.

Specific restoration elements of design discussed below include (1) floodplain and channel grading, and (2) large woody material (LWM) elements, and (3) other habitat elements such as native revegetation.

1. Floodplain and Channel Grading - The proposed terrain surface includes the following elements:
    - *High ground terrace and levee removal* to promote natural floodplain inundation. Grading areas avoid existing wetland areas, and mostly avoid existing mature vegetation. The target elevations of high ground removal areas are determined to coincide with natural floodplain elevations while producing expected material needed for fill areas.

- *Floodplain Swale expansion* in the downstream reach to provide multiple flow paths during moderate winter flows. Swale inlet elevations were targeted to match the adjacent channel fill elevations to promote multi-threaded channels.
- *Partial filling of mainstem channel* in the downstream reach and adjacent to the levee removal grading to similar relative elevations as the proposed floodplain to fully reengage the floodplain. The channel and floodplain grading is intended to be geomorphicaly and hydraulicly dynamic and change over time. The channel fill elevation was targeted to engage the swales and existing side channel at the upstream end of the grading during moderate winter flows but is still slightly lower than the adjacent floodplain, so summer low flows will likely remain in the current mainstem channel until a moderate flood adjusts the terrain. The downstream end of the channel fill grading area ties into the geomorphic grade line, reducing the risk of a head cut developing in the channel due to channel slope variability. In addition, raising the channel bed elevation and reducing incision will promote hyporheic exchange. Increasing flow through the hyporheic zone can recharge the ground water table, and increase cold water up welling into the scour holes and pools providing cold water refugia for fish.

Cut and fill maps highlight the proposed grading and are included in Appendix C – Engineering Planset

2. Large Woody Material - Logjams are designed to mimic racking and accumulation of large wood in natural rivers. The total number of logs and the log length/DBH are summarized in Table 2. The project design includes the following large wood jam types with specific habitat functions in mind:

- Margin Deflector Jam - Improves local stream bed heterogeneity and habitat diversity by simulating natural jams accumulated against fallen logs from the bank. The current design includes 40 margin structures.
- Large Apex Jam – Supports mid-channel bar and island growth to accumulate salmon spawning gravels and increase local floodplain inundation. The current design includes 9 large apex structures.
- Small Apex Jam – Supports smaller mid-channel bar and island growth to accumulate salmon spawning gravels and increase local floodplain inundation. The current design includes 9 small apex structures.
- Channel Spanning Structures – Adds channel complexity by accumulating sediment behind the large members and creating localized scour holes. They also act as a catcher's mitt in the downstream grading area to catch wood and slow down flow to promote floodplain engagement. These structures are porous and are not buried grade control structures, flow can go through and around them, providing flow paths for fish. The current design includes 3 channel spanning structures.
- Floodplain Roughness Logs – Provides roughness to distribute flows, retain fine sediment, and support riparian growth on floodplains. The current design includes 94 floodplain log structures.

Table 2 Log Summary Table

Log Type	Length/ DBH	Quantity	Unit
SPANNING LARGE W/ ROOTWAD	MIN 50' / 18-24"	27	EA
LARGE W/ ROOTWAD	MIN 40' / 18-24"	183	EA
MEDIUM W/ ROOTWAD	MIN 35' / 12-18"	174	EA
SMALL W/ ROOTWAD	MIN 25' / 8-12"	31	EA
PIER LOG	MIN 20' / MIN 10"	238	EA
RACKING	MIN 15' / MIN 6"	345	EA
SLASH		748	CY
NATIVE BOULDER	MIN DIAM 18"	15	EA

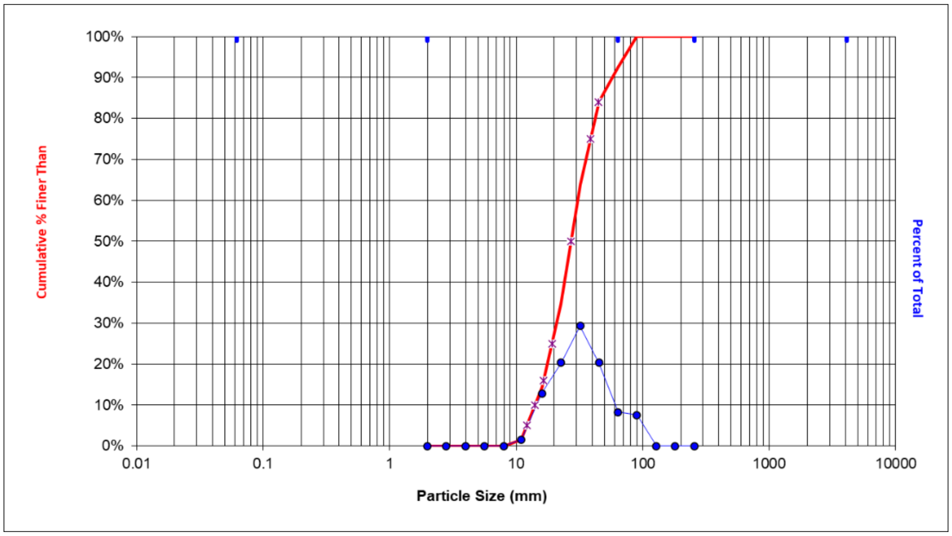
3.1 INCORPORATION OF HIPIII SPECIFIC ACTIVITY CONSERVATION MEASURES FOR ALL INCLUDED PROJECT ELEMENTS

The Tucannon River PA 27/28 Floodplain Restoration Project was designed using HIP activity specific conservation measures. Design and construction drawings and specifications developed for the Phase 0.5 to 1 will follow and include all HIP Conservation Measures Specific to these activities as well as the general conservation and construction measures. Primary project actions are described in the context of the HIP Activity Specific Conservation Measures as follows:

- Combined instream and floodplain grading –
    - Remove Existing Berm - Category 2b. The isolated relatively small berm that will be removed consists of push-up native materials and those materials will be used to fill incised areas on-site. Graded areas will be scarified and used as riparian planting areas.
    - Remove High Ground Terrace – Category 2b. A portion of the downstream high ground terrace is located in a potentially connected area and would further promote floodplain connectivity if removed.
    - Swale Excavation – Category 2f. Excavate two swales connected to the mainstem channel to promote a multi-threaded channel and connected floodplain.
    - Fill Incised Channel Areas - Category 2f. Selectively use berm material to fill some incised channel areas to maximize floodplain engagement and reduce effects of past incision. Specific Conservation Measures ensure that these materials are appropriately sized and placed in incised segments that do not include spawning suitable areas.
- Instream and Floodplain Wood Placements – Category 2d.
    - Medium-to-large wood placements (primarily apex log jam type structures). Medium-to-Large wood structures will be designed to mimic the natural accumulation of wood with no or minimal artificial anchoring. Only natural, non-treated wood materials will be used. Stability analyses will be performed as required.
    - Small wood and single log placements throughout the floodplain and wetlands to increase split-flow and maximize floodplain complexity and habitat. Only natural and non-treated wood materials will be used. Anchoring will consist of passive methods only, such as partial burying or no anchoring at all.
- Invasive Vegetation Management and Revegetation – Categories 3a and 3b. If herbicides are used for invasive vegetation control, only those listed in the HIP manual and appropriate for the targeted species will be used. Application will comply with label application rates and will be transported, mixed, and applied by a licensed applicator, who will prepare and follow the safety/spill response plan.
- Riparian Planting – Category 2e. Native species will be used and the riparian planting plan will be prepared by personnel with native riparian vegetation design experience.

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

Phase 0 to 0.5 of the design was based on LiDAR collected by Geoterra in 2017 and visual field observations. Phase 0.5 to 1 is based on LiDAR collected in 2020 by Quantum Spatial, Inc. Floodplain soils were hand-sampled and pebble counts were taken on select river materials. Two pebble counts were conducted, and distribution graphs were developed as shown in Figure 1. No detailed analyses were performed on these materials.



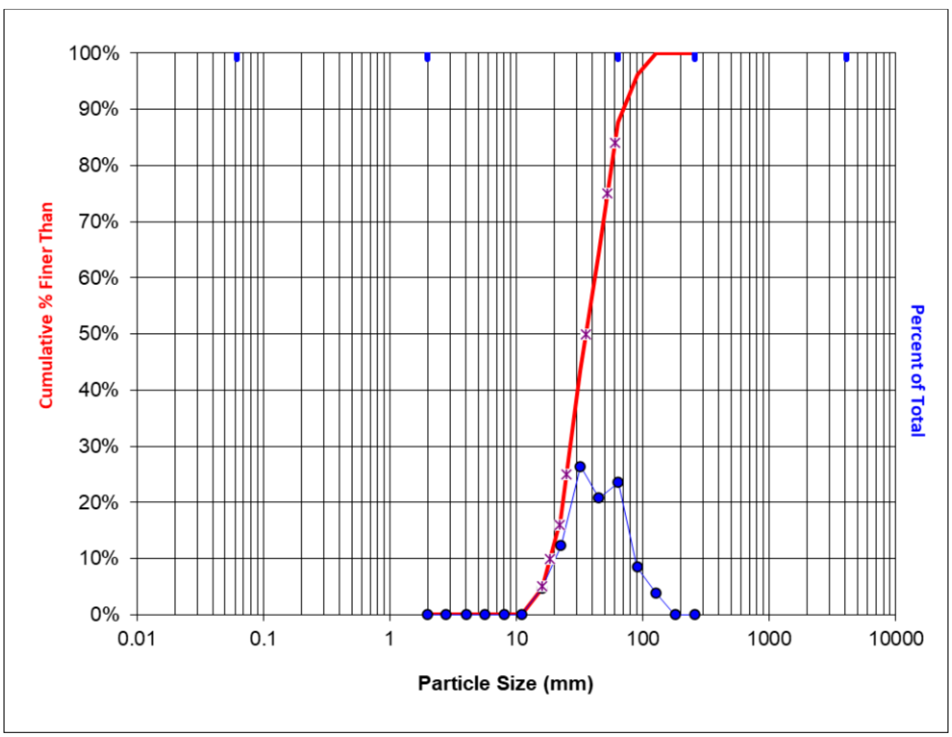


Figure 1 Grain size distribution curves based on two pebble counts

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 Tucannon River drains the northwestern Blue Mountains of Southeast Washington. The watershed contributing to the project reach is 170 square miles (mi^2), with a mean annual precipitation of 36 inches and a mean and maximum elevations of 3,920 and 6,370 feet. The Tucannon River has two active gages, one of which is located just upstream of the project reach at the Turner Road crossing (Table 3). Two sets of flow statistics were developed to inform design: (1) annual peak flow exceedance probabilities inform flood frequencies and (2) flow duration statistics characterize the frequency and duration of the broader flow distribution (including low flows).

Table 3 Table of stream gages on the Tucannon River.

Gage ID	Name	Agency	Dr. Area, mi^2	Record	Notes
35B150 (Ecology), 13344000 (USGS)	Tucannon River near Marengo	Ecology (active), USGS (past)	160	1913-1930 (USGS), 2003-2019	Turner Road Bridge
13344500	Tucannon River near Starbuck	USGS	431	1914-2019	

Peak flow statistics were developed by combining flow records of the two gages to develop an extended peak flow record upon which to develop annual exceedance probabilities. While well downstream of the site, the gage at Starbuck has a more extensive flow record that the gage upstream, which provides an opportunity to extend the flow record at the upstream gage site. To develop this extended record, we performed a linear regression analysis relating contemporaneous peak flows at the two gages which then allowed for estimation of flows in years where the gage at Starbuck was active and the gage at Marengo was inactive. The resulting equation relates flow at Marengo (Q_M) to flow at Starbuck (Q_S): $Q_M = 0.70 \times Q_S + 118.7$. With the resulting extended records, we then ran flood frequency statistics using recently updated USGS Bulletin 17C methods for the gage location at Marengo. Given the negligible drainage area difference between the two sites, we assumed peak flow frequencies developed at the gage reflected those at the site (Table 4).

Table 4 Peak flood statistics for the project reach.

Annual Exceedance Probability	Recurrence Interval, yr	Q, cfs
95%	1.05	215
90%	1.11	270
80%	1.25	380
67%	1.5	540
50%	2	792
20%	5	930
10%	10	2440
4%	25	3560
2%	50	5000
1%	100	5500

Flow duration statistics (developed by USGS) recorded at the gage upstream were also considered to be adequate for the site. The flow duration curve and specific statistics are shown on Figure 2.

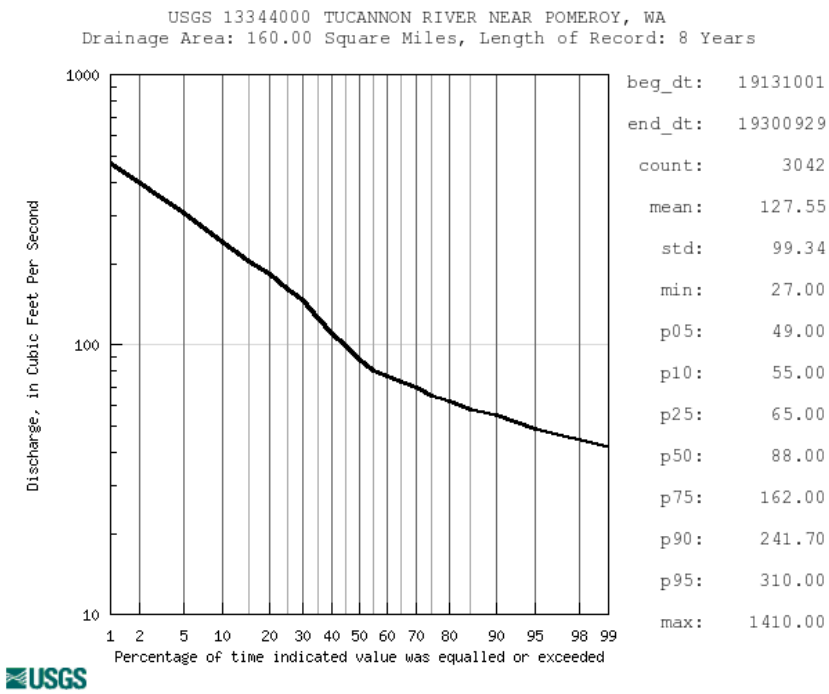


Figure 2 Flow duration curve developed from flows recorded at the historic USGS gage (13344000) located immediately upstream of the site.

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

3.4.1 EXISTING SEDIMENT SUPPLY AND TRANSPORT

Based on the presence of active gravel bars, the reach appears to have a relative abundance of gravel. Anchor's (2011a) sediment budget and transport assessment provides context for the observed sediment dynamics. Their transport assessment made use of shear stress outputs from hydraulic modeling, and subsequent calculations of sediment transport capacity at a range of flows (the results of which are shown in Figure 3). Sediment transport capacity was specifically reported in terms of critical grain diameter, which is the grain size that experiences incipient motion during given flow conditions. The longitudinal trends in modeled critical diameters indicate that the project reach lies in a broader ~2-mile reach (RM 22-24) of declining sediment transport capacity, which suggests the reach acts as a depositional reach.

Anchor (2011a) also measured the flux of suspended sediment at the gage location at Marengo (just upstream of the site), which indicates annual suspended yields are roughly 8500 tons/year. Using a conservative assumption that bedload represents 25% of suspended load (this proportion can vary widely but is commonly assumed to be 10%, Turowski et al. (2010), the estimated gravel load may be as high as 2125 tons/year. Using standard assumptions of gravel density, this translates to about 1400 cubic yards/year. This flux per year suggests a volume deficit created by 1 feet of incision over the entire reach could be replaced with about 5 years of gravel supply. Based on a recent data compilation by Legg (2020), this annual volumetric supply is relatively high for the intermountain west.

In summary, Anchor's sediment transport and supply estimates indicate that the reach is transitional to depositional in nature and has relatively high gravel supplies provided from upstream. These results are consistent with observations of active gravel bars throughout the reach and suggest that there is a naturally high pace of dynamism and habitat formation in the project reach.

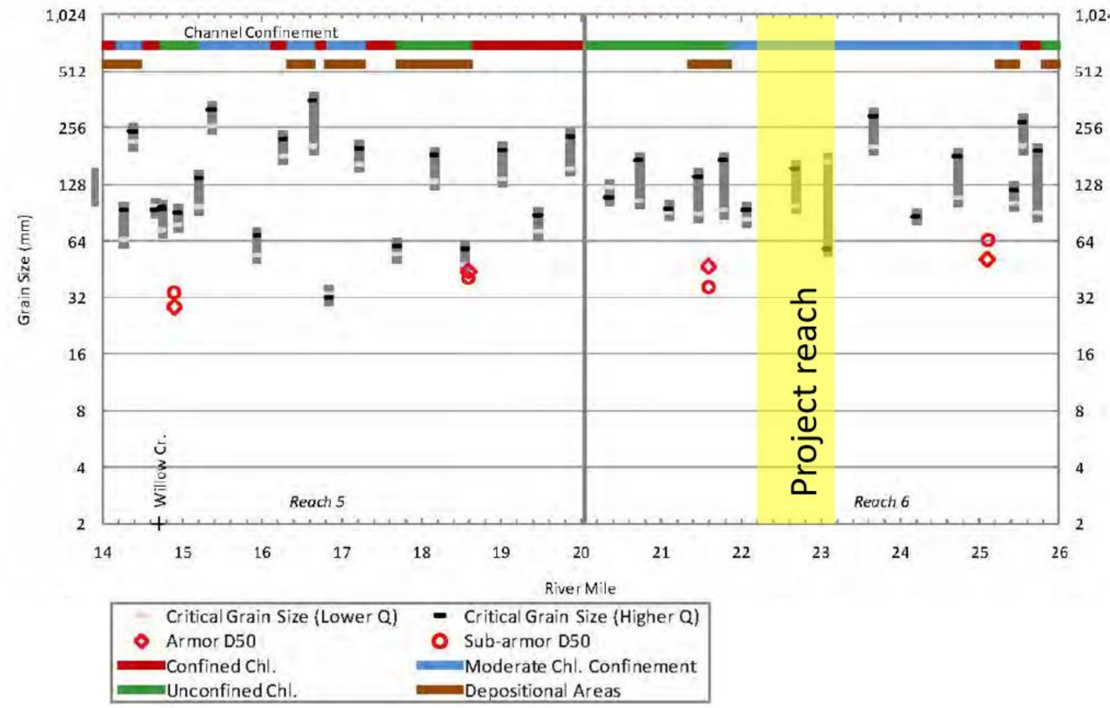


Figure 3 Anchor (2011a) longitudinal plots of modeled sediment transport capacity and measured grain sizes shown.

As described in Section 2.7 in the June 2020 report, the Tucannon River experienced an approximately 25-year flow event in February, 2020. Visual observations of the physical impacts to the project site include:

- A few areas of bank erosion, predominantly in the area of the irrigation diversion upstream from the bridge and along the south bank at the downstream end of the project area near RM 22.3
- Reworked gravel bars sporadically throughout the length of the project area
- Overbank/floodplain gravel and fine sediment deposits sporadically throughout the low floodplain surface
- New woody material deposition and re-positioned woody material within the low floodplain area throughout the project area
- Silt deposition and return flow sheet and gully erosion in the adjacent agricultural fields

Post-flood observations indicate that while some gravels and woody materials were reworked and deposited, and there likely were some additional gravel and wood materials transported into the reach, the result is that the project area is trending closer to the restoration goal originally developed for this project. Based on this, the project plan and design efforts for Phase 0.0 to 0.5 were scaled back.

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

3.5.1 MODEL DEVELOPMENT

A 2D HEC-RAS (version 5.0.7) model was developed to evaluate the existing conditions and proposed design and to conduct a floodplain analysis. This modeling software uses a 2D mesh laid over a high-resolution terrain dataset to provide quality representation of the ground surface while remaining computationally robust and efficient. The primary objective of the hydraulic analysis was to evaluate existing flow patterns, hydraulic parameters, and inundation extents to characterize current riverine conditions within the project reach.

Establishing baseline hydraulic conditions enables quantitative comparison with the proposed condition modeling, representing restoration actions to be completed in future project phases. This comparison is critical to ensure that the design elements meet project goals without increasing risk to adjacent and downstream structures and properties.

CTUIR commissioned a bathymetric LIDAR survey in 2020 following the first phase of construction and the King Grade road raise. This survey provided a high-resolution topographic and bathymetric surface for the existing and proposed model terrains. The LIDAR surface was merged with augmented ground surfaces, built in AutoCAD Civil 3D, to improve the resolution of existing irrigation ditches, and include proposed grading.

Hydraulic modeling requires an assessment of the drag forces that the ground cover and structures exert against the flow to calculate energy losses. In HEC-RAS the magnitude of these forces is represented by the Manning's n values, which are spatially varied and assigned by landcover type in accordance with standard hydraulic reference manuals (Chow, 1959). Typically, Manning's n values decrease as the depth of flow increases; however, this model makes the simplifying assumption that the values are constant through all flow events. This assumption likely overestimates the Manning's n values during extreme flood events, providing a conservative estimate of flood extents. The assigned values are shown in Table 5.

Table 5. Modeled Manning's n Values

Landcover Type	Manning's n Value
Active Channel	0.035
Floodplain – forested, downed trees with undergrowth	0.12
Floodplain – forested, downed trees, cleared undergrowth	0.08
Floodplain – tall grasses	0.075
Floodplain – cultivated, no crop	0.035
Floodplain – light development	0.045
Channel w/ dense WHS	0.1
Channel w/ WHS	0.06

The following flows from the hydrologic analysis were selected for modeling.

Table 6. Modeled Flows

Flow Description	Annual Exeedance (%)	Flow (cfs)
Winter Base Flow	55-65	100
Q2	50%	792
Q10	10%	2440
Q100	1%	5500

The restoration treatments are intended to provide benefits through the full range of flows expected during the design life of the project. Modeling typical winter base flow identifies benefits of the proposed restoration actions during typical winter flow conditions and ensures that the Project does not risk creating a fish passage barrier during migratory periods. The Q2-Q10 events provide an assessment of the upper and lower ends of the range of peak flow events expected to occur with some regularity, and those which are most significant to overall bed load transport and channel formation. Analysis of impacts at the Q100 ensures the Project does not increase risk to adjacent or downstream properties and structures, through the failure of wood structures and/or increased water surface elevations (WSE).

3.5.2 MODEL RESULTS

The analysis of the model results focused on the changes between the existing and proposed conditions water surface elevations (WSE), wetted area, mainstem velocity, and bed shear stresses, as well as depth and velocity on the floodplain where there are proposed wood placements. Together these metrics paint a picture of how the morphology of the channel is expected to respond to the proposed restoration treatments and identify potential risk factors.

The analysis focuses on two regions within the Project reach:

> **Region 1**: Downstream of the Kings Grade Rd. Bridge between RM 22.2 and 22.34. Two new swales will be excavated, the excavated material along with large wood will selectively be used to partially fill the main channel. Large wood structures will be constructed within the channel, and individual logs placed on the floodplain.
>
> **Region 2**: Upstream of the Kings Grade Rd. Bridge between RM 22.9 and 23.1. Large wood structures will be constructed in the channel and individual logs will be placed on the floodplain.

REGION 1: RM22.2 TO 22.34

The model results indicate that the proposed restoration actions will have the intended effects, meeting the stated Project objectives listed in section 1.

Floodplain Connectivity:

The wetted area was increased under target flow conditions, with the greatest benefit seen under the winter base flow condition and decreasing as flows increase. There is no increase in flood extents under the Q100 event, suggesting the project will not increase the risk of flooding. The changes in wetted area are summarized below in Table 7.

Table 7. Modeled Wetted Area

Flow Event	Change in Wetted Area (Acres)	Change in Wetted Area (%)*
Winter Base Flow	+ 1.0	+57%
Q2	+ 0.7	+11%
Q10	+ 0.5	+2%
Q100	0	0%

*Area sampled begins at the downstream extent of Phase 0.5 work constructed in 2020 and extends to the downstream property boundary.

Figure 4 shows the existing vs proposed inundation extents during a Q2 event, with a cross section showing existing and proposed water surface elevations.

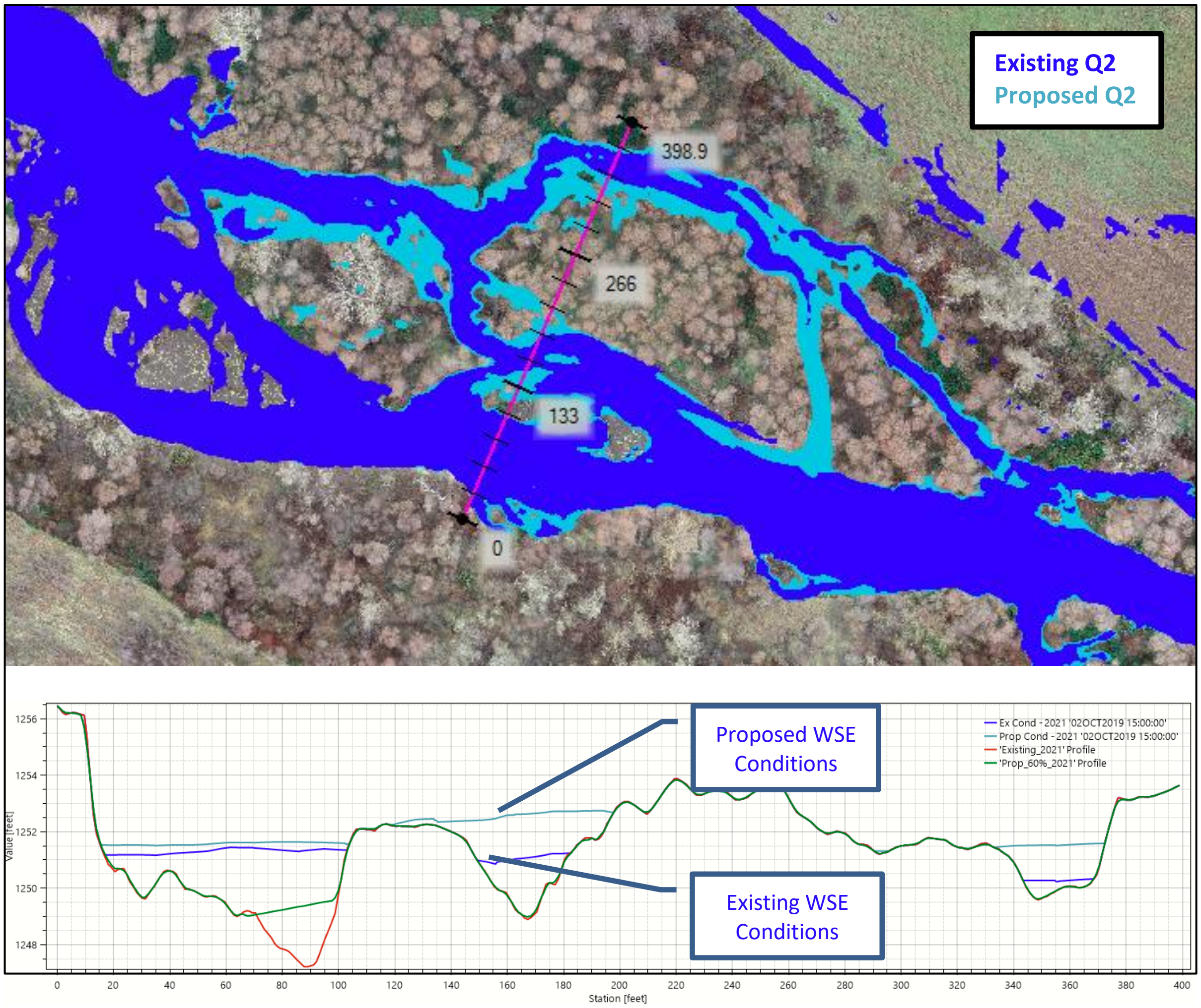


Figure 4. Modeled Q2 Extents and Floodplain Cross-Section.

The two new swale connections are shown to divert 15-30% of the flow from the mainstem into the two side channels and floodplain. The reduction in flow in the mainstem corresponds with an equivalent reduction in stream power, reducing the energy available for sediment transport in the mainstem, and distributing it across the site.

Velocity

The model suggests that during typical annual flow conditions the Project will reduce both the average and maximum velocities within the mainstem channel below the swale connections. Velocities across the floodplain, and in the two connected side channels will increase, providing greater hydraulic diversity across the site.

Table 8. Modeled Mainstem Velocity Impacts

Flow Event	Change in Mean Velocity (%)*	Change in Max Velocity (%)*
Winter Base Flow	- 21%	- 21%
Q2	- 4%	- 6%
Q10	- 3%	+ 5%**

*Area sampled is the existing mainstem within the Phase 1 work area, beginning at the upstream swale excavation, and extending downstream to the Project boundary.

**Velocity increase is localized and is the result of an increased hydraulic gradient immediately downstream of a proposed channel spanning Jam.

Bed Shear Stress

Within the mainstem channel, the model indicates the project will not have a measurable impact on the average bed shear stress; however, it does show a reduction in maximum bed shear at lower flows. A summary of the modeled shear stresses in the mainstem of the project area is summarized in Table 9. The mobile particle classes have been included for reference based on critical shear values identified by Berenbrock and Tranmer (USGS, 2008).

Table 9. Modeled Bed Shear

Model Scenario	Mean Shear* (lb/ft^2)	Mean Particle Class Transported**	Max Shear* (lb/ft^2)	Max Particle Class Transported**
Winter Base - Existing	0.27	Coarse Gravel	2.69	Coarse Cobble
Winter Base - Proposed	**0.37**	**Coarse Gravel**	**1.80**	**Fine Cobble**
Q2 -Existing	1.10	Very Coarse Gravel	5.43	Fine Boulder
Q2 - Proposed	**1.11**	**Very Coarse Gravel**	**4.40**	**Coarse Cobble**
Q10 -Existing	1.42	Fine Cobble	7.88	Fine Boulder
Q10 - Proposed	**1.35**	**Fine Cobble**	**7.40**	**Fine Boulder**

*Shear values were extracted within the footprint of the channel fill area.
**Based on critical shear stresses identified by Berenbrock and Tranmer (USGS, 2008).

See Appendix D for model results figures.

REGION 2: RM22.9 TO RM23.1

The model results in Region 2 were analyzed to determine potential depths and velocities on the floodplain where the placement of floodplain logs is proposed. These logs are approximately 30-feet long with rootwads intact and will be pinned against existing trees and shrubs on a densely vegetated floodplain. The depths and velocities at each proposed log placement were sampled and are summarized in Table 9. See below for log stability analysis.

Table 10. Depths and Velocities at Proposed Floodplain Log Placements.

	Q10 - Depth	Q10 - Velocity	Q100 - Depth	Q100 - Velocity
Average	1.8 ft	1.3 ft/s	2.1 ft	2.5 ft/s
Maximum	2.8 ft	3.4 ft/s	4.7 ft	3.7 ft/s

See Appendix D for model results figures.

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

The project team assessed reach-scale user and property risk using Bureau of Reclamation's Risk Assessment methods (2014, discussed in greater detail in Appendix E.1), which provide recommendations on safety factors and design floods for logjam stability. This analysis found that both user and property risks are low for the reach. Low risks have associated recommendations of 10-year design flood and minimum safety factors of 1.25-1.5 for sliding, buoyancy, and rotation. Log jam buoyancy and scour calculations are included in Appendix E.2.

Wood Habitat Structures

The log structure will not require anchoring that requires cables, chains or other mechanical methods that are not allowed under the HIP III. The apex structures and channel spanning jams exposed to greater depths and velocities will be designed with higher levels of stability to create hardpoints within the reach and aid in the retention of gravels and large wood moving downstream. These larger jams will be designed with native boulder ballast and stream bed material to counteract buoyant forces. Relatively shallow flow depths on the floodplain and the forested riparian area in this reach are favorable for relative logjam stability without significant ballast. Margin structures and floodplain logs are intended to be somewhat mobile and are expected to move periodically during high water events.

Floodplain Logs Upstream of King Grade Road

Floodplain wood placed upstream of the bridge will be strategically placed against and among existing vegetation in areas where the flow depths and velocities are low. The floodplain logs will be woven into existing trees and vegetation to limit mobility. The logs will not be anchored using mechanical pins. The model results (see Table 10) indicate that at maximum depths during the Q10 flow and above may be sufficient to float the logs, with an average depth of approximately 2 feet, which is near the diameter of the logs. Given that the average depth of flow is not significantly greater than the logs, buoyant forces during the average depths may not be great enough to displace these logs. In addition, many of the floodplain logs will be placed in pairs with logs crossing over the top of each other to reduce buoyant forces.

While the logs may be buoyant during extreme flood events, the velocities are not high (< 4 feet per second), and the density of vegetation is sufficient to prevent largescale mobilization that may threaten the Kings Grade Road bridge, and downstream properties. Floodplain logs will be 25-45 feet in length and 18 – 24 inches in diameter with intact rootwads. The length of these members and the presence of rootwads will limit the risk of mobilization if the logs are floated. Additionally, the downstream most floodplain logs have been pinned with pier logs and stacked to create a catcher's mitt protecting King Grade Rd Bridge.

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

Sections in Chapter 3 include technical analyses associated with the project reach. Data collection of in situ site information included: topographical survey, hydrology analysis, hydraulic modeling and stability analysis. The collection of survey data combined with LiDAR provides the base map information for the existing terrain utilized for the proposed design and hydraulic modeling.

Hydrologic analysis provides the design team with expected flow regimes for Tucannon River. Expected annual and bank full discharge flows as well as flood events aid design of channel and floodplain design as well as large wood stability analysis.

Hydraulic modeling informs channel and floodplain design with velocities, shear, and water surface elevations, critical to optimize flow spreading and floodplain connectivity while minimizing flood impacts to surrounding properties. Additionally, hydraulic model output informed placement and design of wood habitat structures and associated stability analysis.

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 WIDTHS UPSTREAM AND DOWNSTREAM OF THE STRUCTURE SHALL BE USED TO DETERMINE THE POTENTIAL FOR CHANNEL DEGRADATION.

Phase I does not include any actions that address profile discontinuities.

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.

Phase I does not include any actions that address profile discontinuities.

4.0 CONSTRUCTION – CONTRACT DOCUMENTATION

4.1 INCORPORATION OF HIPIII GENERAL AND CONSTRUCTION CONSERVATION MEASURES

HIP III Construction Conservation Measures are included in the construction plan set in Appendix C.

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.

The construction plan set, including plan, profile, sections, and detail sheets for the design elements is in Appendix C. Project design specification are including in Appendix F.

4.3 LIST OF ALL PROPOSED PROJECT MATERIALS AND QUANTITIES.

Material quantities for excavation are estimated in units of bank cubic yards (calculated in place prior to removal). Material quantities for excavation are estimated in units of bank cubic yards (calculated in place prior to removal). This quantity does not include increases in volume due to “swell” and “loose” factors that are important to contractors when estimating haul and other costs. It is often preferred by contractors for excavation quantities to be specified on a bank cubic yard basis to eliminate discrepancies between the engineers and contractors estimates of the swell and loose factors.

The estimate shown in Table 11 and Appendix G provides an approximation of quantities and total project costs. This table does not include estimated project costs for permitting, design, monitoring, and/or ongoing maintenance. Estimated costs are presented in 2021 dollars and would need to be adjusted to account for price escalation for implementation in future years.

Note that the actual cost of construction may be impacted by the availability of construction equipment and crews and fluctuation of supply prices at the time the work is bid. W2r makes no warranty, expressed or implied, as to the accuracy of such opinions as compared to bids or actual costs.

Primary assumptions of the cost estimate include:

- Unit costs – include contractor markup, profit, and overhead;
- Mobilization/demobilization – Assumed to be 10% of all other fixed costs;
- Erosion & Water Pollution Control – Assumed to be 3% of all other fixed costs;
- Levee, high ground, and swale grading/excavation – excavation costs assume common excavator, bulldozer, scraper and high capacity dump truck equipment;
- Onsite Disposal – the cost estimate assumes that natural material excavated from the levee, high ground and swales will be used to fill areas in channels;
- Contingencies – 20% construction contingency is included in the total bid estimate to account for future design changes and unforeseen conditions.

	Costs			
Item	**Qty**	**Unit**	**Unit Cost**	**Total**
MOBILIZATION	1	LS	$ 49,000	$ 49,000
TEMPORARY STREAM DIVERSION & PLAN	1	LS	$ 15,000	$ 15,000
EROSION & WATER POLLUTION CONTROL	1	LS	$ 19,000	$ 19,000
CLEARING AND GRUBBING	2	AC	$ 3,500	$ 7,000
EARTHWORK EXCAVATION	3,600	CY	$ 11	$ 39,600
NATIVE WETLAND SEEDING	3.0	AC	$ 2,000	$ 6,000
NATIVE UPLAND SEEDING	7.0	AC	$ 1,500	$ 10,500
WHS TYPE 1 - LARGE APEX JAM	9	EA	$ 14,100	$ 126,900
WHS TYPE 2 - SMALL APEX JAM	9	EA	$ 5,300	$ 47,700
WHS TYPE 3 - MARGIN DEFLECTOR JAM	40	EA	$ 5,000	$ 200,000
WHS TYPE 4 - FLOODPLAIN WOOD	34	EA	$ 1,000	$ 34,000
WHS TYPE 5 - FLOODPLAIN WOOD	30	EA	$ 2,000	$ 60,000
WHS TYPE 6 - HABITAT LOG	27	EA	$ 500	$ 13,500
WHS TYPE 6A - PINNED HABITAT LOGS	2	EA	$ 4,200	$ 8,400
WHS TYPE 7 - CHANNEL SPANNING JAM	3	EA	$ 18,600	$ 55,800
TOTAL CONSTRUCTION COST				**$ 693,000**

Table 11 Estimate of Probable Construction Cost

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

The previous design plan set includes HIP General Aquatic Conservation measures to follow during and post construction, which includes temporary erosion and sediment control (TESC) measures as well as best management practices (BMP's). Use of erosion control measures such as fiber rolls and silt fencing will aid in addressing the stockpiling of spoil material and associated storm water runoff from leaving the site. Temporary access routes will assist with runoff and roadway rutting, while erosion control around stockpiles and staging areas assists with runoff and run-on associated with precipitation events. The stabilized construction entrance helps to prevent erosion associated with heavy equipment entering the site and also provides an area for washout prior to construction equipment leaving the site.

1. SITE ACCESS STAGING AND SEQUENCING PLAN.

Access and staging locations are shown in the design drawings provided in Appendix C. Vehicular access points are strategically located throughout the project area. Access routes follow existing roads and avoid sensitive areas such as wetlands to the highest extents possible. Key entrance points are shown based on land type and access from existing roadways. All staging areas are currently shown outside the ordinary high-water delineation.

Excavated material from the high terrace and swales will be stockpiled adjacent to the mainstem channel fill areas on a gravel bar to minimize the impact and number of times equipment will access the channel or need temporary crossings. All in channel grading will take place after fish salvage and stream diversion.

Detailed construction sequencing that minimizes potential impacts to wildlife, water quality and habitat is included in the design drawings provided in Appendix C.

2. WORK AREA ISOLATION AND DEWATERING PLAN.

Removal of water details for temporary bypass of the river or individual wood structure installations are shown in the design drawings in Appendix C. Details include a step-by-step process and configurations for dewatering and rewatering the river before, during and after bypass. Additional details include bulk bag coffer dam installations and area isolation for large wood structure installations. More information regarding the detailed location for coffer dam locations and dewatering activities are incorporated into the sequencing plan on Sheet C1.2 in Appendix C.

3. EROSION AND POLLUTION CONTROL PLAN.

The design drawings in Appendix C include HIP General Aquatic Conservation Measures applicable to erosion control, stockpiling, dust abatement, spills and invasive species control measures. Subsequent design submittals will include the location of specific BMP measures to be incorporated during construction. Specific measures proposed for the project likely include use of erosion control measures such as fiber rolls and silt fencing to address the stockpiling of spoil material and associated storm water runoff from leaving the site. Temporary access routes will assist with runoff and roadway rutting, while erosion control around stockpiles and staging areas assists with runoff and run-on associated with precipitation events. The stabilized construction entrance helps to prevent erosion associated with heavy equipment entering the site and also provides an area for washout prior to construction equipment leaving the site.

4. SITE RECLAMATION AND RESTORATION PLAN.

Native seeding of all disturbed areas including access routes and staging areas will be completed immediately following construction. The bulk of the project area revegetation including tree and shrub planting will occur after the following phase(s) of the project. Site seeding plan is included in Appendix C, Engineering Planset, Sheet L1.1.

5. LIST PROPOSED EQUIPMENT AND FUELS MANAGEMENT PLAN.

Sheet G2.1 & G2.2 of the design drawings in Appendix C include HIP General Aquatic Conservation Measures applicable to construction equipment and spill prevention, control and counter measures. Section 5 – Equipment of these notes includes conservation measures addressing the use, staging, maintenance and refueling of equipment. Section 9 – Spill, Prevention, Control and Counter Measures of these notes include procedures and precautions for storing, handling any hazardous materials onsite.

4.5 CALENDAR SCHEDULE FOR CONSTRUCTION/IMPLEMENTATION PROCEDURES.

Construction is scheduled to begin July 15, 2021 with the project elements below ordinary high water (OHW) carried out during the in-water work window July 15 – August 30. Project elements in areas above OHW may be completed during August through September. Also see sequencing details on Sheets C1.2and ESC1.1 in Appendix C – Engineering Planset.

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

Site and project specific monitoring details are included in Appendix C, Engineering Planset, Sheet ESC 1.1 and ESC 1.2.

5.0 MONITORING AND ADAPTIVE MANAGEMENT PLAN

5.1 INTRODUCTION

The Tucannon Programmatic is currently working to formalize a basin wide monitoring strategy to support adaptive management decisions for habitat restoration projects within the basin. The approach is being developed by restoration and monitoring practitioners working in the basin and is focusing on using habitat metrics that are currently being measured as part of ongoing restoration and monitoring effort in the basin. Project Area 27/28.1 monitoring and adaptive management plan is being developed to fit within the guidelines being developed for the entire basin.

The project area is being addressed as part of this restoration effort.

5.4 PROJECT REVIEW TEAM TRIGGERS

Project Type	Objective	Trigger/Event/Risk	Management Response
LWD Addition	Maintain LWD density of >2key pieces/bankfull width	Visible and effective LWD Key pieces frequency is below minimum objective of deteriorates prior to the development of adequate recruitment potential is met.	Wood loading or additional structures to raise LWD density to target level.
LWD Addition	Increase quality pool (>1 m deep) density to 1 /7 bankfull width	Quality pools > 1 m deep do not develop	Add more wood/ structures, make structures larger, increase hydraulic purchase, and consider gravel supply and augmentation.
LWD Addition	Do no harm	Structure or treatment is causing harm or has potential to cause harm to infrastructure or environment	Remove or alter structure or parts of the treatment
Floodplain Reconnection	Inundate floodplain during designed bankfull flows	Structures not promoting overbank flow as expected	Build up structures taller/wider
Floodplain Reconnection	Inundate floodplain during bankfull flows	Bed elevation too low, channel too incised	Add structures upstream to encourage sediment recruitment/channel widening, consider gravel augmentation
Floodplain Reconnection	Do no harm	Treatment resulted in flooding or threatening infrastructure	Add setback levee, add structure to divert flood flows, remove problematic structure
Riparian	Hard stem and herbaceous plant cover and densities		
Riparian	Invasive species		

5.5 MONITORING FREQUENCY, TIMING, AND DURATION

BASELINE SURVEY

LiDAR was collected in November 2020 by Quantum Spatial, Inc. Additional survey was conducted in February 2021. Since this project is a multiple year phased survey, summer surveys will be conducted prior to the initiation of each work season.

AS-BUILT SURVEY

An as-built survey was conducted in February 2021 for Phase 0 to 0.5. This survey was confirmed with recent LiDAR and aerial collected during the as-built survey. As-built survey for Phase 0.5 to 1 will be conducted post construction.

MONITORING SITE LAYOUT

The monitoring site layout for the rapid habitat surveys include the entire project implementation area, including the floodplain flow paths.
LiDAR coverage for the project area covers the entire valley bottom.

POST-BANKFULL EVENT SURVEY

The current survey frequency at project site has to either conduct a survey 2 freshets following the as built survey or following the first bank full event and every 5yr flow following the as-built survey through the duration of the Programmatic.

FUTURE SURVEY (RELATED TO FLOW EVENT)

Currently project sponsors visit project sites frequently to visually assess function and safety both during and following freshets and flood flows. The sponsor plans to conduct surveys rapid habitat surveys following significant flow events to make observations in habitat function using the results to track changes in the limiting factors to ensure project restoration goals and objectives are being met.

5.6 MONITORING TECHNIQUE PROTOCOLS

In the Tucannon basin we are using a rapid habitat survey (RHS) protocol combined with strategic LiDAR data to conduct implementation/effectiveness monitoring and longer term change detection monitoring. The rapid habitat monitoring protocol is derived from the CHAMP protocol paired way down to capture changes in LWD structure frequency for jams formed by LWD pieces >6 m long and 0.3 m in dia, develop pool frequency with and estimate for pool area and maximum depth. The protocol also delineated perennial and ephemeral side channels using the CHAMP protocol for small side channels, collecting bankfull width, flow and length.

The use of periodic LiDAR survey for the entire basin are being used to monitoring change detection at the basin scale, though the development of a wide of model layers to develop estimate from automated data set for floodplain connectivity, channel complexity and riparian habitat. Floodplain connectivity is being modeled as existing and disconnected at the 2 and 5 yr flood intervals. Channel complexity is being derived from an automated data layer for the winter low flow (130cfs) and the winter mean flow (300 cfs). Riparian extent and canopy height is being derived from LiDAR data points in 2010 and 2020 and will be extracted from future surveys. The approach to assessing floodplain connectivity is being formalized in the Tucannon Conceptual Restoration Plan and is taking into account connectivity gained from removal of coifing features and recusing incision and entrenchment.

PHOTO DOCUMENTATION AND VISUAL INSPECTION

Photo documentation is being done through both ground based georeferenced photo points of habitat units and as-built LWD structures and aerial photographic imagery and video captured by fixed wing aircraft and low elevation drone video.

LONGITUDINAL PROFILE

Longitudinal profile and changes in the profile are extracted from analysis and modeling products produced from LiDAR survey data.

HABITAT SURVEY

Rapid habitat surveys include:

- A channel delineation for perennial and ephemeral flow paths at base flow (<120 cfs) over the entire project reach
- A count of LWD structures, and a count of LWD key pieces (>6 m long & 0.3 m dia) within bankfull width
- Pool frequency, an estimate of pool surface area and maximum depth.
- Development of georeferenced photo points of pre-project habitat features, post project condition and post high flow habitat changes.

Downstream Channel Fill:

- Monitor for headcuts and/or passage barriers following large flow events.
- Pool frequency, an estimate of pool surface area and maximum depth.
- Channel spanning jam stability and additional racking wood.

LiDAR Survey data products include:

- Channel complexity analysis in the form of 1 yr, mean winter and low winter flow islands
- Floodplain connectivity in the form of connected and disconnected 2 & 5 yr floodplain
- Channel migration analysis channel trace comparisons
- Geomorphic change analysis topographic difference
- Relative elevation change
- Bare Earth and first return modeled layers to illustrate ground layer and vegetation growth and area.

CHANNEL AND FLOODPLAIN CROSS-SECTIONS

We will use LiDAR analysis to make observations in channel and floodplain changes over time beginning with two pre-project surveys collected in 2010 and 2017, and post Phase 0 to 0.5 project LiDAR collected in 2020. Currently the project reach is being used as part of the ad hoc AEM floodplain monitoring project being conducted by Cramer Fish Sciences.

5.7 DATA STORAGE AND ANALYSIS

Data analysis will be conducted as part of the annual Programmatic reporting for project conducted in the Tucannon basin, in the 2021 annual report with future implementation phases in future reports on an annual basis.

Data is stored in its original form at the Snake River Salmon Recovery Board Office. It is also stored in the CTUIR online data base through a Tucannon River portal and at Tucannon.org.

5.8 MONITORING QUALITY ASSURANCE PLAN

Data collection is automated using a GIS supported filed collection guide template to minimized missed data fields or miss assigned data fields. In the office prior to exporting data to storage field personnel export data sets to spreadsheet to assess data point which are out of range or erroneous. One final check of data occurs by plotting spatial date to observe mapping irregularities.

6.0 References

Anchor QEA, 2011a. Tucannon River Geomorphic Assessment and Habitat Restoration Study. Prepared for Columbia Conservation District. April 2011.

Anchor QEA, 2011b. Conceptual Restoration Plan, Reaches 6 to 10 Tucannon River Phase II. Prepared for Columbia Conservation District. April 2011.

United States Geological Survey (USGS). 2008. Simulation of Flow, Sediment Transport, and Sediment Mobility of the Lower Coeur d'Alene River, Idaho. Scientific Investigations Report 2008-5093. Table 7.

CCD (Columbia Conservation District), 2004. Tucannon Subbasin Plan . Prepared for Northwest Power and Conservation Council. May 2004.

Jones, K.L., G.C. Poole, E.J. Quaempts, S. O'Daniel, and T. Beechie. 2008. Umatilla River Vision. October. Available: http://www.ykfp.org/par10/html/CTUIR%20DNR%20Umatilla%20River%20Vision%20100108.pdf

Legg, N.T., 2020. Restoration of Incised Streams: Recognizing gravel as a limited resource using a simple metric for bedload supply. Abstract for the River Restoration Northwest Symposium (2020)

SRSRB (Snake River Salmon Recovery Board), 2006. Snake River Recovery Plan for SE Washington. Prepared for Washington Governor's Salmon Recovery Office. December 2006.

Three Treaty Tribes-Action Agencies. 2008. Columbia Basin Fish Accords. Available: http://www.critfc.org/wp-content/uploads/2012/10/moa.pdf.

Turowski, J. M., Rickenmann, D., & Dadson, S. J. (2010). The partitioning of the total sediment load of a river into suspended load and bedload: a review of empirical data. *Sedimentology*, *57*(4), 1126-1146.

US Bureau of Reclamation (Reclamation). 2014. Large Woody Material – Risk Based Design Guidelines. U.S. Department of the Interior. Pacific Northwest Region. Boise, Idaho. September.

USFWS (U.S. Fish and Wildlife Service), 2010. Bull Trout Final Critical Habitat Justification: Rationale for Why Habitat is Essential, and Documentation of Occupancy . Chapter 15. Mid-Columbia Recovery Unit-Lower Snake River Critical Habitat Unit. Pgs. 428 – 431. September 2010.

APPENDICES

A PHASE 0 TO 0.5 BDR

B WETLANDS ASSESSMENT (PHASE 0 TO 1)

C 80% DESIGN ENGINEERING PLANSET

D MODELING RESULTS FIGURES

E.1 BOR RISK ASSESSMENT

E.2 80% WOOD STABILITY CALCULATIONS

F 80% DESIGN SPECIFICATIONS

G 80% DESIGN COST ESTIMATE

1001 SE Water Ave.
Suite 180
Portland, OR 97214
503.207.6688

Technical Memorandum

Date:	February 11, 2020
To:	Kris Fischer, Confederated Tribes of the Umatilla Indian Reservation (CTUIR)
From:	Elisabeth Bowers, PWS - Wolf Water Resources (W2r)
Project:	Tucannon River Project Area 27/28 Floodplain Restoration Project
Subject:	Wetland Determination

Introduction

The Confederated Tribes of the Umatilla Indian Reservation (CTUIR) proposes to undertake a floodplain restoration project at the Tucannon River Project Area 27/28 (“the Project”) funded by the Bonneville Power Administration as part of their Fish and Wildlife Program. The Project will require Clean Water Act (CWA), Sections 401 and 404 permits and plans to obtain these through the Nationwide Permit (NWP) #27 for Aquatic Habitat Restoration, Establishment, and Enhancement Activities. As a voluntary stream or wetland restoration or enhancement action on private land, pre-construction notification is not required.

Since the primary goal of the Project is to revert this reach of the Tucannon River back to its original state, restoring natural processes, a wetland delineation has not been required by the U.S. Army Corps of Engineers (Corps). However, identifying baseline ecological conditions for the study area is necessary to design the Project in such a way to both restore natural processes and protect the existing natural resources such as wetlands. In addition, identifying wetland and OHWM boundaries will allow the Project team to calculate Project impacts to facilitate the Corps’ review of the Project for CWA permitting under NWP #27.

Therefore, Wolf Water Resources (W2r) wetland scientists determined wetland and OHWM boundaries through a combination of LiDAR-derived contours, hydraulic modeling results, drone imagery, and field verification of wetland/waterway presence/absence based on best professional

1001 SE Water Ave.
Suite 180
Portland, OR 97214
503.207.6688

judgement. This memorandum summarizes site conditions based on office-based analysis as well as field-based observations and data collected for project planning purposes.

Background Research

The study area is located in Columbia County in the southeast corner of Washington along the Tucannon River, a tributary to the Snake River. The headwaters of the Tucannon River are located in the Blue Mountains. The study area has been impacted by agricultural practices, likely since the area was settled in the 1800s.

Prior to the field investigation, W2r staff analyzed National Wetland Inventory data, drone imagery, and LiDAR data for the study area to determine the general layout of the site and where low-lying areas were that could potentially be wetland based on topography (Attachment 1). These data sets indicated that wetlands were likely to be located within the Tucannon River floodplain in the study area.

Field Methods

On January 20th and 21st, Elisabeth Bowers, PWS, and Joe Rudolph, Landscape Ecologist, conducted the wetland field investigation at the Project site. During the field investigation, wetland field indicator data (Attachment 2) was collected at various points to verify whether wetlands were present at particular locations identified during the office-based analysis. A total of 6 sample plots were established. Data was collected as each sample plot according to the methods using the Routine Determination Method for delineating wetlands described in the U.S. Army Corps of Engineers (Corps) Wetlands Delineation Manual (Environmental Laboratory 1987) and the methods and criteria described in the Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Arid West (USACE 2008). The data collected at each sample plot was then used to further refine the wetland mapping provided in Attachment 1. In addition, ground-level color photographs were taken to demonstrate site conditions within the study area (Attachment 3). Photo-point locations are shown in Attachment 1.

1001 SE Water Ave.
Suite 180
Portland, OR 97214
503.207.6688

Findings

The study area is bisected north to south by King Grade Road, which crosses the Tucannon River with a wooden bridge that support vehicles. The study is then bisected east to west by the river itself. Outside the floodplain along the north side of the study area there is a series of hay fields south of Tucannon Road. Grasses grown in these fields appeared to be predominantly oat grass (*Avena sativa*), wheat (*Triticum aestivum*), and water foxtail (*Alopecurus geniculatus*). There is one low area in the field in the northwest quadrant of the study that is potential wetland; however, because it is isolated, it is not thought to be jurisdictional. There is also an irrigation ditch that runs through the field in the northwest quadrant of the study area. This ditch was partially inundated during the field investigation and would likely be considered intermittent based on flow and valley slope.

South of the Tucannon River, above the active floodplain, the study area is composed of heavily grazed grass fields interspersed with vegetation such as Nootka rose (*Rosa nutkana*), Himalayan blackberry (*Rubus armeniacus*), and white alder (*Alnus rhombifolia*). In the southwest quadrant there is a sliver of potential wetland at the lowest point of an access road; however, this small area is isolated and not thought to be jurisdictional. There was a small (<300 square feet) aspen stand (*Populus tremuloides*) observed near this feature.

All other potential wetlands within the study area are associated with the Tucannon River's floodplain. The largest wetland area is located in the northeast quadrant of the study area. This area is a floodplain wetland mosaic characterized as a relatively flat hummocky area with small transitions (as little as 1 foot) in elevation between wetland and upland. This area was dominated by reed canarygrass (*Phalaris arundinacea*), Himalayan blackberry, and white alder throughout. A portion of this area is still used for cattle grazing and there is an irrigation ditch that crosses from this quadrant to the northwest quadrant through a culvert under King Grade Road and connects with the previously mentioned irrigation ditch. In the northwest quadrant of the study area, there are a series of floodplain wetlands that are likely connected to the mainstem of the Tucannon River during higher flood flows and may be associated with relict side channels of the river. There was evidence of beaver activity in this area, shown near photo-point 2 (Attachment 3), and these wetland areas are dominated white alder, black cottonwood (*Populus balsamifera*), cluster rose (*Rosa pisocarpa*), and reed canarygrass. There were also a couple of small (<300 square feet) aspen stands observed near SP-04 (Attachment 1).

1001 SE Water Ave.
Suite 180
Portland, OR 97214
503.207.6688

Native soils across the study area are largely composed of dark silt loams. Within the floodplain there was a higher content of silts, sand, and organics as well as a restrictive layer of floodplain gravels and cobbles. Wetland hydrology indicators consisted largely of high water table, saturation, and drainage patterns.

According to W2r's analysis of wetland presence, the study area contains approximately 8.1 acres of wetland and 0.1 acre of isolated wetland, which is not thought to be under the Corps' jurisdiction and is labeled in Attachment 1.

The study area has many qualities that make it an ideal restoration target. This Tucannon River reach's unconfined floodplain and relatively low gradient give it the basic geomorphic elements necessary for an interconnected and dynamic channel-floodplain system, which is apparent through some of the existing relict side channel features. The biological functional value is also great, with extensive juvenile and spawning use by ESA-listed Chinook salmon, as well as the reach serving as a migratory corridor for bull trout. In addition to aquatic species, during the field investigation, a variety of terrestrial species including owls, red-tailed hawks, northern harriers, belted kingfishers, wild turkeys, woodpeckers, waterfowl, deer, and cougars were either observed or evidence of these species was observed.

Conclusion

W2r determined wetland and OHWM boundaries through a combination of LiDAR-derived contours, hydraulic modeling results, drone imagery, and the results of the wetland field investigation. Identifying these boundaries will assist the Project design team in designing a project that will result in an increase in aquatic resource functions and services. This will also allow the Project team to calculate Project impacts to facilitate the Corps' review of the Project for CWA permitting under NWP #27.

Disclaimer

This report documents the observations, best professional judgment, and conclusions of the investigators. It is correct and complete to the best of our knowledge. It should be considered a precursor to a Preliminary Jurisdictional Determination (PJD) of wetlands and other waters and used at your own discretion unless reviewed and approved in writing by the Corps.

1001 SE Water Ave.
Suite 180
Portland, OR 97214
503.207.6688

References

1. Environmental Laboratory. 1987. "Corps of Engineers Wetlands Delineation Manual," Technical Report Y-87-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, Miss.

2. USACE (U.S. Army Corps of Engineers). 2008. Environmental Laboratory. ERDC/EL TR-08-28. Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Arid West Region (Version 2.0). September 2008

Attachments

- Attachment 1: Potentially Jurisdictional Water Features
- Attachment 2: Wetland Determination Data Forms
- Attachment 3: Ground-Level Color Photographs

THIS PAGE LEFT BLANK INTENTIONALLY

Path: L:\Shared\W2r\GIS\GIS Projects\2019\20190026 - Tucannon River\maps\Wetland Maps\Wetland Determination Map.aprx

Study Area
Irrigation Ditch
Potential Wetland

Point Type
Photo Point
Sample Plot
Aspen

Approximate OHWM
Upstream
Downstream

N

0 400 800 1,600 US Feet

Attachment 1:
Potentially Jurisdictional
Water Features

Esri, HERE, Garmin, (c) OpenStreetMap contributors, and the GIS user community, Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

THIS PAGE LEFT BLANK INTENTIONALLY

WETLAND DETERMINATION DATA FORM – Arid West Region

Project/Site: Tucannon River Project Area 27/28 City/County: Columbia County Sampling Date: 01/20/20

Applicant/Owner: Confederated Tribes of the Umatilla Indian Reservation State: WA Sampling Point: SP-01

Investigator(s): Elisabeth Bowers/Joe Rudolph Section, Township, Range: Section 8, Township 11N, Range 40E

Landform (hillslope, terrace, etc.): terrace Local relief (concave, convex, none): none Slope (%): 1

Subregion (LRR): B, Columbia/Snake River Plateau Lat: 46.45508706 Long: -117.82775788 Datum: WGS84

Soil Map Unit Name: Patit Creek silt loam, 0 to 3 percent slopes (PkA) NWI classification: PEM1C

Are climatic / hydrologic conditions on the site typical for this time of year? Yes ✓ No ___ (If no, explain in Remarks.)

Are Vegetation ___, Soil ___, or Hydrology ___ significantly disturbed? Are "Normal Circumstances" present? Yes ✓ No ___

Are Vegetation ___, Soil ___, or Hydrology ___ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

	Yes	No
Hydrophytic Vegetation Present?	✓	
Hydric Soil Present?		✓
Wetland Hydrology Present?		✓
Is the Sampled Area within a Wetland?		✓

Remarks:

On a higher area within the floodplain

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: 20 ft radius)	Absolute % Cover	Dominant Species?	Indicator Status
1. Alnus rhombifolia	50	Yes	FACW
2.			
3.			
4.			
	50 = Total Cover		
Sapling/Shrub Stratum (Plot size: ___)			
1. N/A			
2.			
3.			
4.			
5.			
	___ = Total Cover		
Herb Stratum (Plot size: 5 foot radius)			
1. Galium aparine	35	Yes	FACU
2. Rubus armeniacus	1	No	FAC
3. Phalaris arundinacea (part dead)	5	No	FACW
4.			
5.			
6.			
7.			
8.			
	41 = Total Cover		
Woody Vine Stratum (Plot size: ___)			
1. N/A			
2.			
	___ = Total Cover		

% Bare Ground in Herb Stratum 59 % Cover of Biotic Crust ___

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 1 (A)

Total Number of Dominant Species Across All Strata: 2 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 50 (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species		x 1 =	
FACW species	55	x 2 =	110
FAC species	1	x 3 =	3
FACU species	35	x 4 =	140
UPL species		x 5 =	
Column Totals:	91 (A)		253 (B)

Prevalence Index = B/A = 2.78

Hydrophytic Vegetation Indicators:

- ___ Dominance Test is >50%
- ✓ Prevalence Index is ≤3.0[1]
- ___ Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes ✓ No ___

Remarks:

SOIL

Sampling Point: SP-01

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-6	10YR 3/1	100	-	-	-	-	silt loam	
6-8	10YR 3/1	100	-	-	-	-	silt loam	river gravels and shovel refusal

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5) (**LRR C**)
- ___ 1 cm Muck (A9) (**LRR D**)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Loamy Mucky Mineral (F1)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)
- ___ Vernal Pools (F9)

Indicators for Problematic Hydric Soils[3]:

- ___ 1 cm Muck (A9) (**LRR C**)
- ___ 2 cm Muck (A10) (**LRR B**)
- ___ Reduced Vertic (F18)
- ___ Red Parent Material (TF2)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present):

Type: River gravels/cobbles

Depth (inches): 8 inches

Hydric Soil Present? Yes ___ No ✓

Remarks:

Shovel refusal at 8 inches. This area is higher within the floodplain.

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ___ Saturation (A3)
- ___ Water Marks (B1) (**Nonriverine**)
- ___ Sediment Deposits (B2) (**Nonriverine**)
- ___ Drift Deposits (B3) (**Nonriverine**)
- ___ Surface Soil Cracks (B6)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Water-Stained Leaves (B9)
- ___ Salt Crust (B11)
- ___ Biotic Crust (B12)
- ___ Aquatic Invertebrates (B13)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Oxidized Rhizospheres along Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tilled Soils (C6)
- ___ Thin Muck Surface (C7)
- ___ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

- ___ Water Marks (B1) (**Riverine**)
- ___ Sediment Deposits (B2) (**Riverine**)
- ___ Drift Deposits (B3) (**Riverine**)
- ___ Drainage Patterns (B10)
- ___ Dry-Season Water Table (C2)
- ___ Crayfish Burrows (C8)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Shallow Aquitard (D3)
- ___ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes ___ No ✓ Depth (inches): ___

Water Table Present? Yes ___ No ✓ Depth (inches): ___

Saturation Present? (includes capillary fringe) Yes ___ No ✓ Depth (inches): ___

Wetland Hydrology Present? Yes ___ No ✓

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Drone imagery, LiDAR, Height above water surface (HAWS) mapping

Remarks:

There didn't seem to be a water table within 12 inches of the soil surface - though shovel refusal was at 8 inches. Soils were dry.

WETLAND DETERMINATION DATA FORM – Arid West Region

Project/Site: Tucannon River Project Area 27/28 City/County: Columbia County Sampling Date: 01/20/20

Applicant/Owner: Confederated Tribes of the Umatilla Indian Reservation State: WA Sampling Point: SP-02

Investigator(s): Elisabeth Bowers/Joe Rudolph Section, Township, Range: Section 8, Township 11N, Range 40E

Landform (hillslope, terrace, etc.): terrace Local relief (concave, convex, none): concave Slope (%): 1

Subregion (LRR): B, Columbia/Snake River Plateau Lat: 46.45553858 Long: -117.82763690 Datum: WGS84

Soil Map Unit Name: Patit Creek silt loam, 0 to 3 percent slopes (PkA) NWI classification: PEM1C

Are climatic / hydrologic conditions on the site typical for this time of year? Yes ✓ No ____ (If no, explain in Remarks.)

Are Vegetation ____, Soil ____, or Hydrology ____ significantly disturbed? Are "Normal Circumstances" present? Yes ✓ No ____

Are Vegetation ____, Soil ____, or Hydrology ____ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes ✓ No ____	**Is the Sampled Area within a Wetland?**	**Yes ✓ No ____**
Hydric Soil Present?	Yes ✓ No ____		
Wetland Hydrology Present?	Yes ✓ No ____		

Remarks:

Within an abandoned side channel; low area

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: 20 ft radius)	Absolute % Cover	Dominant Species?	Indicator Status
1. Alnus rhombifolia	20	Yes	FACW
2. Acer saccharinum	50	Yes	FAC
3.			
4.			
	70 = Total Cover		
Sapling/Shrub Stratum (Plot size: ____)			
1. N/A			
2.			
3.			
4.			
5.			
	____ = Total Cover		
Herb Stratum (Plot size: ____)			
1. N/A			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
	____ = Total Cover		
Woody Vine Stratum (Plot size: ____)			
1. N/A			
2.			
	____ = Total Cover		

% Bare Ground in Herb Stratum 100 % Cover of Biotic Crust ____

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 2 (A)

Total Number of Dominant Species Across All Strata: 2 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 100 (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species	____	x 1 =	____
FACW species	____	x 2 =	____
FAC species	____	x 3 =	____
FACU species	____	x 4 =	____
UPL species	____	x 5 =	____
Column Totals:	____ (A)		____ (B)

Prevalence Index = B/A = ____

Hydrophytic Vegetation Indicators:

✓ Dominance Test is >50%

___ Prevalence Index is ≤3.0[1]

___ Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)

___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? **Yes ✓ No ____**

Remarks:

SOIL

Sampling Point: SP-02

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-1	10YR 3/1	100	-	-	-	-	silt	
1-10	10YR 3/1	98	7.5YR 4/4	2	C	PL	silty sand	river gravels

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5) (**LRR C**)
- ___ 1 cm Muck (A9) (**LRR D**)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ Sandy Gleyed Matrix (S4)
- ✓ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Loamy Mucky Mineral (F1)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)
- ___ Vernal Pools (F9)

Indicators for Problematic Hydric Soils[3]:

- ___ 1 cm Muck (A9) (**LRR C**)
- ___ 2 cm Muck (A10) (**LRR B**)
- ___ Reduced Vertic (F18)
- ___ Red Parent Material (TF2)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present):

Type: River gravels/cobbles

Depth (inches): 10 inches

Hydric Soil Present? Yes ✓ No ___

Remarks:

Shovel refusal at 10 inches. This area is low within the floodplain.

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ✓ Saturation (A3)
- ___ Water Marks (B1) (**Nonriverine**)
- ___ Sediment Deposits (B2) (**Nonriverine**)
- ___ Drift Deposits (B3) (**Nonriverine**)
- ___ Surface Soil Cracks (B6)
- ___ Inundation Visible on Aerial Imagery (B7)
- ✓ Water-Stained Leaves (B9)
- ___ Salt Crust (B11)
- ___ Biotic Crust (B12)
- ___ Aquatic Invertebrates (B13)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Oxidized Rhizospheres along Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tilled Soils (C6)
- ___ Thin Muck Surface (C7)
- ___ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

- ___ Water Marks (B1) (**Riverine**)
- ___ Sediment Deposits (B2) (**Riverine**)
- ___ Drift Deposits (B3) (**Riverine**)
- ✓ Drainage Patterns (B10)
- ___ Dry-Season Water Table (C2)
- ___ Crayfish Burrows (C8)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Shallow Aquitard (D3)
- ___ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes ___ No ✓ Depth (inches): ___

Water Table Present? Yes ___ No ✓ Depth (inches): ___

Saturation Present? (includes capillary fringe) Yes ✓ No ___ Depth (inches): 5" bgs*

Wetland Hydrology Present? Yes ✓ No ___

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Drone imagery, LiDAR, Height above water surface (HAWS) mapping

Remarks:

*below ground surface

WETLAND DETERMINATION DATA FORM – Arid West Region

Project/Site: Tucannon River Project Area 27/28 City/County: Columbia County Sampling Date: 01/20/20

Applicant/Owner: Confederated Tribes of the Umatilla Indian Reservation State: WA Sampling Point: SP-03

Investigator(s): Elisabeth Bowers/Joe Rudolph Section, Township, Range: Section 5, Township 11N, Range 40E

Landform (hillslope, terrace, etc.): terrace Local relief (concave, convex, none): concave Slope (%): 1

Subregion (LRR): B, Columbia/Snake River Plateau Lat: 46.45867784 Long: -117.83228502 Datum: WGS84

Soil Map Unit Name: Mondovi silt loam, 0 to 3 percent slopes (MoA) NWI classification: No

Are climatic / hydrologic conditions on the site typical for this time of year? Yes ✓ No ___ (If no, explain in Remarks.)

Are Vegetation ___, Soil ___, or Hydrology ___ significantly disturbed? Are "Normal Circumstances" present? Yes ✓ No ___

Are Vegetation ___, Soil ___, or Hydrology ___ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes ___	No ✓	**Is the Sampled Area within a Wetland?** **Yes** ___ **No** ✓
Hydric Soil Present?	Yes ___	No ✓	
Wetland Hydrology Present?	Yes ___	No ✓	

Remarks:

low area along edge of hay field

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: ___)	Absolute % Cover	Dominant Species?	Indicator Status
1. N/A			
2.			
3.			
4.			
= Total Cover			
Sapling/Shrub Stratum (Plot size: ___)			
1. N/A			
2.			
3.			
4.			
5.			
= Total Cover			
Herb Stratum (Plot size: ___)			
1. Salsola tragus	60	Yes	FACU
2. Avena sativa	15	No	UPL
3. Triticum aestivum	15	No	UPL
4. Schedonorus arundinaceus	10	No	FACU
5.			
6.			
7.			
8.			
= Total Cover	100		
Woody Vine Stratum (Plot size: ___)			
1. N/A			
2.			
= Total Cover			

% Bare Ground in Herb Stratum 0 % Cover of Biotic Crust ___

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 0 (A)

Total Number of Dominant Species Across All Strata: 0 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 0 (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species		x 1 =
FACW species		x 2 =
FAC species		x 3 =
FACU species		x 4 =
UPL species		x 5 =
Column Totals:	(A)	(B)

Prevalence Index = B/A = ___

Hydrophytic Vegetation Indicators:

- ___ Dominance Test is >50%
- ___ Prevalence Index is ≤3.0[1]
- ___ Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? **Yes** ___ **No** ✓

Remarks:

SOIL

Sampling Point: SP-03

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-17	10YR 3/3	100	-	-	-	-	silt loam	plowed soil

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

___ Histosol (A1)
___ Histic Epipedon (A2)
___ Black Histic (A3)
___ Hydrogen Sulfide (A4)
___ Stratified Layers (A5) (**LRR C**)
___ 1 cm Muck (A9) (**LRR D**)
___ Depleted Below Dark Surface (A11)
___ Thick Dark Surface (A12)
___ Sandy Mucky Mineral (S1)
___ Sandy Gleyed Matrix (S4)
___ Sandy Redox (S5)
___ Stripped Matrix (S6)
___ Loamy Mucky Mineral (F1)
___ Loamy Gleyed Matrix (F2)
___ Depleted Matrix (F3)
___ Redox Dark Surface (F6)
___ Depleted Dark Surface (F7)
___ Redox Depressions (F8)
___ Vernal Pools (F9)

Indicators for Problematic Hydric Soils[3]:

___ 1 cm Muck (A9) (**LRR C**)
___ 2 cm Muck (A10) (**LRR B**)
___ Reduced Vertic (F18)
___ Red Parent Material (TF2)
___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present):

Type: ______

Depth (inches): ______

Hydric Soil Present? Yes ______ No ✓

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

___ Surface Water (A1)
___ High Water Table (A2)
___ Saturation (A3)
___ Water Marks (B1) (**Nonriverine**)
___ Sediment Deposits (B2) (**Nonriverine**)
___ Drift Deposits (B3) (**Nonriverine**)
___ Surface Soil Cracks (B6)
___ Inundation Visible on Aerial Imagery (B7)
___ Water-Stained Leaves (B9)
___ Salt Crust (B11)
___ Biotic Crust (B12)
___ Aquatic Invertebrates (B13)
___ Hydrogen Sulfide Odor (C1)
___ Oxidized Rhizospheres along Living Roots (C3)
___ Presence of Reduced Iron (C4)
___ Recent Iron Reduction in Tilled Soils (C6)
___ Thin Muck Surface (C7)
___ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

___ Water Marks (B1) (**Riverine**)
___ Sediment Deposits (B2) (**Riverine**)
___ Drift Deposits (B3) (**Riverine**)
___ Drainage Patterns (B10)
___ Dry-Season Water Table (C2)
___ Crayfish Burrows (C8)
___ Saturation Visible on Aerial Imagery (C9)
___ Shallow Aquitard (D3)
___ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes ______ No ✓ Depth (inches): ______

Water Table Present? Yes ______ No ✓ Depth (inches): ______

Saturation Present? (includes capillary fringe) Yes ______ No ✓ Depth (inches): ______

Wetland Hydrology Present? Yes ______ No ✓

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Drone imagery, LiDAR, Height above water surface (HAWS) mapping

Remarks:

Aerial imagery shows a dark vegetated area

WETLAND DETERMINATION DATA FORM – Arid West Region

Project/Site: Tucannon River Project Area 27/28 City/County: Columbia County Sampling Date: 01/20/20

Applicant/Owner: Confederated Tribes of the Umatilla Indian Reservation State: WA Sampling Point: SP-04

Investigator(s): Elisabeth Bowers/Joe Rudolph Section, Township, Range: Section 9, Township 11N, Range 40E

Landform (hillslope, terrace, etc.): terrace Local relief (concave, convex, none): concave Slope (%): 1

Subregion (LRR): B, Columbia/Snake River Plateau Lat: 46.45603496 Long: -117.82179332 Datum: WGS84

Soil Map Unit Name: Patit Creek silt loam, 0 to 3 percent slopes (PkA) NWI classification: No

Are climatic / hydrologic conditions on the site typical for this time of year? Yes ✓ No ___ (If no, explain in Remarks.)

Are Vegetation ___, Soil ___, or Hydrology ___ significantly disturbed? Are "Normal Circumstances" present? Yes ✓ No ___

Are Vegetation ___, Soil ___, or Hydrology ___ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes ✓ No ___	Is the Sampled Area within a Wetland?	Yes ✓ No ___
Hydric Soil Present?	Yes ✓ No ___		
Wetland Hydrology Present?	Yes ✓ No ___		

Remarks:

within floodplain terrace

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: ___)	Absolute % Cover	Dominant Species?	Indicator Status
1. N/A			
2.			
3.			
4.			
	___ = Total Cover		
Sapling/Shrub Stratum (Plot size: 10 ft radius)			
1. Rosa pisocarpa	15	Yes	FAC
2.			
3.			
4.			
5.			
	15 = Total Cover		
Herb Stratum (Plot size: 5 foot radius)			
1. Juncus effusus	10	No	FACW
2. Equisetum arvense	2	No	FAC
3. Phalaris arundinacea	70	Yes	FACW
4.			
5.			
6.			
7.			
8.			
	82 = Total Cover		
Woody Vine Stratum (Plot size: ___)			
1. N/A			
2.			
	___ = Total Cover		

% Bare Ground in Herb Stratum 8 % Cover of Biotic Crust ___

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 2 (A)

Total Number of Dominant Species Across All Strata: 2 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 100 (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species	___	x 1 = ___
FACW species	___	x 2 = ___
FAC species	___	x 3 = ___
FACU species	___	x 4 = ___
UPL species	___	x 5 = ___
Column Totals:	___ (A)	___ (B)

Prevalence Index = B/A = ___

Hydrophytic Vegetation Indicators:

✓ Dominance Test is >50%

___ Prevalence Index is ≤3.0[1]

___ Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)

___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes ✓ No ___

Remarks:

SOIL

Sampling Point: SP-04

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox Features %	Type[1]	Loc[2]	Texture	Remarks
0-12	10YR 3/1	100	-	-	-	-	silt	see notes on redox features
12-17	10YR 3/1	100	-	-	-	-	silt	gravels in layer

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5) (**LRR C**)
- ___ 1 cm Muck (A9) (**LRR D**)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Loamy Mucky Mineral (F1)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ✓ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)
- ___ Vernal Pools (F9)

Indicators for Problematic Hydric Soils[3]:

- ___ 1 cm Muck (A9) (**LRR C**)
- ___ 2 cm Muck (A10) (**LRR B**)
- ___ Reduced Vertic (F18)
- ___ Red Parent Material (TF2)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present):

Type: ______

Depth (inches): ______

Hydric Soil Present? Yes ✓ No ___

Remarks:

Both of these soil layers seemed to be predominantly silt with some organic content that is assumed to have been masking the redox concentrations in the soil layers.

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ___ Surface Water (A1)
- ✓ High Water Table (A2)
- ✓ Saturation (A3)
- ___ Water Marks (B1) (**Nonriverine**)
- ___ Sediment Deposits (B2) (**Nonriverine**)
- ___ Drift Deposits (B3) (**Nonriverine**)
- ___ Surface Soil Cracks (B6)
- ✓ Inundation Visible on Aerial Imagery (B7)
- ✓ Water-Stained Leaves (B9)
- ___ Salt Crust (B11)
- ___ Biotic Crust (B12)
- ___ Aquatic Invertebrates (B13)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Oxidized Rhizospheres along Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tilled Soils (C6)
- ___ Thin Muck Surface (C7)
- ___ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

- ___ Water Marks (B1) (**Riverine**)
- ___ Sediment Deposits (B2) (**Riverine**)
- ___ Drift Deposits (B3) (**Riverine**)
- ✓ Drainage Patterns (B10)
- ___ Dry-Season Water Table (C2)
- ___ Crayfish Burrows (C8)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Shallow Aquitard (D3)
- ___ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present?	Yes ___	No ✓	Depth (inches): ___
Water Table Present?	Yes ✓	No ___	Depth (inches): 12" bgs*
Saturation Present? (includes capillary fringe)	Yes ✓	No ___	Depth (inches): 8" bgs*

Wetland Hydrology Present? Yes ✓ No ___

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Drone imagery, LiDAR, Height above water surface (HAWS) mapping

Remarks:

*below ground surface

WETLAND DETERMINATION DATA FORM – Arid West Region

Project/Site: Tucannon River Project Area 27/28 City/County: Columbia County Sampling Date: 01/21/20

Applicant/Owner: Confederated Tribes of the Umatilla Indian Reservation State: WA Sampling Point: SP-05

Investigator(s): Elisabeth Bowers/Joe Rudolph Section, Township, Range: Section 9, Township 11N, Range 40E

Landform (hillslope, terrace, etc.): terrace Local relief (concave, convex, none): concave Slope (%): 0.5

Subregion (LRR): B, Columbia/Snake River Plateau Lat: 46.45434635 Long: -117.8193075 Datum: WGS84

Soil Map Unit Name: Patit Creek silt loam, 0 to 3 percent slopes (PkA) NWI classification: No

Are climatic / hydrologic conditions on the site typical for this time of year? Yes ✓ No ____ (If no, explain in Remarks.)

Are Vegetation ____, Soil ____, or Hydrology ____ significantly disturbed? Are "Normal Circumstances" present? Yes ✓ No ____

Are Vegetation ____, Soil ____, or Hydrology ____ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes ✓	No ____
Hydric Soil Present?	Yes ✓	No ____
Wetland Hydrology Present?	Yes ✓	No ____

Is the Sampled Area within a Wetland? Yes ✓ No ____

Remarks:

In hummocky reed canarygrass area

VEGETATION – Use scientific names of plants.

	Absolute % Cover	Dominant Species?	Indicator Status
Tree Stratum (Plot size: 20 foot radi⊞)			
1. Alnus rhombifolia	30	Yes	FACW
2.			
3.			
4.			
	30 = Total Cover		
Sapling/Shrub Stratum (Plot size: ____)			
1.			
2.			
3.			
4.			
5.			
	____ = Total Cover		
Herb Stratum (Plot size: ____)			
1. Phalaris arundinacea	98	Yes	FACW
2. Galium aparine	2	No	FACU
3.			
4.			
5.			
6.			
7.			
8.			
	100 = Total Cover		
Woody Vine Stratum (Plot size: ____)			
1. N/A			
2.			
	____ = Total Cover		

% Bare Ground in Herb Stratum ____ % Cover of Biotic Crust ____

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 2 (A)

Total Number of Dominant Species Across All Strata: 2 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 100 (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species	____	x 1 = ____
FACW species	____	x 2 = ____
FAC species	____	x 3 = ____
FACU species	____	x 4 = ____
UPL species	____	x 5 = ____
Column Totals:	____ (A)	____ (B)

Prevalence Index = B/A = ____

Hydrophytic Vegetation Indicators:

✓ Dominance Test is >50%

__ Prevalence Index is ≤3.0[1]

__ Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)

__ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes ✓ No ____

Remarks:

SOIL

Sampling Point: SP-05

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth	Matrix		Redox Features					
(inches)	Color (moist)	%	Color (moist)	%	Type[1]	Loc[2]	Texture	Remarks
0-4	10YR 3/1	100	-	-	-	-	silt loam	root layer
4-10	10YR 3/1	95	7.5YR 4/4	5	C	M	silt loam	
10-16	10YR 4/1	90	7.5YR 4/6	10	C	M	silt loam	some sand

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5) (**LRR C**)
- ___ 1 cm Muck (A9) (**LRR D**)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Loamy Mucky Mineral (F1)
- ___ Loamy Gleyed Matrix (F2)
- ✓ Depleted Matrix (F3)
- ✓ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)
- ___ Vernal Pools (F9)

Indicators for Problematic Hydric Soils[3]:

- ___ 1 cm Muck (A9) (**LRR C**)
- ___ 2 cm Muck (A10) (**LRR B**)
- ___ Reduced Vertic (F18)
- ___ Red Parent Material (TF2)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present):

Type: ______

Depth (inches): ______

Hydric Soil Present? Yes ✓ No ___

Remarks:

Some gravel throughout all layers.

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ___ Surface Water (A1)
- ✓ High Water Table (A2)
- ✓ Saturation (A3)
- ___ Water Marks (B1) (**Nonriverine**)
- ___ Sediment Deposits (B2) (**Nonriverine**)
- ___ Drift Deposits (B3) (**Nonriverine**)
- ___ Surface Soil Cracks (B6)
- ___ Inundation Visible on Aerial Imagery (B7)
- ✓ Water-Stained Leaves (B9)
- ___ Salt Crust (B11)
- ___ Biotic Crust (B12)
- ___ Aquatic Invertebrates (B13)
- ___ Hydrogen Sulfide Odor (C1)
- ✓ Oxidized Rhizospheres along Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tilled Soils (C6)
- ___ Thin Muck Surface (C7)
- ___ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

- ___ Water Marks (B1) (**Riverine**)
- ___ Sediment Deposits (B2) (**Riverine**)
- ___ Drift Deposits (B3) (**Riverine**)
- ✓ Drainage Patterns (B10)
- ___ Dry-Season Water Table (C2)
- ___ Crayfish Burrows (C8)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Shallow Aquitard (D3)
- ___ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present?	Yes ___	No ✓	Depth (inches): ___
Water Table Present?	Yes ✓	No ___	Depth (inches): 14" bgs*
Saturation Present? (includes capillary fringe)	Yes ✓	No ___	Depth (inches): 4" bgs*

Wetland Hydrology Present? Yes ✓ No ___

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Drone imagery, LiDAR, Height above water surface (HAWS) mapping

Remarks:

*below ground surface; the water table was rising slowly while we were there.

WETLAND DETERMINATION DATA FORM – Arid West Region

Project/Site: Tucannon River Project Area 27/28 City/County: Columbia County Sampling Date: 01/21/20

Applicant/Owner: Confederated Tribes of the Umatilla Indian Reservation State: WA Sampling Point: SP-06

Investigator(s): Elisabeth Bowers/Joe Rudolph Section, Township, Range: Section 9, Township 11N, Range 40E

Landform (hillslope, terrace, etc.): terrace Local relief (concave, convex, none): convex Slope (%): 1

Subregion (LRR): B, Columbia/Snake River Plateau Lat: 46.45432112 Long: -117.81936178 Datum: WGS84

Soil Map Unit Name: Patit Creek silt loam, 0 to 3 percent slopes (PkA) NWI classification: No

Are climatic / hydrologic conditions on the site typical for this time of year? Yes ✓ No ___ (If no, explain in Remarks.)

Are Vegetation ___, Soil ___, or Hydrology ___ significantly disturbed? Are "Normal Circumstances" present? Yes ✓ No ___

Are Vegetation ___, Soil ___, or Hydrology ___ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

	Yes	No
Hydrophytic Vegetation Present?	✓	
Hydric Soil Present?		✓
Wetland Hydrology Present?		✓
Is the Sampled Area within a Wetland?		✓

Remarks:

Approximately 1 foot higher than SP-05

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: 20 ft radius)	Absolute % Cover	Dominant Species?	Indicator Status
1. Alnus rhombifolia	50	Yes	FACW
2.			
3.			
4.			
	50 = Total Cover		
Sapling/Shrub Stratum (Plot size: 10 ft radius)			
1. Rubus armeniacus	5	Yes	FAC
2.			
3.			
4.			
5.			
	5 = Total Cover		
Herb Stratum (Plot size: 5 foot radius)			
1. Phalaris arundinacea	100	Yes	FACW
2.			
3.			
4.			
5.			
6.			
7.			
8.			
	100 = Total Cover		
Woody Vine Stratum (Plot size: ___)			
1. N/A			
2.			
	___ = Total Cover		

% Bare Ground in Herb Stratum ___ % Cover of Biotic Crust ___

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 3 (A)

Total Number of Dominant Species Across All Strata: 3 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 100 (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species	___	x 1 = ___
FACW species	___	x 2 = ___
FAC species	___	x 3 = ___
FACU species	___	x 4 = ___
UPL species	___	x 5 = ___
Column Totals:	___ (A)	___ (B)

Prevalence Index = B/A = ___

Hydrophytic Vegetation Indicators:

- ✓ Dominance Test is >50%
- ___ Prevalence Index is ≤3.0[1]
- ___ Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes ✓ No ___

Remarks:

SOIL

Sampling Point: SP-06

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-14	10YR 3/1	100	-	-	-	-	silt loam	
14-16	10YR 3/1	95	10YR 3/4	5	C	M	silt loam	
16-17	10YR 4/1	93	7.5YR 3/4	7	C	M	silt loam	no sand or gravel

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

- ___ Histosol (A1)
- ___ Histic Epipedon (A2)
- ___ Black Histic (A3)
- ___ Hydrogen Sulfide (A4)
- ___ Stratified Layers (A5) (**LRR C**)
- ___ 1 cm Muck (A9) (**LRR D**)
- ___ Depleted Below Dark Surface (A11)
- ___ Thick Dark Surface (A12)
- ___ Sandy Mucky Mineral (S1)
- ___ Sandy Gleyed Matrix (S4)
- ___ Sandy Redox (S5)
- ___ Stripped Matrix (S6)
- ___ Loamy Mucky Mineral (F1)
- ___ Loamy Gleyed Matrix (F2)
- ___ Depleted Matrix (F3)
- ___ Redox Dark Surface (F6)
- ___ Depleted Dark Surface (F7)
- ___ Redox Depressions (F8)
- ___ Vernal Pools (F9)

Indicators for Problematic Hydric Soils[3]:

- ___ 1 cm Muck (A9) (**LRR C**)
- ___ 2 cm Muck (A10) (**LRR B**)
- ___ Reduced Vertic (F18)
- ___ Red Parent Material (TF2)
- ___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present):

Type: ______

Depth (inches): ______

Hydric Soil Present? Yes ___ No ✓

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ___ Surface Water (A1)
- ___ High Water Table (A2)
- ___ Saturation (A3)
- ___ Water Marks (B1) (**Nonriverine**)
- ___ Sediment Deposits (B2) (**Nonriverine**)
- ___ Drift Deposits (B3) (**Nonriverine**)
- ___ Surface Soil Cracks (B6)
- ___ Inundation Visible on Aerial Imagery (B7)
- ___ Water-Stained Leaves (B9)
- ___ Salt Crust (B11)
- ___ Biotic Crust (B12)
- ___ Aquatic Invertebrates (B13)
- ___ Hydrogen Sulfide Odor (C1)
- ___ Oxidized Rhizospheres along Living Roots (C3)
- ___ Presence of Reduced Iron (C4)
- ___ Recent Iron Reduction in Tilled Soils (C6)
- ___ Thin Muck Surface (C7)
- ___ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

- ___ Water Marks (B1) (**Riverine**)
- ___ Sediment Deposits (B2) (**Riverine**)
- ___ Drift Deposits (B3) (**Riverine**)
- ___ Drainage Patterns (B10)
- ___ Dry-Season Water Table (C2)
- ___ Crayfish Burrows (C8)
- ___ Saturation Visible on Aerial Imagery (C9)
- ___ Shallow Aquitard (D3)
- ___ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes ___ No ✓ Depth (inches): ___

Water Table Present? Yes ___ No ✓ Depth (inches): ___

Saturation Present? (includes capillary fringe) Yes ___ No ✓ Depth (inches): ___

Wetland Hydrology Present? Yes ___ No ✓

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Drone imagery, LiDAR, Height above water surface (HAWS) mapping

Remarks:

Soil is dry.

Photo Point 1: Looking southeast along the irrigation ditch.

Photo Point 2: Looking west along a backwater area.

Photo Point 3: Looking toward SP-1.

Photo Point 4: Looking east toward SP-3.

Photo Point 5: Looking toward SP-4.

Photo Point 6: Looking northwest across fenced wetland area.

Photo Point 7: Looking southeast along irrigation ditch in northeast quadrant.

Photo Point 8: Looking toward SP-5.

Photo Point 9: Looking west along the irrigation ditch from King Grade Road.

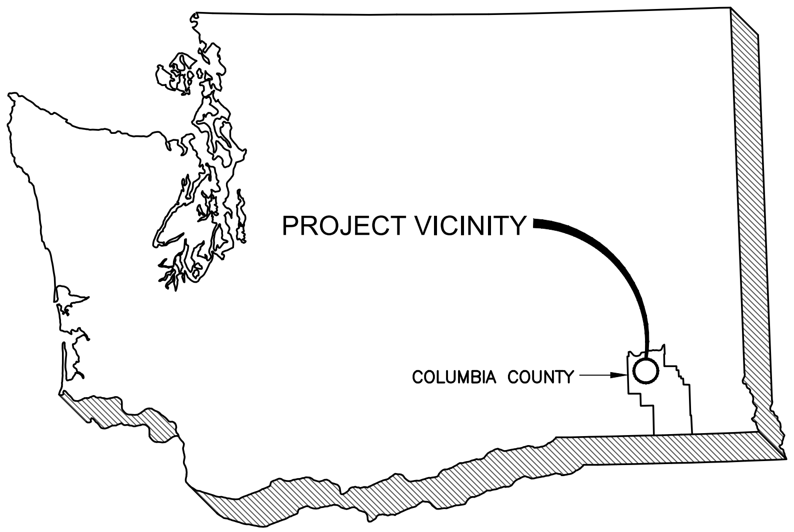
Photo Point 10: Looking west along the Tucannon River from the King Grade Road Bridge.

Photo Point 11: Drone image facing the northeast quadrant of the study area.

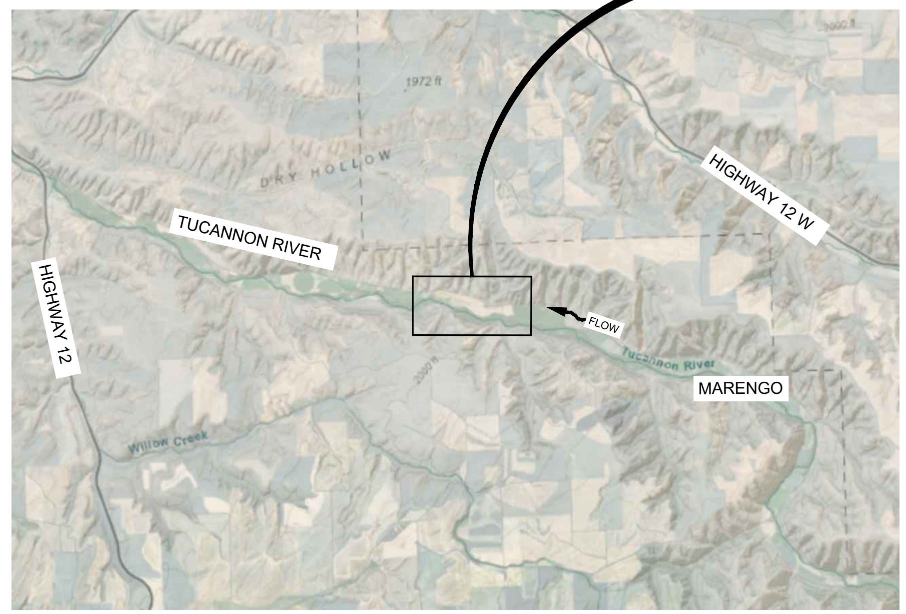
Photo Point 12: Drone image facing the northwest quadrant of the study area.

TUCANNON RIVER RESTORATION PROJECT
PROJECT AREA 27/28, PHASE 0.5 - 1
COLUMBIA COUNTY, WA

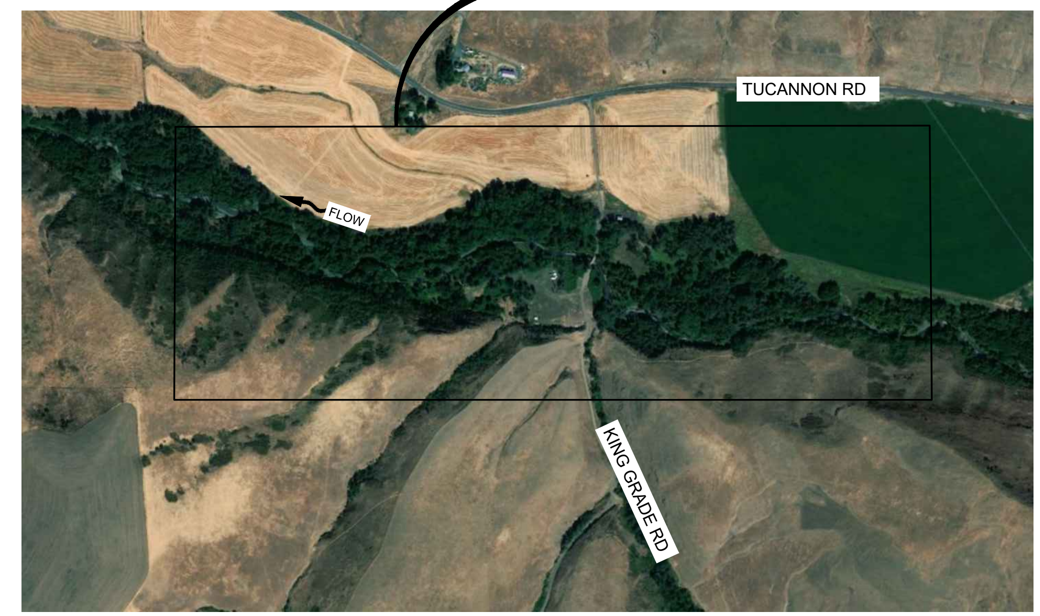
80% DESIGN
JULY 2021



REGIONAL MAP
NTS



PROJECT VICINITY
NTS



PROJECT SITE
NTS

PROJECT TEAM

PROJECT OWNER
CONFEDERATED TRIBES OF THE UMATILLA INDIAN RESERVATION (CTUIR)

Kris Fischer, Project Leader
46411 TI'MINE WAY,
PENDLETON, OR 97801
VOICE: (541) 429-7547

ENGINEER
WOLF WATER RESOURCES, INC
AMANDA JONES, PE
AJones@wolfwaterresources.com
1001 SE WATER AVE, SUITE #180
PORTLAND, OR 97214
(503) 207-6688

PROJECT INFO

SPATIAL REFERENCE
HORIZONTAL:
NAD 83 WASHINGTON STATE PLANE (POLYCONIC) SOUTH ZONE, US FT
VERTICAL: NAVD88
LIDAR: QUANTUM DIGITAL TERRAIN MODEL

PROJECT SITE LOCATION:
1143 TUCANNON RD, DAYTON, WA 99328
COLUMBIA COUNTY
LATITUDE: 46.454844°
LONGITUDE:117.821104°
WATERBODY: TUCANNON RIVER

SHEET INDEX

WDFW-APPROVED IN-WATER WORK WINDOW
JULY 15 TO SEPTEMBER 30

DWG: Z:\Shared\W2\CAD\20190024-Tucannon\DWG\PHASE 0.5-1 SHEETS\G1.1-TUC-COVER.dwg USER: ajones
DATE: Jul 16, 2021 1:33pm XREFS:X-TB-22X34

AMANDA JONES
STATE OF WASHINGTON
21008109
REGISTERED PROFESSIONAL ENGINEER
RENEWS: 08/28/2021

WOLF WATER RESOURCES, INC.
1001 SE WATER AVE, SUITE #180
PORTLAND, OR 97214
503.207.6688

CONFEDERATED TRIBES OF THE UMATILLA INDIAN RESERVATION
46411 Ti'mine Way
Pendleton, OR 97801
541.429.7010

CTUIR
TUCANNON RIVER
PROJECT AREA 27/28
PHASE 0.5 - 1
COLUMBIA COUNTY, WA

VICINITY MAP & SHEET INDEX

REVISION NUMBER

No.	Date	Revision
X	DATE	NOTE

Date	Designed By
07/2021	AJ
Drawn By	Checked By
RW, AJ	MW, AJ

SCALE 0 1"

JOB NO. 20190026

SHEET NO. G1.1

80% DESIGN
JULY 2021

GENERAL NOTES:

1. DRIVING DIRECTIONS:
   FOLLOW I-84 E TO I-82 W TOWARDS HERMISTON/UMATILLA. TAKE EXIT 1 FOR US-395 S. FOLLOW US-730 E TO US-12 E. TURN RIGHT ON TURNER ROAD AND FOLLOW UNTIL THE FORK ON THE ROAD. TURN LEFT ONTO GWINN ROAD. TAKE A SHARP LEFT ON TO KING GRADE ROAD. KEEP ON KING GRADE ROAD UNTIL IT REACHES THE BRIDGE CROSSING TUCANNON RIVER.
2. TOPOGRAPH GATHERED BY QUANTUM IN FALL 2020 AND PUBLISHED IN MARCH 2021.
3. AERIAL COLLECTED BY W2R IN FEB 2021.
4. HORIZONTAL DATUM IS NAD83 WASHINGTON STATE PLANE SOUTH, US FT.
5. VERTICAL DATUM IS NAVD88, FT.
6. ALL SCALES SHOWN ARE FOR 22" X 34" SHEETS.
7. ALL EQUIPMENT SHALL BE WASHED PRIOR TO MOBILIZATION TO THE SITE TO MINIMIZE THE INTRODUCTION OF FOREIGN MATERIALS AND FLUIDS TO THE PROJECT SITE. ALL EQUIPMENT SHALL BE FREE OF OIL, HYDRAULIC FLUID, AND DIESEL FUEL LEAKS. TO PREVENT INVASION OF NOXIOUS WEEDS OR THE SPREAD OF WHIRLING DISEASE SPORES. ALL EQUIPMENT SHALL BE CLEANED TO REMOVE MUD AND SOIL PRIOR TO MOBILIZATION INTO THE PROJECT AREA. IT WILL BE THE CONTRACTOR'S RESPONSIBILITY TO INSURE THAT THESE AND ANY ADDITIONAL POLLUTION CONTROL MEASURES HAVE BEEN TAKEN PER THE SPECIFICATIONS.
8. ALL NON-NATIVE MATERIALS ENCOUNTERED DURING EXCAVATION ACTIVITIES SHALL BE REMOVED FROM THE FLOODPLAIN WITH THE EXCEPTION OF RIP RAP THAT MAY BE USED AS BURIED LARGE WOOD BALLAST MATERIAL IN LIEU OF IMPORTED BOULDER BALLAST.
9. CONTRACTOR STAGING AREAS ARE SHOWN ON SHEET C1.1.
10. CONTRACTOR SHALL RESTORE EXISTING ACCESS ROAD AND REMOVE NEW ACCESS ROADS AS SPECIFIED BEFORE COMPLETION OF CONSTRUCTION.
11. THE CONTRACTOR SHALL ATTEND A MANDATORY PRE-BID MEETING ON SITE.
12. ALL WORK SHALL CONFORM TO THE PLANS & SPECIFICATIONS UNLESS INDICATED OTHERWISE BY CONTRACT DOCUMENTS.
13. CONTRACTOR SHALL ALLOW FOR EXPANSION OF EXCAVATED MATERIAL AND COMPACTION OF PLACED MATERIAL AT NO ADDITIONAL COST.
14. CONTRACTOR SHALL ATTEND MANDATORY PRE-CONSTRUCTION MEETINGS WITH CTUIR AND THE ENGINEER.

WORK PERIODS:

ALL GRADING SHALL BE LIMITED TO WDFW-APPROVED IN-WATER WINDOW OF JULY 15TH - AUGUST 30TH

CONSTRUCTION ACCESS/TRAFFIC CONTROL:

1. CONTRACTOR SHALL SUBMIT AN ACCESS, STAGING , AND STOCKPILE PLAN TO CTUIR FOR APPROVAL PRIOR TO MOBILIZATION.
2. ACCESS TO/ALONG ROADWAYS SHALL BE MAINTAINED AT ALL TIMES.
3. THE CONTRACTOR IS SOLELY RESPONSIBLE FOR OBTAINING ANY REQUIRED TRAFFIC CONTROL OR ACCESS PERMITS.
4. THE CONTRACTOR IS SOLELY RESPONSIBLE FOR PROVIDING ANY REQUIRED TRAFFIC CONTROL INCLUDING, BUT NOT LIMITED TO, SIGNAGE AND FLAGGERS.
5. ALL EQUIPMENT, MATERIALS, AND PERSONNEL SHALL REMAIN WITHIN THE WORK AREA BOUNDARY.
6. THE CONTRACTOR SHALL KEEP THE WORK AREAS IN NEAT CONDITION, FREE OF DEBRIS AND LITTER FOR THE DURATION OF THE PROJECT.
7. CONTRACTOR SHALL IMPLEMENT MEASURES TO CONTROL AND MINIMIZE WIND BLOWN DUST FROM THE SITE.
8. ACCESS ROUTES OTHER THAN ESTABLISHED ROADS SHALL NOT BE CLEARED OR GRADED.
9. ALL DISTURBED AREAS INCLUDING ROADS, DRIVEWAYS AND ACCESS ROUTES SHALL BE RESTORED TO ORIGINAL CONDITION OR BETTER AND RE-VEGETATED PER PLANS (TBD).
10. ALL DISTURBED AREAS OUTSIDE THE LIMITS OF DISTURBANCE SHALL BE RESTORED TO ORIGINAL CONDITION OR BETTER AT NO ADDITIONAL COST TO THE OWNER.

LEGEND AND SYMBOLS

- 1 — EX MINOR CONTOUR
- 5 — EX MAJOR CONTOUR
- 1 — PROP MINOR CONTOUR
- 5 — PROP MAJOR CONTOUR
- TYPICAL YEARLY HIGH WATER EXTENT
- EXISTING ROAD
- ACCESS ROAD
- APPROX GRADING AREA LIMIT
- WETLAND BOUNDARY
- STAGING AREA
- FILL
- CUT
- NO ACCESS
- COFFER DAM
- WHS TYPE 1 - LARGE APEX
- WHS TYPE 2 - SMALL APEX
- WHS TYPE 3 - MARGIN DEFLECTOR JAM
- WHS TYPE 4 - FLOODPLAIN WOOD (1 LOG)
- WHS TYPE 5 - FLOODPLAIN WOOD (2 LOGS)
- WHS TYPE 6 - HABITAT WOOD (PINNED AND UNPINNED)
- WHS TYPE 6A - PINNED HABITAT WOOD STRUCTURE
- WHS TYPE 7 - CHANNEL SPANNING JAM

ABBREVIATIONS:

APPROX	APPROXIMATE
BDA	BEAVER DAM ANALOGUE
BFE	BASE FLOOD ELEVATION
BMP	BEST MANAGEMENT PRACTICE
CAR	CONTRACTING AGENCY REPRESENTATIVE (CREST)
CHNL	CHANNEL
CL	CENTERLINE
CONC	CONCRETE
CONSTR	CONSTRUCTION
CTUIR	CONFEDERATED TRIBES OF THE UMATILLA INDIAN RESERVATION
CY	CUBIC YARD
DEPT	DEPARTMENT
EG	EXISTING GRADE/GROUND
ELEV, EL	ELEVATION
ENH	ENHANCEMENT
ESC	EROSION AND SEDIMENT CONTROL
EX, EXIST	EXISTING
FG	FINISHED GRADE/GROUND
FT	FEET
GB	GRADE BREAK
HAB	HABITAT
HVF	HIGH VISIBILITY FENCE
IN	INCHES
IE	INVERT ELEVATION
LBS	POUNDS
LS	LIVESTAKE
LW	LARGE WOOD
MGMT	MANAGEMENT
MIN	MINIMUM
N/A	NOT AVAILABLE
NIC	NOT IN CONTRACT
NAD83	NORTH AMERICAN DATUM (1983)
NAVD88	NORTH AMERICAN VERTICAL DATUM (1988)
NTS	NOT TO SCALE
OHW	ORDINARY HIGH WATER
OHWM	ORDINARY HIGH WATER MARK
PROP	PROPOSED
PIP	PROTECT IN PLACE
PLS	PURE LIVE SEED
REINF	REINFORCED
ROW	RIGHT OF WAY
S	SLOPE
SF	SQUARE FEET
SHT	SHEET
SPEC	SPECIFICATION
ST	STREET
STA	STATION
STD	STANDARD
SY	SQUARE YARD
TEMP	TEMPORARY
TESC	TEMPORARY EROSION AND SEDIMENT CONTROL
TOB	TOP OF BANK
TOE	TOE OF SLOPE
TOP	TOP OF SLOPE
TYP	TYPICAL
VIF	VERIFY IN FIELD
W/	WITH
W/O	WITHOUT
WDFW	WASHINGTON DEPARTMENT OF FISH AND WILDLIFE
WHS	WOOD HABITAT STRUCTURE
WSDOT	WASHING STATE DEPARTMENT OF TRANSPORTATION
WSE	WATER SURFACE ELEVATION

AMANDA JONES STATE OF WASHINGTON 21008109 REGISTERED PROFESSIONAL ENGINEER
RENEWS: 08/28/2021

WOLF WATER RESOURCES, INC.
1001 SE WATER AVE, SUITE #180
PORTLAND, OR 97214
503.207.6688

CONFEDERATED TRIBES OF THE UMATILLA INDIAN RESERVATION
46411 Timine Way
Pendleton, OR 97801
541.429.7010

CTUIR
TUCANNON RIVER
PROJECT AREA 27/28
PHASE 0.5 - 1
COLUMBIA COUNTY, WA

NOTES & ABBREVIATIONS

REVISION NUMBER

No.	Date	Revision
X	DATE	NOTE

Date	Designed By
07/2021	AJ
Drawn By	Checked By
RW, AJ	MW, AJ

SCALE 0 1"

JOB NO. 20190026

SHEET NO. G1.2

DWG: Z:\Shared\W2r\CAD\20190024-Tucannon\DWG\PHASE 0.5-1 SHEETS\G1.2-TUC- GENERAL NOTES.dwg USER: ajones
DATE: Jul 16, 2021 2:41pm XREFS: X-TB-22X34

HIP GENERAL CONSERVATION MEASURES APPLICABLE TO ALL ACTIONS

DOCUMENTATION: TO BE POSTED ONSITE BY THE CONTRACTOR IN A LOCATION VISIBLE TO THE PUBLIC.

A) NAME(S), PHONE NUMBER(S), AND ADDRESS(ES) OF THE PERSON(S) RESPONSIBLE FOR OVERSIGHT.
B) A DESCRIPTION OF HAZARDOUS MATERIALS THAT WILL BE USED, INCLUDING INVENTORY, STORAGE, AND HANDLING PROCEDURES.
C) PROCEDURES TO CONTAIN AND CONTROL A SPILL OF ANY HAZARDOUS MATERIAL GENERATED, USED OR STORED ON-SITE, INCLUDING NOTIFICATION OF PROPER AUTHORITIES.
D) A STANDING ORDER TO CEASE WORK IN THE EVENT OF HIGH FLOWS EXCEPT AS NECESSARY TO MINIMIZE RESOURCE DAMAGE (ABOVE THOSE ADDRESSED IN THE DESIGN AND IMPLEMENTATION PLANS) OR EXCEEDANCE OF TAKE OR WATER QUALITY LIMITATIONS.

SITE PREPARATION

1) SITE LAYOUT AND FLAGGING: PRIOR TO CONSTRUCTION, THE ACTION AREA WILL BE CLEARLY FLAGGED TO IDENTIFY THE FOLLOWING:
A) SENSITIVE RESOURCE AREAS, SUCH AS AREAS BELOW ORDINARY HIGH WATER, SPAWNING AREAS,SPRINGS, AND WETLANDS;
B) EQUIPMENT ENTRY AND EXIT POINTS;
C) ROAD AND STREAM CROSSING ALIGNMENTS;
D) STAGING, STORAGE, AND STOCKPILE AREAS; AND
E) NO-SPRAY AREAS AND BUFFERS.

2) 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 FLOOD PLAINS WILL BE MINIMIZED TO LESSEN SOIL DISTURBANCE AND COMPACTION, AND IMPACTS TO VEGETATION.
B) VEHICLE USE AND HUMAN ACTIVIES, 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 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 RE-VEGETATED. ROAD AND PATH OBLITERATION REFERS TO THE MOST COMPREHENSIVE DEGREE OF DECOMMISSIONING AND INVOLVES RE-COMPACTING 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, INCLUDING THEIR OCCUPIED HABITAT AND APPROPRIATE BUFFERS, DURING SENSITIVE LIFE STAGES (I.E. NESTING AND CRITICAL BREEDING PERIODS). SEE SPECIES-SPECIFIC CONSERVATION MEASURES FOR EACH LISTED SPECIES THAT MAY OCCUR WITHIN THE PROJECT AREA FOR MORE INFORMATION.

3) TEMPORARY STREAM CROSSINGS:
A) EXISTING STREAM CROSSINGS, FORDS, OR BEDROCK WILL BE PREFERENTIALLY USED WHENEVER POSSIBLE.
B) IF AN EXISTING STREAM CROSSING IS NOT ACCESSIBLE, TEMPORARY CROSSINGS WILL BE INSTALLED. TREATED WOOD SHALL NOT BE USED ON TEMPORARY BRIDGE CROSSINGS OR IN LOCATIONS IN CONTACT WITH OR OVER WATER.
C) TEMPORARY BRIDGES AND CULVERTS WILL BE INSTALLED TO ALLOW FOR EQUIPMENT AND VEHICLE CROSSING OVER PERENNIAL STREAMS DURING CONSTRUCTION.
D) FOR PROJECTS THAT REQUIRE EQUIPMENT AND VEHICLES TO CROSS IN THE WET:
I. THE LOCATION AND NUMBER OF ALL WET CROSSINGS MUST BE APPROVED BY BPA AND CLEARLY INDICATED ON DESIGN DRAWINGS.
II.VEHICLES AND MACHINERY WILL CROSS STREAMS AT RIGHT ANGLES TO THE MAIN CHANNEL WHEREVER POSSIBLE.
III. NO STREAM CROSSINGS WILL OCCUR 300-FEET UPSTREAM OR 100-FEET DOWNSTREAM OF AN EXISTING REDD OR SPAWNING FISH.
IIII. AFTER PROJECT COMPLETION, TEMPORARY STREAM CROSSINGS WILL BE OBLITERATED AND THE STREAM CHANNEL AND BANKS RESTORED.

4) STAGING, STORAGE, AND STOCKPILE AREAS:
D) 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, OR ON AN ADJACENT, ESTABLISHED ROAD AREA IN A LOCATION AND MANNER THAT WILL PRECLUDE EROSION INTO OR CONTAMINATION OF THE STREAM OR FLOODPLAIN. STAGING AREAS MAY BE CLOSER THAN 150 FEET IF THE AREA IS ABOVE (ELEVATION) THE 100-YR FLOODPLAIN AND SPILL PREVENTION MEASURES ARE APPROVED BY THE EC LEAD.
E) 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 PLANS. RECOMMEND REFERRING TO AREAS AS "NATRAL MATERIAL STOCKPILE AREA" WITH A NOTE THAT STATES VEHICLE STORAGE, EQUIPMENT STORAGE, AHZARDOUS MATERIALS, FUELING, AND SERVICING NOT PERMITTED IN THIS AREA.
F) 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.
G) ANY MATERIAL NOT USED IN RESTORATION, AND NOT NATIVE TO THE FLOODPLAIN, WILL BE REMOVED TO A LOCATION OUTSIDE OF THE 100-YEAR FLOODPLAIN FOR DISPOSAL.

5) EQUIPMENT: MECHANIZED EQUIPMENT AND VEHICLES WILL BE SELECTED, OPERATED, AND MAINTAINED IN A MANNER THAT MINIMIZES ADVERSE IMPACTS ON THE ENVIRONMENT (E.G., MINIMALLY-SIZED, LOW PRESSURE TIRES; MINIMAL HARD-TURN PATHS FOR TRACKED VEHICLES. ALL VEHICLES AND OTHER MECHANIZED EQUIPMENT WILL BE:
A) STORED, FUELED, AND MAINTAINED IN A VEHICLE STAGING AREA PLACED 150 FEET OR MORE FROM ANY NATURAL WATER BODY OR WETLAND OR ON AN ADJACENT, ESTABLISHED ROAD AREA;
B) REFUELED IN A VEHICLE STAGING AREA PLACED 150 FEET OR MORE FROM A NATURAL WATERBODY OR WETLAND, OR IN AN ISOLATED HARD ZONE, SUCH AS A PAVED PARKING LOT OR ADJACENT, ESTABLISHED ROAD (THIS MEASURE APPLIES ONLY TO GAS OR DIESEL-POWERED EQUIPMENT WITH TANKS LARGER THAN 5 GALLONS);
C) BIODEGRADABLE LUBRICANTS AND FLUIDS SHALL BE USED ON EQUIPMENT OPERATION IN THE STREAM CHANNEL AND LIVE WATER.
D) INSPECTED DAILY FOR FLUID LEAKS BEFORE LEAVING THE VEHICLE STAGING AREA FOR OPERATION WITHIN 150 FEET OF ANY NATURAL WATER BODY OR WETLAND; AND
E) THOROUGHLY CLEANED BEFORE OPERATION BELOW ORDINARY HIGH WATER (OHW), AND AS OFTEN AS NECESSARY DURING OPERATION,TO REMAIN GREASE FREE.

6) EROSION CONTROL: EROSION CONTROL MEASURES WILL BE PREPARED AND CARRIED OUT, COMMENSURATE IN SCOPE WITH THE ACTION, THAT MAY INCLUDE THE FOLLOWING:
A) TEMPORARY EROSION CONTROLS.
I. TEMPORARY EROSION CONTROLS WILL BE IN PLACE BEFORE ANY SIGNIFICANT ALTERATION OF THE ACTION SITE AND APPROPRIATELY INSTALLED DOWN SLOPE OF PROJECT ACTIVITY WITHIN THE RIPARIAN BUFFER AREA UNTIL SITE REHABILITATION IS COMPLETE.
II. 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.
III. 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. BIODEGRADABLE NETTING MAY BE USED SO THAT THEY CAN DECOMPOSE ON SITE.
IV. 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.
V. SEDIMENT WILL BE REMOVED FROM EROSION CONTROLS ONCE IT HAS REACHED 1/3 OF THE EXPOSED HEIGHT OF THE CONTROL.
VI. 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:

7) TIMING OF IN-WATER WORK: APPROPRIATE STATE (OREGON DEPARTMENT OF FISH AND WILDLIFE (ODFW), WASHINGTON DEPARTMENT OF FISH AND WILDLIFE (WDFW), IDAHO DEPARTMENT OF FISH AND GAME (IDFG), MONTANA FISH WILDLIFE AND PARKS (MFWP) GUIDELINES FOR TIMING OF IN-WATER WORK WINDOWS (IWW) WILL BE FOLLOWED.
A) BULL TROUT - WHILE UTILIZING THE APPROPRIATE STATE DESIGNATED IN-WATER WORK PERIOD WILL LESSEN THE RISK TO BULL TROUT, THIS ALONE MAY NOT BE SUFFICIENT TO ADEQUATELY PROTECT LOCAL BULL TROUT POPULATIONS. THIS IS ESPECIALLY TRUE IF WORK IS OCCURRING IN SPAWNING AND REARING AREAS BECAUSE EGGS, ALEVIN, AND FRY ARE IN THE SUBSTRATE OR CLOSELY ASSOCIATED HABITATS NEARLY YEAR ROUND. SOME AREAS MAY NOT HAVE DESIGNATED IN-WATER WORK WINDOWS FOR BULL TROUT OF IF THEY DO, THEY MAN CONFLICT WITH WORK WINDOWS FOR SALMON AND STEELHEAD. IF THIS IS THE CASE, OR IF PROPOSED WORK IS TO OCCUR WITHIN BULL TROUT SPAWNING AND REARING HABITATS, PROJECT PROPONENTS WILL CONTACT THE APPROPRIATE USFWS FIELD OFFICE (SEE APPENDIX B IN THIS BO) TO INSURE THAT ALL REASONABLE IMPLEMENTATION MEASURES ARE CONSIDERED AND AN APPROPRIATE IN-WATER WORK WINDOW IS BEING USED TO MINIMIZE PROJECT EFFECTS.
B) LAMPREY - THE PROJECT SPONSOR AND/OR THEIR CONTRACTORS WILL AVOID WORKING IN STREAM OR RIVER CHANNELS THAT CONTAIN PACIFIC LAMPREY FROM MARCH 1 TO JULY 1 IN LOW TO MID ELEVATION REACHES (<5,000 FEET). IN HIGH ELEVATION REACHES(>5,000 FEET), THE PROJECT SPONSOR WILL AVOID WORKING IN STREAM OR RIVER CHANNELS FROM MARCH 1 TO AUGUST 1. IF EITHER TIMEFRAME IS INCOMPATIBLE WITH THE OTHER OBJECTIVES, THE AREA WILL BE SURVEYED FOR NESTS AND LAMPREY PRESENCE, AND AVOIDED IF POSSIBLE. IF LAMPREYS ARE KNOW TO EXIST, THE PROJECT SPONSOR WILL UTILIZE DE-WATERING AND SALVAGE PROCEDURES OUTLINED IN US FISH AND WILDLIFE SERVICE (2010).

8) DUST ABATEMENT: THE PROJECT SPONSOR WILL DETERMINE THE APPROPRIATE DUST CONTROL MEASURES (IF NECESSARY) BY CONSIDERING SOIL TYPE, EQUIPMENT USAGE, PREVAILING WIND DIRECTION, AND THE EFFECTS CAUSED BY OTHER EROSION AND SEDIMENT CONTROL MEASURES. IN ADDITION, THE FOLLOWING CRITERIA WILL BE FOLLOWED:
A) WORK WILL BE SEQUENCED AND SCHEDULED TO REDUCE EXPOSED BARE SOIL SUBJECT TO WIND EROSION.
B) 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 A 50:50 (LIGNINSULFONATE TO WATER) SOLUTION.
C) 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).
D) SPILL CONTAINMENT EQUIPMENT WILL BE AVAILABLE DURING APPLICATION OF DUST ABATEMENT CHEMICALS.
E) PETROLEUM-BASED PRODUCTS WILL NOT BE USED FOR DUST ABATEMENT.

9) SPILL PREVENTION, CONTROL, AND COUNTER MEASURES: THE USE OF MECHANIZED MACHINERY INCREASES THE RISK FOR ACCIDENTAL SPILLS OF FUEL, LUBRICANTS, HYDRAULIC FLUID, OR OTHER CONTAMINANTS INTO THE RIPARIAN ZONE OR DIRECTLY INTO THE WATER. ADDITIONALLY, UNCURED CONCRETE AND FORM MATERIALS ADJACENT TO THE ACTIVE STREAM CHANNEL MAY RESULT IN ACCIDENTAL DISCHARGE INTO THE WATER. THESE CONTAMINANTS CAN DEGRADE HABITAT, AND INJURE OR KILL AQUATIC FOOD ORGANISMS AND ESA-LISTED SPECIES. THE PROJECT SPONSOR WILL ADHERE TO THE FOLLOWING MEASURES:
A) A DESCRIPTION OF HAZARDOUS MATERIALS TO BE USED (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.

10) INVASIVE SPECIES - EQUIPMENT CLEANING AND MAINTENANCE: THE FOLLOWING MEASURES WILL BE FOLLOWED TO AVOID INTRODUCTION OF INVASIVE PLANTS AND NOXIOUS WEEDS INTO PROJECT AREAS:
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. 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 ARE USED.

80% DESIGN
JULY 2021

AMANDA JONES
STATE OF WASHINGTON
21008109
REGISTERED PROFESSIONAL ENGINEER
RENEWS: 08/28/2021

WOLF WATER RESOURCES, INC.
1001 SE WATER AVE, SUITE #180
PORTLAND, OR 97214
503.207.6688

CONFEDERATED TRIBES OF THE
UMATILLA INDIAN RESERVATION
46411 Timine Way
Pendleton, OR 97801
541.429.7010

CTUIR
TUCANNON RIVER
PROJECT AREA 27/28
PHASE 0.5 - 1
COLUMBIA COUNTY, WA

HIP IV CONSERVATION NOTES 1

REVISION NUMBER

No.	Date	Revision
X	DATE	NOTE

Date	Designed By
07/2021	AJ
Drawn By	**Checked By**
RW, AJ	MW, AJ

SCALE
0 1"

JOB NO.
20190026

SHEET NO.
G2.1

80% DESIGN
JULY 2021

WORK AREA ISOLATION & FISH SALVAGE

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. WHEN WORK AREA ISOLATION IS REQUIRED, DESIGN PLANS WILL INCLUDE ALL ISOLATION ELEMENTS, FISH RELEASE AREAS, AND, WHEN A PUMP IS USED TO DE-WATER THE ISOLATION AREA AND FISH ARE PRESENT, A FISH SCREEN THAT MEETS NMFS'S FISH SCREEN CRITERIA (NMFS 2011, OR MOST CURRENT). 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.

FOR SALVAGE OPERATIONS IN KNOWN BULL TROUT SPAWNING AND REARING HABITAT, ELECTRO-FISHING SHALL ONLY OCCUR FROM MAY 01 TO JUL 31. NO ELECTRO-FISHING WILL OCCUR IN ANY BULL TROUT OCCUPIED HABITAT AFTER AUG 15. BULL TROUT ARE VERY TEMPERATURE SENSITIVE AND GENERALLY SHOULD NOT BE ELECTRO-SHOCKED OR OTHERWISE HANDLED WHEN TEMPERATURES EXCEED 15 DEGREES CELSIUS. SALVAGE ACTIVITIES SHOULD TAKE PLACE 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 TO FISH SPECIES PRESENT.

SALVAGE OPERATIONS WILL FOLLOW THE ORDERING, METHODOLOGIES, AND CONSERVATION MEASURES SPECIFIED BELOW IN STEPS 1 THROUGH 6. STEPS 1 AND 2 WILL BE IMPLEMENTED FOR ALL PROJECTS WHERE WORK AREA ISOLATION IS NECESSARY ACCORDING TO CONDITIONS ABOVE. ELECTRO-FISHING (STEP 3) CAN BE IMPLEMENTED TO ENSURE ALL FISH HAVE BEEN REMOVED FOLLOWING STEPS 1 AND 2, OR WHEN OTHER MEANS OF FISH CAPTURE MAY NOT BE FEASIBLE OR EFFECTIVE. DE-WATERING AND RE-WATERING (STEPS 4 AND 5) WILL BE IMPLEMENTED UNLESS WETTED IN-STREAM WORK IS DEEMED TO BE MINIMALLY HARMFUL TO FISH, AND IS BENEFICIAL TO OTHER AQUATIC SPECIES. DE-WATERING WILL NOT BE CONDUCTED IN AREAS KNOWN TO BE OCCUPIED BY LAMPREY, UNLESS LAMPREYS ARE SALVAGED USING GUIDANCE SET FORTH IN US FISH AND WILDLIFE SERVICE (2010).

1) ISOLATE:

A) BLOCK NETS WILL BE INSTALLED AT UPSTREAM AND DOWNSTREAM LOCATIONS AND MAINTAINED IN A SECURED POSITION TO EXCLUDE FISH FROM ENTERING THE PROJECT AREA.

B) 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.

C) IF BLOCK NETS REMAIN IN PLACE MORE THAN ONE DAY, THE NETS WILL BE MONITORED AT LEAST DAILY TO ENSURE THEY ARE SECURED TO THE BANKS AND FREE OF ORGANIC ACCUMULATION. IF THE PROJECT IS WITHIN BULL TROUT SPAWNING AND REARING HABITAT, THE BLOCK NETS MUST BE CHECKED EVERY FOUR HOURS FOR FISH IMPINGEMENT ON THE NET. LESS FREQUENT INTERVALS MUST BE APPROVED THROUGH A VARIANCE REQUEST.

D) NETS WILL BE MONITORED HOURLY ANYTIME THERE IS IN-STREAM DISTURBANCE.

2) SALVAGE: -AS DESCRIBED BELOW, FISH TRAPPED WITHIN THE ISOLATED WORK AREA WILL BE CAPTURED TO MINIMIZE THE RISK OF INJURY, THEN RELEASED AT A SAFE SITE:

A) REMOVE AS MANY FISH AS POSSIBLE PRIOR TO DE-WATERING.
B) DURING DE-WATERING, ANY REMAINING FISH WILL BE COLLECTED BY HAND OR DIP NETS.
C) SEINES WITH A MESH SIZE TO ENSURE CAPTURE OF THE RESIDING ESA-LISTED FISH WILL BE USED.
D) MINNOW TRAPS WILL BE LEFT IN PLACE OVERNIGHT AND USED IN CONJUNCTION WITH SEINING.
E) IF BUCKETS ARE USED TO TRANSPORT FISH:
- I. THE TIME FISH ARE IN A TRANSPORT BUCKET WILL BE LIMITED, AND WILL BE RELEASED AS QUICKLY AS POSSIBLE;
- II. THE NUMBER OF FISH WITHIN A BUCKET WILL BE LIMITED BASED ON SIZE, AND FISH WILL BE OF RELATIVELY COMPARABLE SIZE TO MINIMIZE PREDATION;
- III. AERATORS FOR BUCKETS WILL BE USED OR THE BUCKET WATER WILL BE FREQUENTLY CHANGED WITH COLD CLEAR WATER AT 15 MINUTE OR MORE FREQUENT INTERVALS.
- IV. BUCKETS WILL BE KEPT IN SHADED AREAS OR WILL BE COVERED BY A CANOPY IN EXPOSED AREAS.
- V. DEAD FISH WILL NOT BE STORED IN TRANSPORT BUCKETS, BUT WILL BE LEFT ON THE STREAM BANK TO AVOID MORTALITY COUNTING ERRORS.

F) AS RAPIDLY AS POSSIBLE (ESPECIALLY FOR TEMPERATURE-SENSITIVE BULL TROUT), FISH WILL BE RELEASED IN AN AREA THAT PROVIDES ADEQUATE COVER AND FLOW REFUGE. UPSTREAM RELEASE IS GENERALLY PREFERRED, BUT FISH RELEASED DOWNSTREAM WILL BE SUFFICIENTLY OUTSIDE OF THE INFLUENCE OF CONSTRUCTION.
G) SALVAGE WILL BE SUPERVISED BY A QUALIFIED FISHERIES BIOLOGIST EXPERIENCED WITH WORK AREA ISOLATION AND COMPETENT TO ENSURE THE SAFE HANDLING OF ALL FISH.

3) ELECTROFISHING: ELECTROFISHING WILL BE USED ONLY AFTER OTHER SALVAGE METHODS HAVE BEEN EMPLOYED OR WHEN OTHER MEANS OF FISH CAPTURE ARE DETERMINED TO NOT BE FEASIBLE OR EFFECTIVE. IF ELECTROFISHING WILL BE USED TO CAPTURE FISH FOR SALVAGE, THE SALVAGE OPERATION WILL BE LED BY AN EXPERIENCED FISHERIES BIOLOGIST AND THE FOLLOWING GUIDELINES WILL BE FOLLOWED:

A) THE NMFS'S ELECTROFISHING GUIDELINES (NMFS 2000).
B) ONLY DIRECT CURRENT (DC) OR PULSED DIRECT CURRENT (PDC) WILL BE USED AND CONDUCTIVITY MUST BE TESTED.
- I. IF CONDUCTIVITY IS LESS THAN 100 MS, VOLTAGE RANGES FROM 900 TO 1100 WILL BE USED.
- II. FOR CONDUCTIVITY RANGES BETWEEN 100 TO 300 MS, VOLTAGE RANGES WILL BE 500 TO 800.
- III. FOR CONDUCTIVITY GREATER THAN 300 MS, VOLTAGE WILL BE LESS THAN 400.

C) ELECTROFISHING WILL BEGIN WITH A MINIMUM PULSE WIDTH AND RECOMMENDED VOLTAGE AND THEN GRADUALLY INCREASE TO THE POINT WHERE FISH ARE IMMOBILIZED.
D) THE ANODE WILL NOT INTENTIONALLY CONTACT FISH.
E) ELECTROFISHING SHALL NOT BE CONDUCTED WHEN THE WATER CONDITIONS ARE TURBID AND VISIBILITY IS POOR. THIS CONDITION MAY BE EXPERIENCED WHEN THE SAMPLER CANNOT SEE THE STREAM BOTTOM IN ONE FOOT OF WATER.
G) IF MORTALITY OR OBVIOUS INJURY (DEFINED AS DARK BANDS ON THE BODY, SPINAL DEFORMATIONS, DE-SCALING OF 25% OR MORE OF BODY, AND TORPIDITY OR INABILITY TO MAINTAIN UPRIGHT ATTITUDE AFTER SUFFICIENT RECOVERY TIME) OCCURS DURING ELECTROFISHING, OPERATIONS WILL BE IMMEDIATELY DISCONTINUED, MACHINE SETTINGS, WATER TEMPERATURE AND CONDUCTIVITY CHECKED, AND PROCEDURES ADJUSTED OR ELECTROFISHING POSTPONED TO REDUCE MORTALITY.

4) DEWATER: DEWATERING, WHEN NECESSARY, WILL BE CONDUCTED OVER A SUFFICIENT PERIOD OF TIME TO ALLOW SPECIES TO NATURALLY MIGRATE OUT OF THE WORK AREA AND WILL BE LIMITED TO THE SHORTEST LINEAR EXTENT PRACTICABLE.

A) DIVSERION AROUND THE CONSTRUCTION SITE MAY BE ACCOMPLISHED WITH A COFFERDAM AND A BYPASS CULVERT OR PIPE, OR A LINED, NON-ERODIBLE DIVERSION DITCH. WHERE GRAVITY FEED IS NOT POSSIBLE, A PUMP MAY BE USED, BUT MUST BE OPERATED IN SUCH A WAY AS TO AVOID REPETITIVE DEWATERING AND REWATERING OF THE SITE. IMPOUNDMENT BEHIND THE COFFERDAM MUST OCCUR SLOWLY THROUGH THE TRANSITION, WHILE CONSTANT FLOW IS DELIVERED TO THE DOWNSTREAM REACHES.
B) ALL PUMPS WILL HAVE FISH SCREENS TO AVOID JUVENILE FISH IMPINGEMENT OR ENTRAINMENT, AND WILL BE OPERATED IN ACCORDANCE WITH NMFS'S CURRENT FISH SCREEN CRITERIA (NMFS 2011, OR MOST RECENT VERSION). IF THE PUMPING RATE EXCEEDS 3 CUBIC FEET PER SECOND (CFS), A NMFS ENGINEERING REVIEW WILL BE NECESSARY. IF THE SCREEN IS IN AN ISOLATED AREA WITH NO FISH (SALMONIDS OR LARVAL LAMPREY), A LARGER MESH SCREEN MA BE USED.
C) DISSIPATION OF FLOW ENERGY AT THE BYPASS OUTFLOW WILL BE PROVIDED TO PREVENT DAMAGE TO RIPARIAN VEGETATION AND/OR STREAM CHANNEL.
D) SEEPAGE WATER WILL BE PUMPED TO A TEMPORARY STORAGE AND TREATMENT SITE OR INTO UPLAND AREAS TO ALLOW WATER TO PERCOLATE THROUGH SOIL OR TO FILTER THROUGH VEGETATION PRIOR TO REENTERING THE STREAM CHANNEL
E) IN AREAS OCCUPIED BY LARVAL LAMPREY, TO THE EXTENT POSSIBLE, SALVAGE USING GUIDANCE DESCRIBED IN ABOVE SECTION "CONSERVATION MEASURES FOR SALVAGE OF NATIVE FISH, LAMPREY AND MUSSELS"(WHICH IS BASED ON USFWS 2010) OR MOST RECENT GUIDANCE.
F) IN AREAS OCCUPIED BY NATIVE FRESHWATER MUSSELS, TO THE EXTENT POSSIBLE, SALVAGE USING GUIDANCE DEVELOPED BY THE XERCES SOCIETY (BLEVINS ET AL. 2018, 2019).

5) RE-WATERING: UPON PROJECT COMPLETION, THE CONSTRUCTION SITE WILL BE SLOWLY RE-WATERED TO PREVENT LOSS OF SURFACE FLOW DOWNSTREAM AND TO PREVENT A SUDDEN INCREASE IN STREAM TURBIDITY. DURING RE-WATERING, THE SITE WILL BE MONITORED TO PREVENT STRANDING OF AQUATIC ORGANISMS BELOW THE CONSTRUCTION SITE.

6) SALVAGE NOTICE: MONITORING AND RECORDING OF FISH PRESENCE, HANDLING, AND MORTALITY MUST OCCUR DURING THE DURATION OF THE ISOLATION, SALVAGE, ELECTROFISHING, DEWATERING, AND REWATERING OPERATIONS. ONCE OPERATIONS ARE COMPLETED, A SALVAGE REPORT WILL DOCUMENT PROCEDURES USED, ANY FISH INJURIES OR DEATHS (INCLUDING NUMBERS OF FISH AFFECTED), AND CAUSES OF ANY DEATHS.

CONSTRUCTION AND POST-CONSTRUCTION CONSERVATION MEASURES FOR AQUATIC SPECIES

1) FISH PASSAGE: FISH PASSAGE WILL BE PROVIDED FOR ANY ADULT OR JUVENILE FISH LIKELY TO BE PRESENT IN THE ACTION AREA DURING CONSTRUCTION, UNLESS PASSAGE DID NOT EXIST BEFORE CONSTRUCTION OR THE STREAM IS NATURALLY IMPASSABLE AT THE TIME OF CONSTRUCTION. IF THE PROVISION OF TEMPORARY FISH PASSAGE DURING CONSTRUCTION WILL INCREASE NEGATIVE EFFECTS ON AQUATIC SPECIES OF INTEREST OR THEIR HABITAT, A VARIANCE CAN BE REQUESTED FROM THE NMFS BRANCH CHIEF AND THE FWS FIELD OFFICE SUPERVISOR (APPENDIX B OF THIS BO). PERTINENT INFORMATION, SUCH AS THE SPECIES AFFECTED, LENGTH OF STREAM REACH AFFECTED, PROPOSED TIME FOR THE PASSAGE BARRIER, AND ALTERNATIVES CONSIDERED, WILL BE INCLUDED IN THE VARIANCE REQUEST.

2) CONSTRUCTION AND DISCHARGE WATER:
A) SURFACE WATER MAY BE DIVERTED TO MEET CONSTRUCTION NEEDS, BUT ONLY IF DEVELOPED SOURCES ARE UNAVAILABLE OR INADEQUATE.
B) DIVERSIONS WILL NOT EXCEED 10% OF THE AVAILABLE FLOW.
C) ALL CONSTRUCTION DISCHARGE WATER WILL BE COLLECTED AND TREATED USING THE BEST AVAILABLE TECHNOLOGY APPLICABLE TO SITE CONDITIONS.
D) TREATMENTS TO REMOVE DEBRIS, NUTRIENTS, SEDIMENT, PETROLEUM HYDROCARBONS, METALS AND OTHER POLLUTANTS LIKELY TO BE PRESENT WILL BE PROVIDED.

3) MINIMIZE TIME AND EXTENT OF DISTURBANCE: EARTHWORK (INCLUDING DRILLING, EXCAVATION, DREDGING, FILLING AND COMPACTING) IN WHICH MECHANIZED EQUIPMENT IS IN STREAM CHANNELS, RIPARIAN AREAS, AND WETLANDS WILL BE COMPLETED AS QUICKLY AS POSSIBLE. MECHANIZED EQUIPMENT WILL BE USED IN STREAMS ONLY WHEN PROJECT SPECIALISTS BELIEVE THAT SUCH ACTIONS ARE THE ONLY REASONABLE ALTERNATIVE FOR IMPLEMENTATION, OR WOULD RESULT IN LESS SEDIMENT IN THE STREAM CHANNEL OR DAMAGE (SHORT- OR LONG-TERM) TO THE OVERALL AQUATIC AND RIPARIAN ECOSYSTEM RELATIVE TO OTHER ALTERNATIVES. TO THE EXTENT FEASIBLE, MECHANIZED EQUIPMENT WILL WORK FROM THE TOP OF THE BANK,UNLESS WORK FROM ANOTHER LOCATION WOULD RESULT IN LESS HABITAT DISTURBANCE.

4) CESSATION OF WORK: PROJECT OPERATIONS WILL CEASE UNDER THE FOLLOWING CONDITIONS:
A) HIGH FLOW CONDITIONS THAT MAY RESULT IN INUNDATION OF THE PROJECT AREA, EXCEPT FOR EFFORTS TO AVOID OR MINIMIZE RESOURCE DAMAGE;
B) WHEN ALLOWABLE WATER QUALITY IMPACTS, AS DEFINED BY THE STATE CWA SECTION 401 WATER QUALITY CERTIFICATION, HAVE BEEN EXCEEDED; OR
C) WHEN "INCIDENTAL TAKE" LIMITATIONS HAVE BEEN REACHED OR EXCEEDED.

5) SITE RESTORATION: WHEN CONSTRUCTION IS COMPLETE:
A) ALL STREAM BANKS, SOILS, AND VEGETATION WILL BE CLEANED UP AND RESTORED AS NECESSARY USING STOCKPILED LARGE WOOD, TOPSOIL, AND NATIVE CHANNEL MATERIAL.
B) ALL PROJECT RELATED WASTE WILL BE REMOVED.
C) ALL TEMPORARY ACCESS ROADS, CROSSINGS, AND STAGING AREAS WILL BE OBLITERATED. WHEN NECESSARY FOR RE-VEGETATION AND INFILTRATION OF WATER, COMPACTED AREAS OF SOIL WILL BE LOOSENED.
D) ALL DISTURBED AREAS WILL BE REHABILITATED IN A MANNER THAT RESULTS IN SIMILAR OR IMPROVED CONDITIONS RELATIVE TO PRE-PROJECT CONDITIONS. THIS WILL BE ACHIEVED THROUGH REDISTRIBUTION OF STOCKPILED MATERIALS, SEEDING, AND/OR PLANTING WITH LOCAL NATIVE SEED MIXES OR PLANTS.

6) RE-VEGETATION: LONG-TERM SOIL STABILIZATION OF DISTURBED SITES WILL BE ACCOMPLISHED WITH REESTABLISHMENT OF NATIVE VEGETATION USING THE FOLLOWING CRITERIA:
A) PLANTING AND SEEDING WILL OCCUR PRIOR TO OR AT THE BEGINNING OF THE FIRST GROWING SEASON AFTER CONSTRUCTION.
B) AN APPROPRIATE MIX OF SPECIES THAT WILL ACHIEVE ESTABLISHMENT, SHADE, AND EROSION CONTROL OBJECTIVES, PREFERABLY FORB, GRASS, SHRUB, OR TREE SPECIES NATIVE TO THE PROJECT AREA OR REGION AND APPROPRIATE TO THE SITE WILL BE USED.
C) VEGETATION, SUCH AS WILLOW, SEDGE AND RUSH MATS, WILL BE SALVAGED FROM DISTURBED OR ABANDONED FLOOD PLAINS, STREAM CHANNELS, OR WETLANDS.
D) INVASIVE SPECIES WILL NOT BE USED.
E) SHORT-TERM STABILIZATION MEASURES MAY INCLUDE THE USE OF NON-NATIVE STERILE SEED MIX (WHEN NATIVE SEEDS ARE NOT AVAILABLE), WEED-FREE CERTIFIED STRAW, JUTE MATTING, AND OTHER SIMILAR TECHNIQUES.
F) SURFACE FERTILIZER WILL NOT BE APPLIED WITHIN 50 FEET OF ANY STREAM CHANNEL, WATER BODY, OR WETLAND.
G) FENCING WILL BE INSTALLED AS NECESSARY TO PREVENT ACCESS TO RE-VEGETATED SITES BY LIVESTOCK OR UNAUTHORIZED PERSONS.
H) RE-ESTABLISHMENT OF VEGETATION IN DISTURBED AREAS WILL ACHIEVE AT LEAST 70% OF PRE-PROJECT CONDITIONS WITHIN 3 YEARS.
I) INVASIVE PLANTS WILL BE REMOVED OR CONTROLLED UNTIL NATIVE PLANT SPECIES ARE WELL ESTABLISHED (TYPICALLY 3 YEARS POST-CONSTRUCTION).

7) IMPLEMENTATION MONITORING: PROJECT SPONSOR STAFF OR THEIR DESIGNATED REPRESENTATIVE WILL PROVIDE IMPLEMENTATION MONITORING TO ENSURE COMPLIANCE WITH THE APPLICABLE BIOLOGICAL OPINION, INCLUDING:
A) GENERAL CONSERVATION MEASURES ARE ADEQUATELY FOLLOWED; AND
B) EFFECTS TO LISTED SPECIES ARE NOT GREATER THAN PREDICTED AND INCIDENTAL TAKE LIMITATIONS ARE NOT EXCEEDED.

8) CWA SECTION 401 WATER QUALITY CERTIFICATION: THE PROJECT SPONSOR OR DESIGNATED REPRESENTATIVE WILL COMPLETE AND RECORD WATER QUALITY OBSERVATIONS TO ENSURE THAT IN-WATER WORK IS NOT DEGRADING WATER QUALITY. DURING CONSTRUCTION, CWA SECTION 401 WATER QUALITY CERTIFICATION PROVISIONS PROVIDED BY THE OREGON DEPARTMENT OF ENVIRONMENTAL QUALITY, WASHINGTON DEPARTMENT OF ECOLOGY, OR IDAHO DEPARTMENT OF ENVIRONMENTAL QUALITY WILL BE FOLLOWED. TURBIDITY MONITORING SHALL BE CONDUCTED IN ACCORDANCE WITH THE HIP III TURBIDITY MONITORING PROTOCOL OUTLINED BELOW AND RECORDED ON THE PROJECT COMPLETION FORM.

TURBIDITY MONITORING PROTOCOL

THE PROJECT SPONSOR SHALL COMPLETE AND RECORD THE FOLLOWING WATER QUALITY OBSERVATIONS ON THE HIP 4 PROJECT COMPLETION FORM (PCF). IF THE GEOMORPHOLOGY OF THE PROJECT AREA (E.G., SILTY OR CLAYLIKE MATERIALS) OR THE NATURE OF THE ACTION (E.G., LARGE AMOUNTS OF BARE EARTH EXPOSURE) SHALL PRECLUDE THE SUCCESSFUL COMPLIANCE WITH THESE TRIGGERS, NOTIFY YOUR EC LEAD & THE SERVICES IN ADVANCE OF THE LIKELIHOOD OF AN EXCEEDANCE AND SEEK ADDITIONAL RECOMMENDATIONS.

A) TAKE A BACKGROUND TURBIDITY MEASUREMENT APPROXIMATELY 100 FEET UPSTREAM FROM THE PROJECT AREA USING A RECENTLY-CALIBRATED TURBIDIMETER. RECORD THE OBSERVATION, LOCATION, AND TIME OF THE BACKGROUND MEASUREMENT BEFORE MONITORING AT THE DOWNSTREAM POINT, KNOWN AS THE MEASUREMENT COMPLIANCE POINT. IF THE BACKGROUND TURBIDITY IS LESS THAN 20 NTU, THEN USE VISUAL OBSERVATIONS (FIGURE 1).

B) TAKE A SECOND MEASUREMENT OR OBSERVATION AT THE MEASUREMENT COMPLIANCE POINT, IMMEDIATELY DOWNSTREAM OF THE DISTURBANCE AREA, APPROXIMATELY:
- I) 50 FEET DOWNSTREAM FOR STREAMS THAT ARE LESS THAN 30 FEET WIDE;
- II) 100 FEET DOWNSTREAM FOR STREAMS BETWEEN 30 AND 100 FEET WIDE;
- IV) 200 FEET DOWNSTREAM FOR STREAMS GREATER THAN 100 FEET WIDE; AND
- V) 300 FEET FROM THE DISCHARGE POINT OR NONPOINT SOURCE FOR LOCATIONS SUBJECT TO TIDAL OR COASTAL SCOUR.
- VI) RECORD THE DOWNSTREAM OBSERVATION, LOCATION, AND TIME.

C) TURBIDITY SHALL BE MEASURED (STEPS 1-2) EVERY 2 HOURS 11WHILE WORK IS BEING IMPLEMENTED.

D) AN EXCEEDANCE OCCURS WHENEVER BOTH OF THE FOLLOWING CONDITIONS ARE EXCEEDED:

E) DOWNSTREAM TURBIDITY EXCEEDS 40 NTU,

F) DOWNSTREAM TURBIDITY EXCEEDS 10% ABOVE BACKGROUND

NOTE: FOR ANY STREAM WITH A BACKGROUND TURBIDITY OF 20 NTU OR LESS, IF YOU CANNOT SEE THE BOTTOM IN 2 FEET OF WATER AT EACH 2 HOUR INTERVAL, THEN TURBIDITY HAS LIKELY SURPASSED 40 NTUS AND YOU MUST ADJUST YOUR PROCEDURES. THIS WOULD ALLOW WORK TO CONTINUE WITH A TURBIDITY OF UNDER ABOUT 30-40 NTU. TURBIDITY OVER 40 NTU SHOULD BE AVOIDED.

I) IF AN EXCEEDANCE OCCURS THEN ADJUSTMENTS OR CORRECTIVE MEASURES MUST BE TAKEN IN ORDER TO REDUCE TURBIDITY. THE NMFS STAFF BIOLOGISTS OF THE AREA CAN PROVIDE TECHNICAL ASSISTANCE.

J) IF EXCEEDANCES OCCUR FOR MORE THAN TWO CONSECUTIVE MONITORING INTERVALS (AFTER 4 HOURS), THE ACTIVITY MUST STOP UNTIL THE TURBIDITY LEVEL RETURNS TO BACKGROUND, AND THE EC LEAD MUST BE NOTIFIED AFTER THE PROJECT IS CONCLUDED. THE EC LEAD SHALL DOCUMENT THE REASONS FOR THE EXCEEDANCES AND THE CORRECTIVE MEASURES TAKEN. THIS IS VERY IMPORTANT AS BPA IS REQUIRED TO REPORT TO THE SERVICES UPON ALL EXCEEDANCES.

K) IF AT ANY TIME, MONITORING, INSPECTIONS, OR OBSERVATIONS/SAMPLES SHOW THAT THE TURBIDITY CONTROLS ARE INEFFECTIVE, IMMEDIATELY MOBILIZE WORK CREWS TO REPAIR, REPLACE, OR REINFORCE CONTROLS AS NECESSARY. DOCUMENT THOSE OCCURRENCES IN THE PROJECT COMPLETION FORM (PCF).

AMANDA JONES
STATE OF WASHINGTON
21008109
REGISTERED PROFESSIONAL ENGINEER
RENEWS: 08/28/2021

WOLF WATER RESOURCES, INC.
1001 SE WATER AVE, SUITE #180
PORTLAND, OR 97214
503.207.6688

CONFEDERATED TRIBES OF THE
UMATILLA INDIAN RESERVATION
46411 Timine Way
Pendleton, OR 97801
541.429.7010

CTUIR
TUCANNON RIVER
PROJECT AREA 27/28
PHASE 0.5 - 1
COLUMBIA COUNTY, WA

HIP IV CONSERVATION NOTES 2

REVISION NUMBER

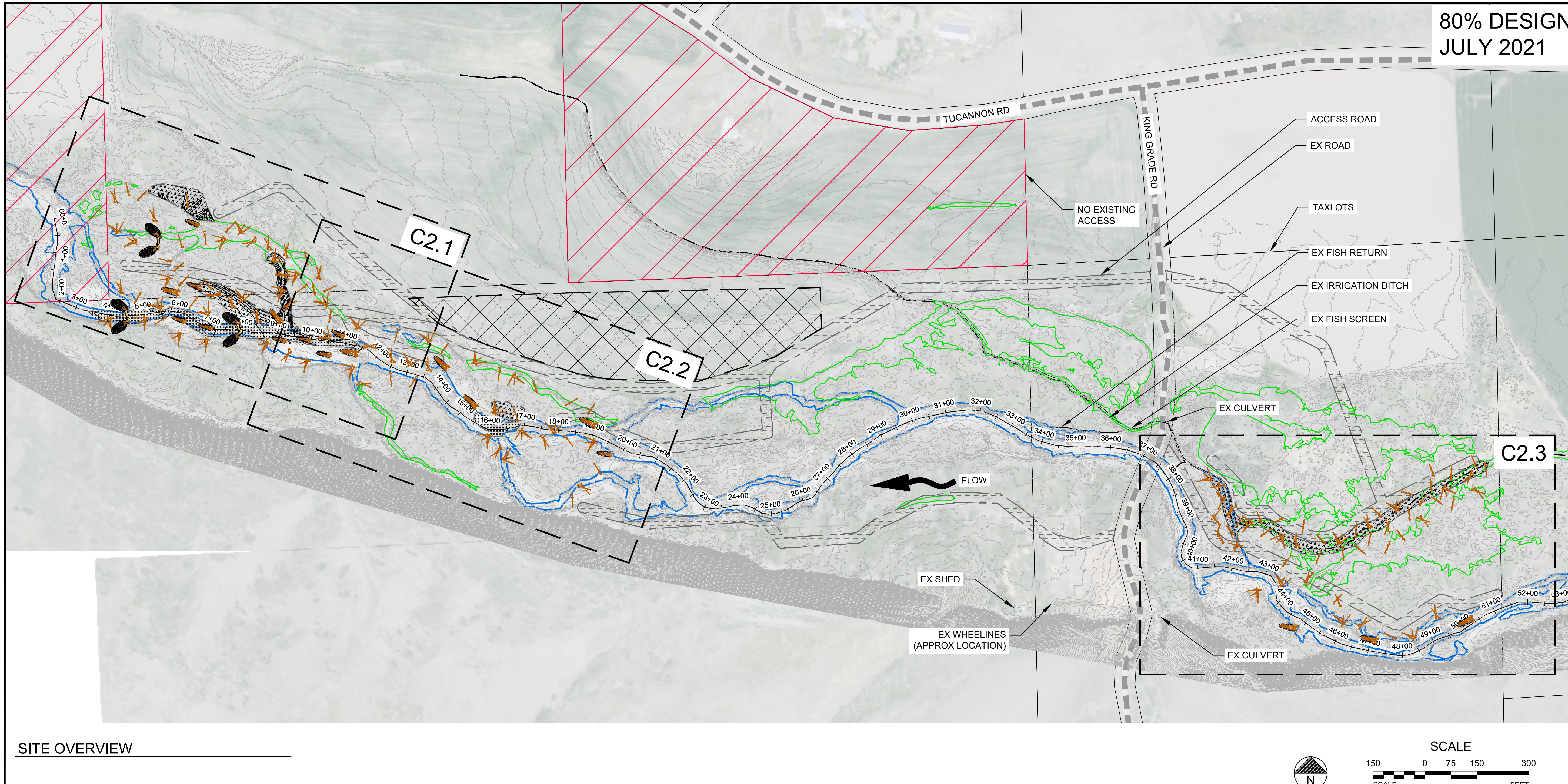
No.	Date	Revision
X	DATE	NOTE

Date	Designed By
07/2021	AJ
Drawn By	Checked By
RW, AJ	MW, AJ

SCALE

JOB NO.
20190026

SHEET NO.
G2.2



SITE OVERVIEW

AMANDA JONES
STATE OF WASHINGTON
21008109
REGISTERED PROFESSIONAL ENGINEER
RENEWS: 08/28/2021

WOLF WATER RESOURCES, INC.
1001 SE WATER AVE, SUITE #180
PORTLAND, OR 97214
503.207.6688

CONFEDERATED TRIBES OF THE UMATILLA INDIAN RESERVATION
46411 Timine Way
Pendleton, OR 97801
541.429.7010

CTUIR TUCANNON RIVER

PROJECT AREA 27/28
PHASE 0.5 - 1
COLUMBIA COUNTY, WA

SITE OVERVIEW

REVISION NUMBER

No.	Date	Revision
X	DATE	NOTE

Date	Designed By
07/2021	AJ
Drawn By	Checked By
RW, AJ	MW, AJ

SCALE 0 1"

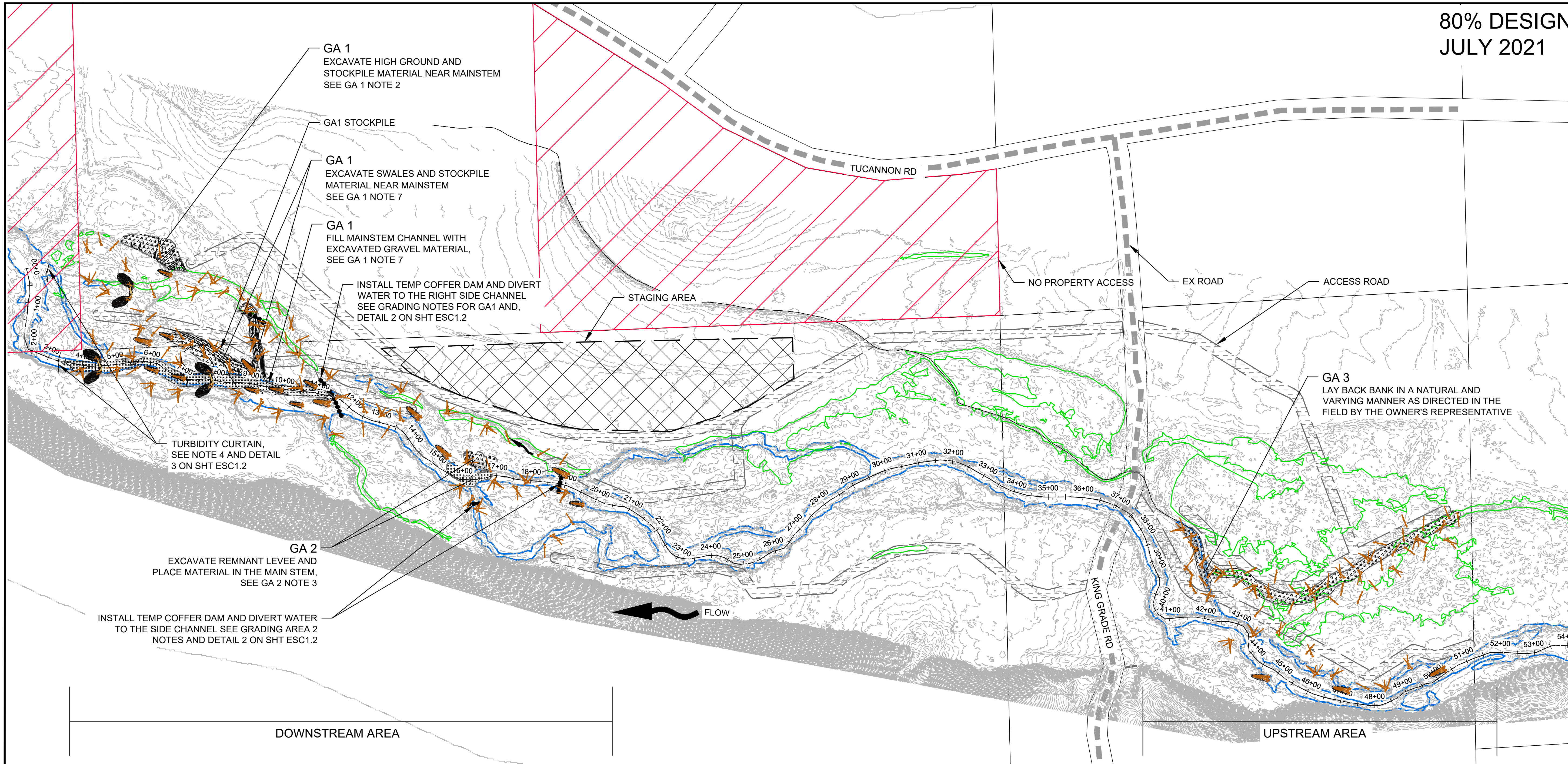
JOB NO. 20190026

SHEET NO. C1.1

5 OF 17

DWG: Z:\Shared\W2r\CAD\20190024-Tucannon\DWG\PHASE 0.5-1 SHEETS\C1 X-TUC- SITE OVERVIEW.dwg USER: ajones
DATE: Jul 16, 2021 1:35pm XREFS: X-DESIGN X-AERIAL_Large X-SURVEY X-WHS X-TB-22X34

80% DESIGN
JULY 2021



SITE ACCESS, STAGING & SEQUENCING

DOWNSTREAM WATER MANAGEMENT AND PHASING NOTES:

GRADING AREA 1 (GA1)

1. FLAG AREAS TO BE CLEARED AND GRUBBED. OWNER'S REPRESENTATIVE SHALL REVIEW AND APPROVE MARKED AREAS BEFORE CLEARING.
2. EXCAVATE HIGH GROUND IN GA 1 AND STOCKPILE EXCAVATED MATERIAL NEAR MAINSTEM. FINISHED GRADE SHALL BE VERIFIED PRIOR TO PLACING WHS.
3. CONSTRUCT WHS IN AND AROUND GA 1 EXCEPT FOR IN MAINSTEM.
4. INSTALL COFFER DAM NEAR STA 12+50 TO DIVERT WATER INTO SIDE CHANNEL.
5. PLACE FISH EXCLUSION NETTING AT THE DOWNSTEAM EXTENT TO PREVENT FISH FROM ENTERING THE WORK AREA AND PERFORM FISH SALVAGE THROUGH GA1.
6. INSTALL TURBIDITY CURTAIN OR OTHER APPROVED TURBIDITY MANAGEMENT NEAR STA 3+50 TO PREVENT TURBIDITY DOWNSTREAM OF THE PROJECT AREA.
7. EXCAVATE SWALES AND PLACE EXCAVATED MATERIAL FROM SWALES AND THE HIGH GROUND IN THE MAINSTEM TUCANNON PER SHEET C2.1 AND CONSTRUCT WHS THROUGHOUT GA1.
8. REMOVE COFFER DAM ONE BULK BAG AT A TIME AND SLOWLY RETURN FLOWS TO THE MAIN STEM TUCANNON. MONITOR TURBIDITY DOWNSTREAM OF THE PROJECT AND REPLACE COFFER DAM AS NEEDED TO REDUCE TURBIDITY.
9. RESTORE ACCESS ROUTES AND STAGING AREAS NO LONGER NECESSARY FOR FUTURE PHASES OF WORK.

GRADING AREA 2 (GA2)

1. FLAG AREAS TO BE CLEARED AND GRUBBED. OWNER'S REPRESENTATIVE SHALL REVIEW AND APPROVE MARKED AREAS BEFORE CLEARING.
2. CONSTRUCT COFFER DAM NEAR STA 19+00 TO DIVERT WATER TO THE RIGHT SIDE CHANNEL. INSTALL FISH EXCLUSION NETTING TO PREVENT FISH FROM ENTERING THE WORK AREA.
3. PLACE FISH EXCLUSION NETTING AT THE DOWNSTEAM EXTENT OF GA2 NEAR STA 12+00 TO PREVENT FISH FROM ENTERING THE WORK AREA AND PERFORM FISH SALVAGE THROUGH GA2.
4. EXCAVATE LEVEE AND PLACE EXCAVATED MATERIAL IN THE MAINSTEM PER THE PLAN AND PROFILE ON SHEETS C2.1 AND C2.2, AND CONSTRUCT WHS FROM STA 12+00 TO 19+00.
5. REMOVE COFFER DAM ONE BULK BAG AT A TIME AND SLOWLY RETURN FLOWS TO THE MAIN STEM TUCANNON. MONITOR TURBIDITY DOWNSTREAM OF THE PROJECT AND REPLACE COFFER DAM AS NEEDED TO REDUCE TURBIDITY.
6. RESTORE ACCESS ROUTES AND STAGING AREAS NO LONGER NECESSARY FOR FUTURE PHASES OF WORK.

UPSTREAM WATER MANAGEMENT AND PHASING NOTES:

1. LAYBACK THE BANK AS DIRECTED IN THE FIELD BY THE OWNER'S REPRESENTATIVE.
2. INSTALL LOG JAMS AND FLOODPLAIN WOOD AFTER COMPLETION OF GRADING.

AMANDA JONES, STATE OF WASHINGTON, 21008109, REGISTERED PROFESSIONAL ENGINEER
RENEWS: 08/28/2021

WOLF WATER RESOURCES, INC.
1001 SE WATER AVE, SUITE #180
PORTLAND, OR 97214
503.207.6688

CONFEDERATED TRIBES OF THE UMATILLA INDIAN RESERVATION
46411 Timine Way
Pendleton, OR 97801
541.429.7010

CTUIR
TUCANNON RIVER
PROJECT AREA 27/28
PHASE 0.5 - 1
COLUMBIA COUNTY, WA

SITE ACCESS, STAGING & SEQUENCING

REVISION NUMBER

No.	Date	Revision
X	DATE	NOTE

Date	Designed By
07/2021	AJ
Drawn By	Checked By
RW, AJ	MW, AJ

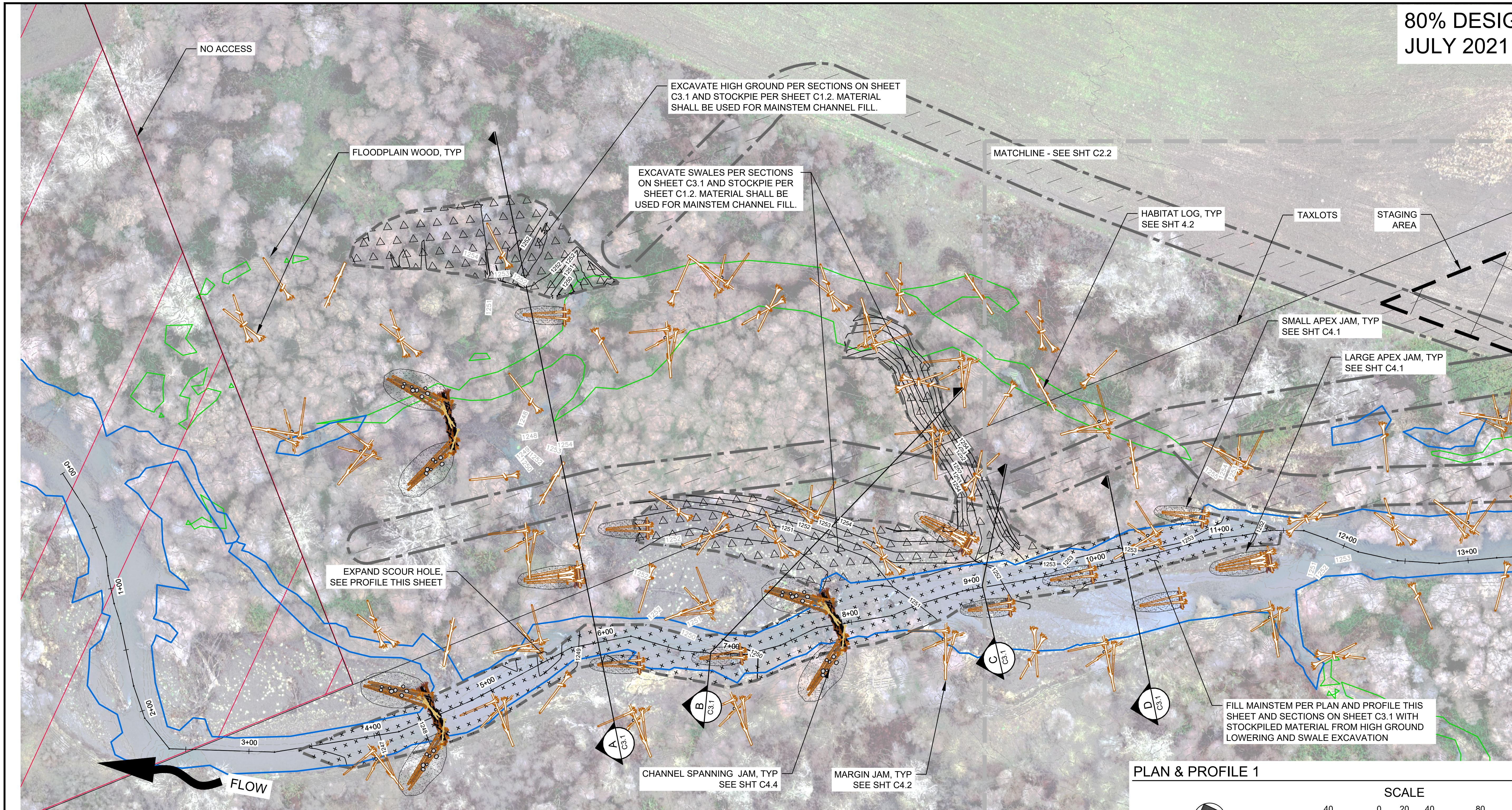
SCALE 0 1"

JOB NO. 20190026

SHEET NO. C1.2

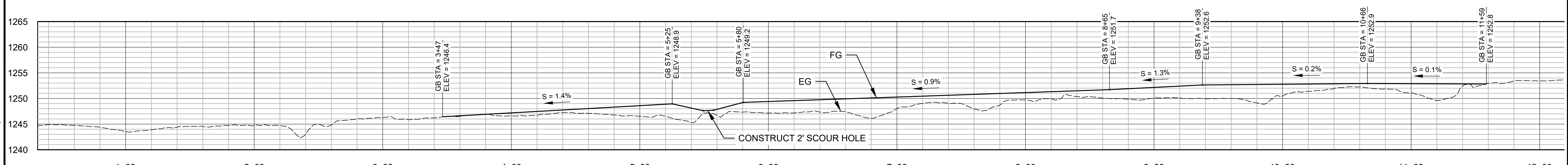
DWG: Z:\Shared\W2r\CAD\20190026-Tucannon\DWG\PHASE 0.5-1 SHEETS\C1.2-TUC-PHASING&WATMNGMT.dwg USER: ajones
DATE: Jul 16, 2021 2:41pm XREFS: X-TB-22X34 X-DESIGN X-SURVEY X-WHS X-AERIAL X-SURFACE

80% DESIGN
JULY 2021



PLAN & PROFILE 1

SCALE
40 0 20 40 80
SCALE FEET



PROFILE VERTICAL SCALE: 1" = 40'
PROFILE HORIZONTAL SCALE: 1" = 5'

DWG: Z:\Shared\WWR\CAD\2019\0026-Tucannon\DWG\PHASE 0.5-1 SHEETS\C2.X-TUC-GRADINGPLANS&PROF.dwg USER: ajones
DATE: Jul 16, 2021 2:44pm XREFS: X-SURVEY X-TB-22X34 X-WHS X-DESIGN X-AERIAL

AMANDA JONES, STATE OF WASHINGTON, 21008109, REGISTERED PROFESSIONAL ENGINEER
RENEWS: 08/28/2021

WOLF WATER RESOURCES, INC.
1001 SE WATER AVE. SUITE #180
PORTLAND, OR 97214
503.207.6688

CONFEDERATED TRIBES OF THE
UMATILLA INDIAN RESERVATION
46411 Timine Way
Pendleton, OR 97801
541.429.7010

CTUIR
TUCANNON RIVER
PROJECT AREA 27/28
PHASE 0.5 - 1
COLUMBIA COUNTY, WA

PLAN & PROFILE 1

REVISION NUMBER

No.	Date	Revision
X	DATE	NOTE

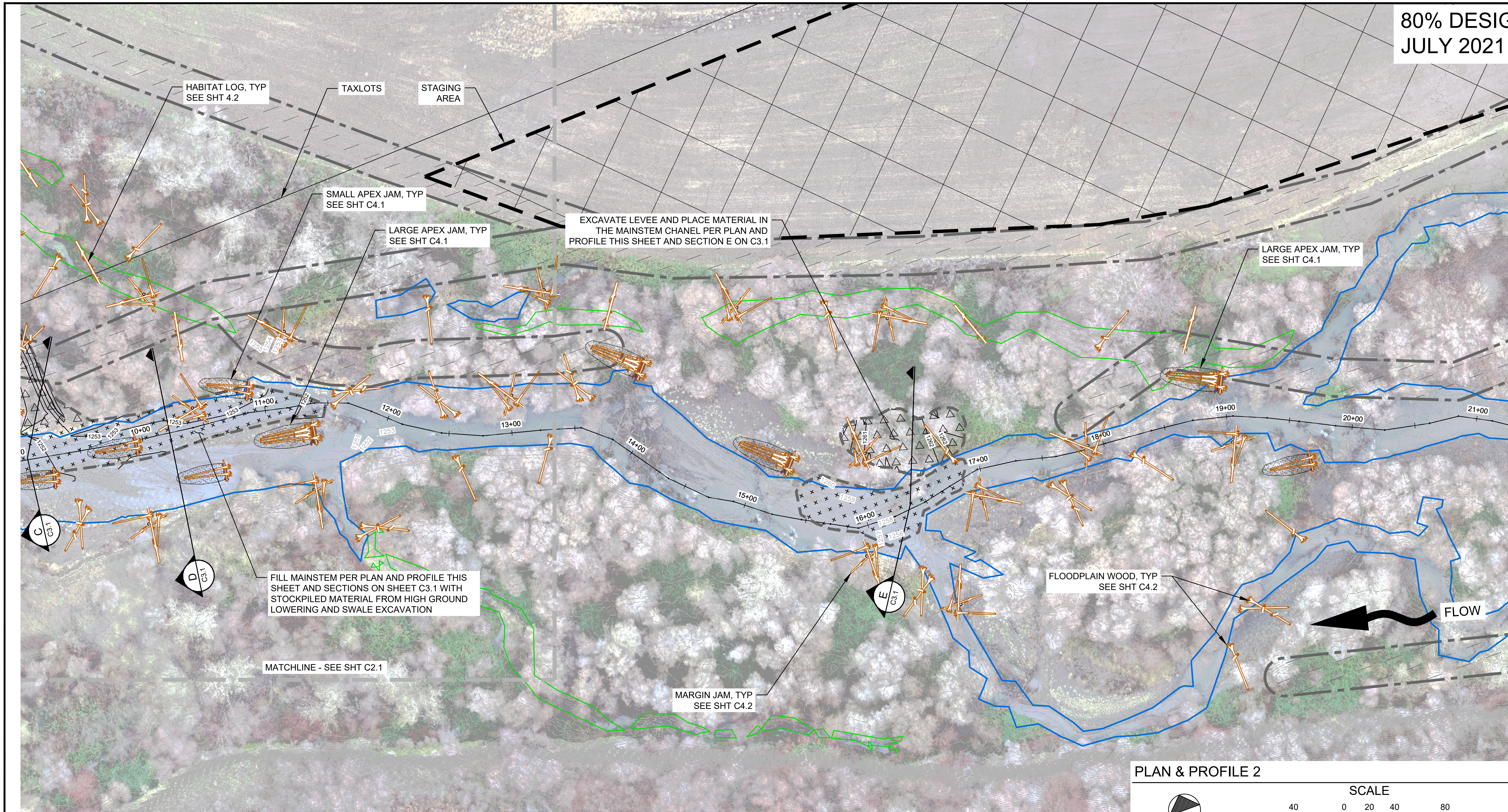
Date	Designed By
07/2021	AJ
Drawn By	Checked By
RW, AJ	MW, AJ

SCALE 0 1"

JOB NO.
20190026

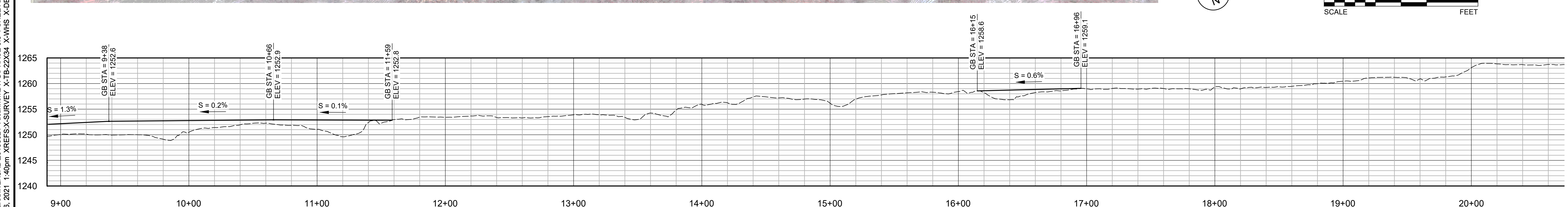
SHEET NO.
C2.1
7 OF 17

80% DESIGN
JULY 2021



PLAN & PROFILE 2

SCALE
40 0 20 40 80
SCALE FEET



PROFILE VERTICAL SCALE: 1" = 40'
PROFILE HORIZONTAL SCALE: 1" = 5'

DWG: Z:\Shared\W\21CAD\20190024-Tucannon\DWG\PHASE 0.5-1 SHEETS\C2.X-TUC-GRADINGPLANS&PROF.dwg USER: ajones
DATE: Jul 16, 2021 1:40pm XREFS:X-SURVEY X-TB-22X34 X-WHS X-DESIGN X-AERIAL

AMANDA JONES
STATE OF WASHINGTON
21008109
REGISTERED PROFESSIONAL ENGINEER
RENEWS: 08/28/2021

WOLF WATER RESOURCES, INC.
1001 SE WATER AVE, SUITE #180
PORTLAND, OR 97214
503.207.6688

CONFEDERATED TRIBES OF THE
UMATILLA INDIAN RESERVATION
46411 Timine Way
Pendleton, OR 97801
541.429.7010

CTUIR
TUCANNON RIVER
PROJECT AREA 27/28
PHASE 0.5 - 1
COLUMBIA COUNTY, WA

PLAN & PROFILE 2

REVISION NUMBER

No.	Date	Revision
X	DATE	NOTE

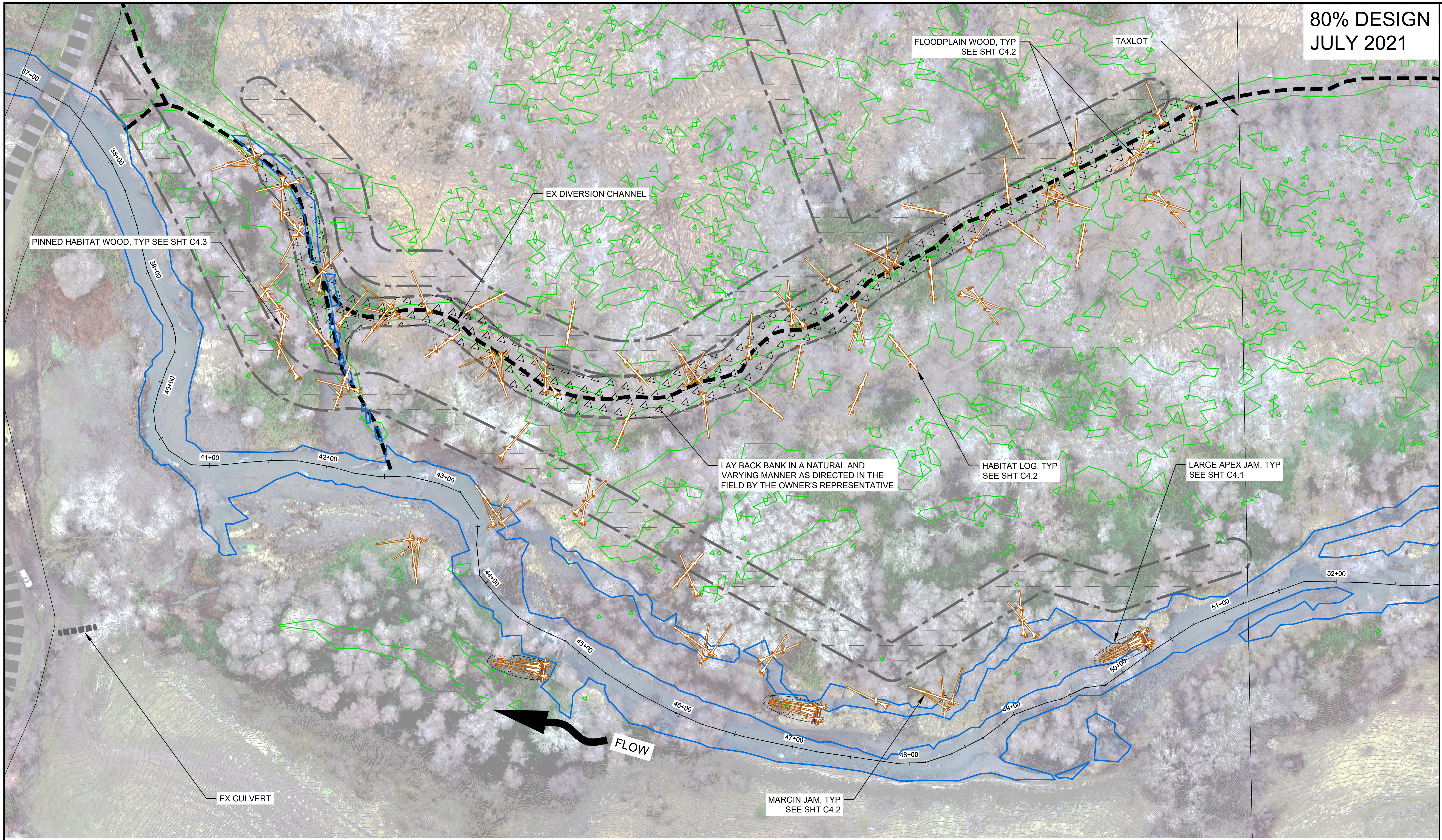
Date	Designed By
07/2021	AJ
Drawn By	Checked By
RW, AJ	MW, AJ

SCALE
0 1"

JOB NO.
20190026

SHEET NO.
C2.2
8 OF 17

80% DESIGN
JULY 2021



PLAN 3

SCALE
40 0 20 40 80
SCALE FEET

N

AMANDA JONES
STATE OF WASHINGTON
21008109
REGISTERED PROFESSIONAL ENGINEER

RENEWS: 08/28/2021

WOLF WATER RESOURCES, INC.
1001 SE WATER AVE, SUITE #180
PORTLAND, OR 97214
503.207.6688

CONFEDERATED TRIBES OF THE UMATILLA INDIAN RESERVATION
46411 Timíne Way
Pendleton, OR 97801
541.429.7010

CTUIR
TUCANNON RIVER
PROJECT AREA 27/28
PHASE 0.5 - 1
COLUMBIA COUNTY, WA

PLAN 3

REVISION NUMBER

No.	Date	Revision
X	DATE	NOTE

Date	Designed By
07/2021	AJ
Drawn By	Checked By
RW, AJ	MW, AJ

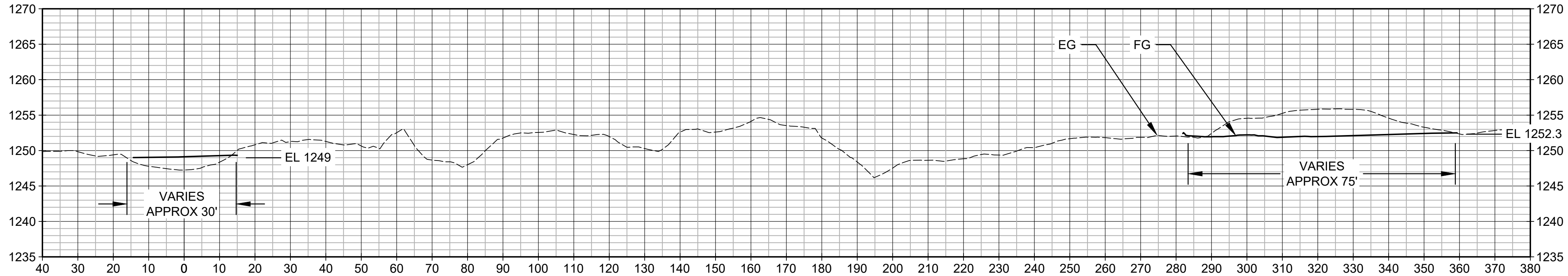
SCALE
0 1"

JOB NO.
20190026

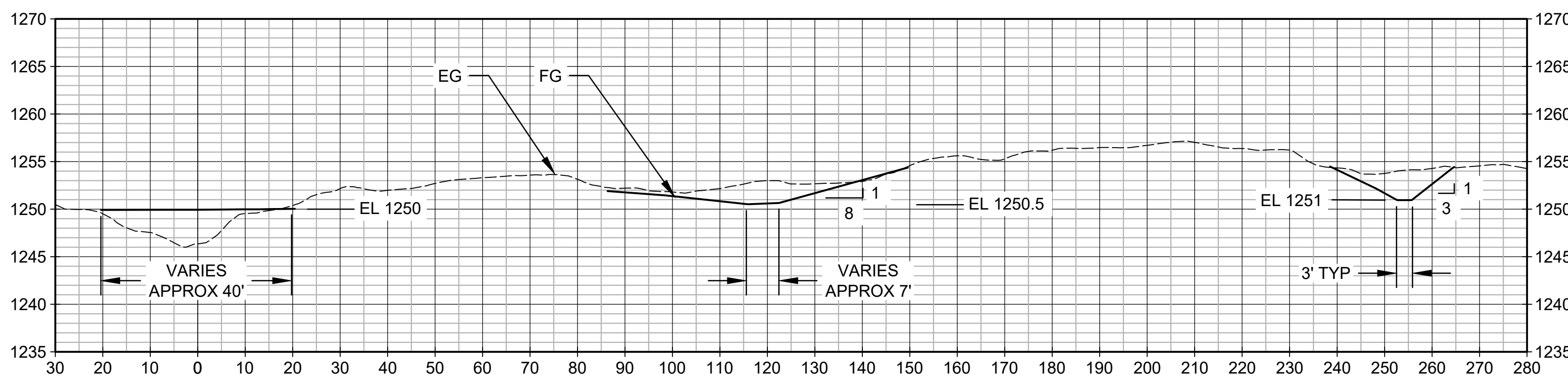
SHEET NO.
C2.3

DWG: Z:\Shared\W21\CAD\20190024-Tucannon\DWG\PHASE 0.5-1 SHEETS\C2.X-TUC-GRADINGPLANS&PROF.dwg USER: ajones
DATE: Jul 16, 2021 1:40pm XREFS: X-SURVEY X-TB-22X34 X-WHS X-DESIGN X-AERIAL

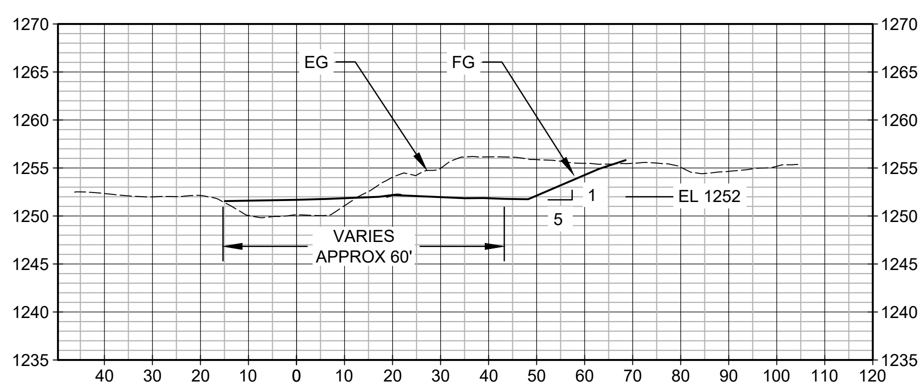
80% DESIGN
JULY 2021



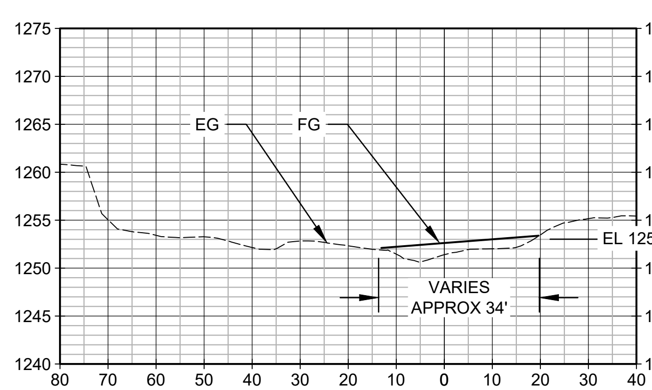
A SECTION: STA 5+93
SCALE: HORIZONTAL 1" = 20'
VERTICAL EXAGGERATION = 1:2



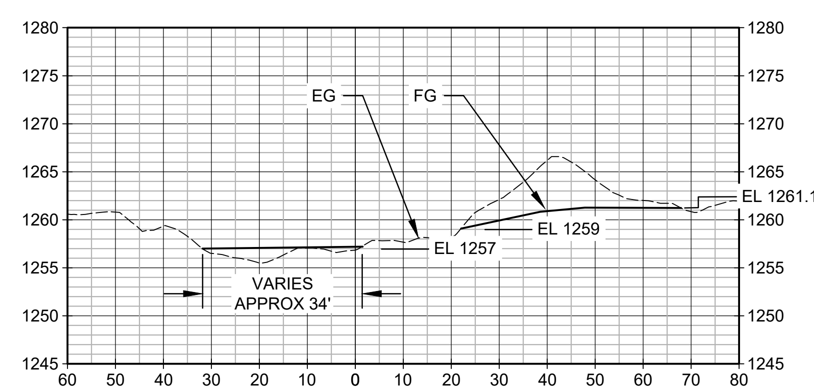
B SECTION: STA 6+84
SCALE: HORIZONTAL 1" = 20'
VERTICAL EXAGGERATION = 1:2



C SECTION: STA 9+07
SCALE: HORIZONTAL 1" = 20'
VERTICAL EXAGGERATION = 1:2



D SECTION: STA 10+20
SCALE: HORIZONTAL 1" = 20'
VERTICAL EXAGGERATION = 1:2



E SECTION: STA 16+36
SCALE: HORIZONTAL 1" = 20'
VERTICAL EXAGGERATION = 1:2

NOTES:

1. SECTION VERTICAL EXAGGERATION IS 1:2.
2. VERTICAL DATUM IS ELEVATION IN UNITS OF FEET (NAVD88).
3. CHANNEL SECTIONS ARE LOOKING DOWNSTREAM.

AMANDA JONES
STATE OF WASHINGTON
21008109
REGISTERED PROFESSIONAL ENGINEER
RENEWS: 08/28/2021

WOLF WATER RESOURCES, INC.
1001 SE WATER AVE, SUITE #180
PORTLAND, OR 97214
503.207.6688

CONFEDERATED TRIBES OF THE
UMATILLA INDIAN RESERVATION
46411 Ti'mine Way
Pendleton, OR 97801
541.429.7010

CTUIR
TUCANNON RIVER
PROJECT AREA 27/28
PHASE 0.5 - 1
COLUMBIA COUNTY, WA

SECTIONS

REVISION NUMBER

No.	Date	Revision
X	DATE	NOTE

Date	Designed By
07/2021	AJ
Drawn By	Checked By
RW, AJ	MW, AJ

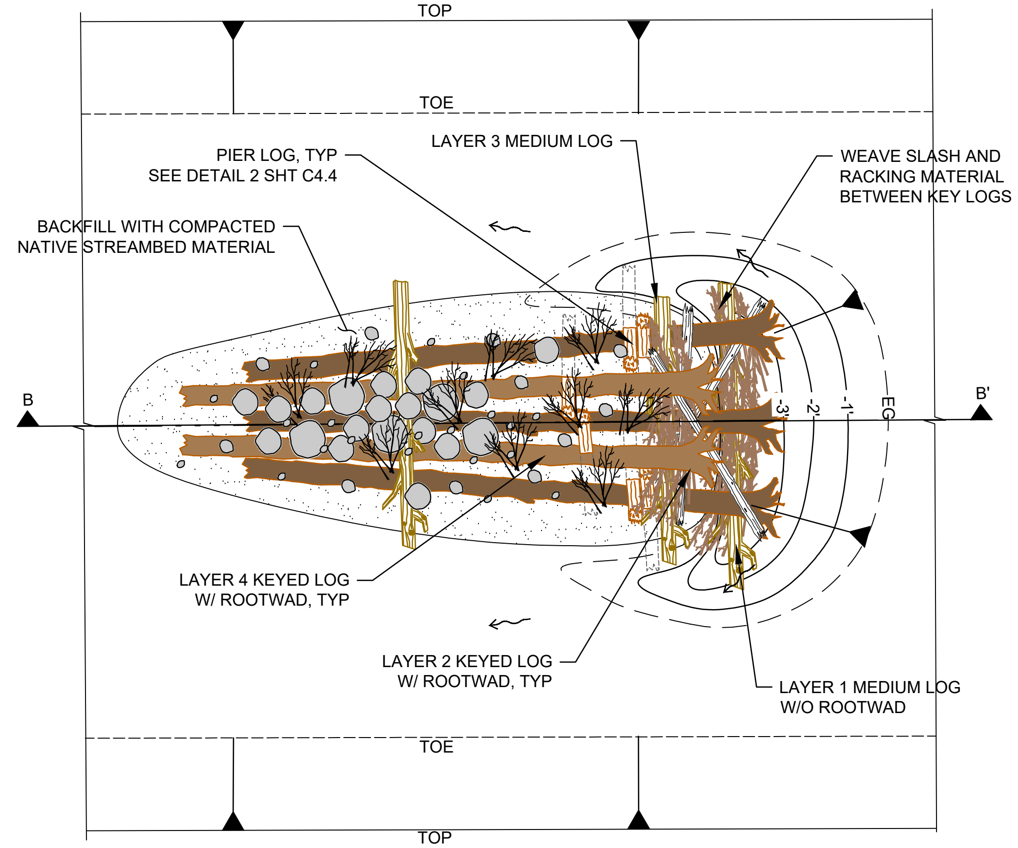
SCALE 0 1"

JOB NO.
20190026

SHEET NO.
C3.1
10 OF 17

DWG: Z:\Shared\W2r\CAD\20190024-Tucannon\DWG\PHASE 0.5-1 SHEETS\C3.X-SECTIONS.dwg USER: ajones
DATE: Jul 16, 2021 2:44pm XREFS:X-DESIGN X-TB-22X34

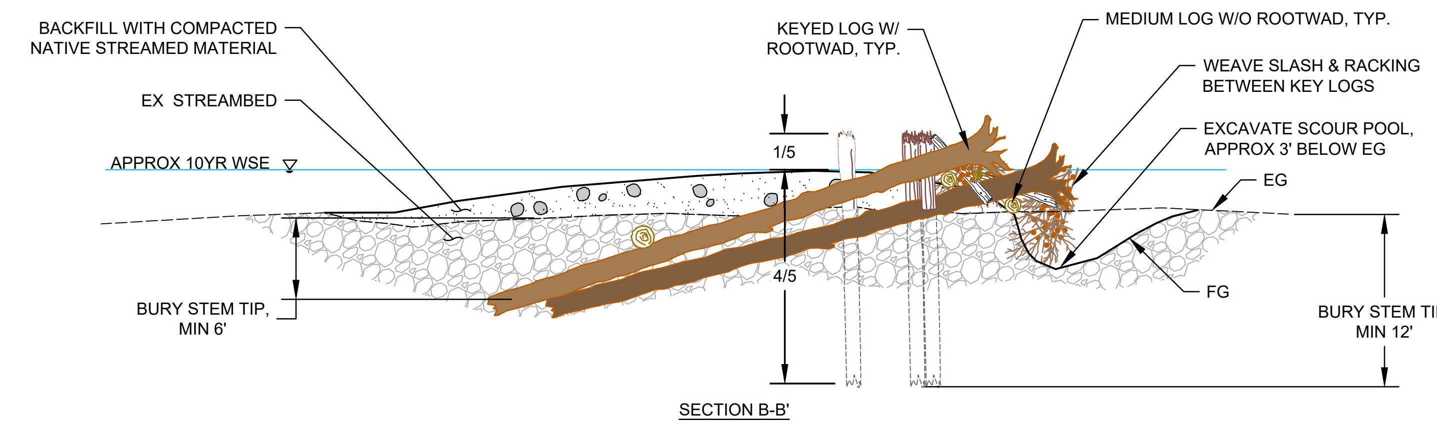
80% DESIGN
JULY 2021



PLAN

1 WHS TYPE 1 - LARGE APEX JAM

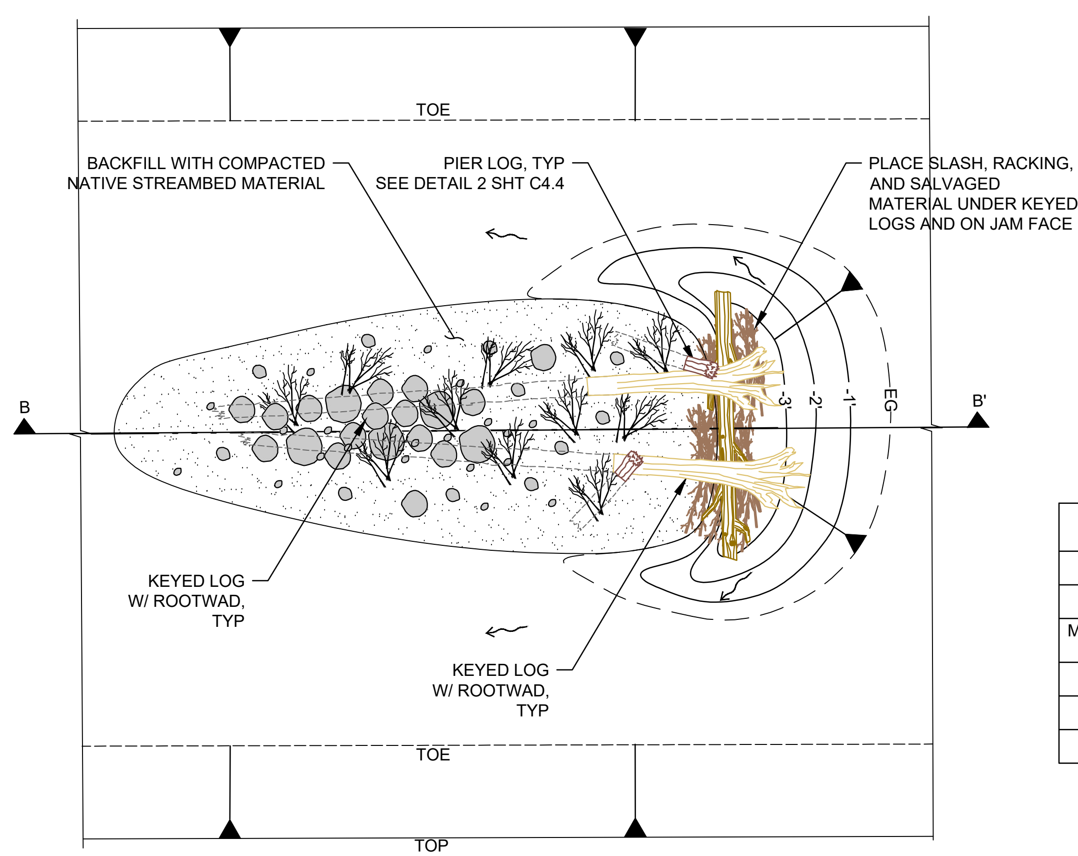
NOT TO SCALE



SECTION B-B'

WHS TYPE 1

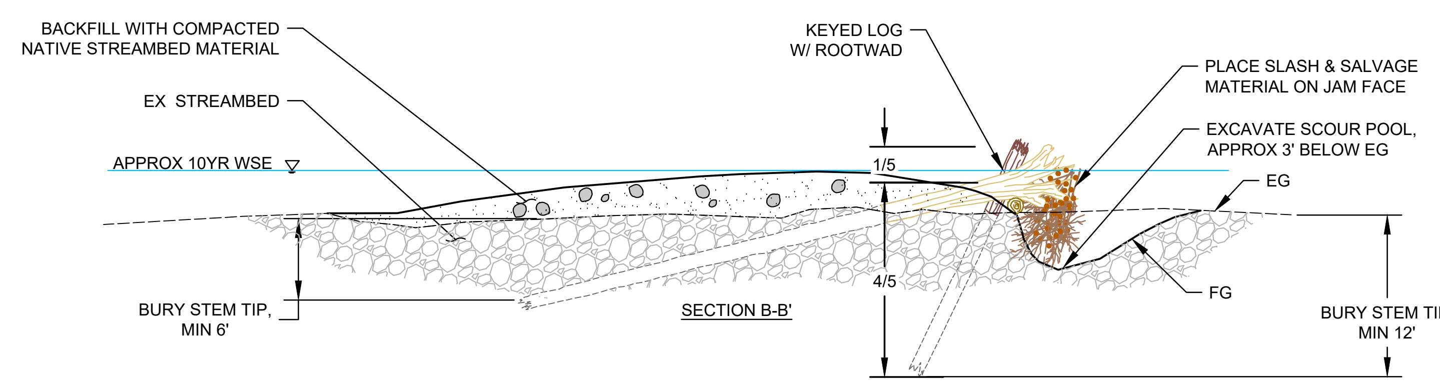
Piece Summary		
Piece	QTY	LENGTH / DBH
PIER LOG	6	MIN 20' / MIN 10"
LARGE W/ RW	5	MIN 40' / 18-24"
MEDIUM W/ OR W/O RW	3	MIN 40' / 12-18"
RACKING WOOD	10	MIN 15' / MIN 6"
SLASH	20 CY	



PLAN

2 WHS TYPE 2 - SMALL APEX JAM

NOT TO SCALE



SECTION B-B'

WHS TYPE 2

Piece Summary		
Piece	QTY	LENGTH / DBH
PIER LOG	2	MIN 20' / MIN 10"
MEDIUM W/ OR W/O RW	1	MIN 40' / MIN 12-18"
LARGE W/ RW	2	MIN 40' / 18-24"
RACKING WOOD	4	MIN 15' / MIN 6"
SLASH	5 CY	

LOG INSTALLATION NOTES:

1. NATIVE STREAMBED BACKFILL SHALL BE PLACED IN 12" LIFTS AND COMPACTED TO FIRM UNYIELDING CONDITION.
2. CONTRACTOR TO COORDINATE LOG PLACEMENT WITH ENGINEER PRIOR TO CONSTRUCTION. ENGINEER SHALL APPROVE PLACEMENT BEFORE COMPLETION.
3. WHERE POSSIBLE, LOGS PROTRUDING FROM BANK SHALL BE PLACED CANTILEVERED BETWEEN EXISTING LIVE TREES. THE SUPPORTING TREE NEAREST TO THE BANK SHALL BE ON THE DOWNSTREAM SIDE OF THE LOGS.
4. EMBEDDED LOGS SHALL BE INSTALLED BY EXCAVATING A TRENCH, PLACING THE LOG, BACKFILLING, AND MACHINE COMPACTING BACKFILL PER SPECIFICATIONS. WHERE EXCAVATION IS NOT POSSIBLE LOG ENDS SHALL BE TIED INTO NATIVE MATERIAL AND BURIED WITH NATIVE MATERIAL PER SPECIFICATIONS.
5. SALVAGE ADJACENT BOULDERS FOR USE IN STRUCTURE.
6. FOR BURIED KEYED LOGS EMBED A MINIMUM OF ⅔ THE TOTAL LENGTH OF THE LOG. MIN 6' COVER AT STEM TIP (MEASURED FROM EG).
7. EMBED ROOTWAD AS NEEDED TO ACHIEVE REQUIRED BURIAL DEPTH AND ALLOW FOR FULL CONTACT BETWEEN THE BOTTOM OF THE LOG AND THE BOTTOM OF THE CHANNEL. BACKFILL AROUND ROOTWAD WITH NATIVE STREAMBED MATERIAL.
8. SEE SPECIFICATIONS FOR TREE SPECIES. KEYED LOG DIAMETER MEASURED AT BREAST HEIGHT (DBH) AND LENGTH AS SHOWN ON PLANS.
9. CRUSH ALL EXPOSED SAW-CUT FACES.

# DENOTES PLACEMENT ORDER

AMANDA JONES
STATE OF WASHINGTON
21008109
REGISTERED PROFESSIONAL ENGINEER
RENEWS: 08/28/2021

WOLF WATER RESOURCES, INC.
1001 SE WATER AVE, SUITE #180
PORTLAND, OR 97214
503.207.6688

CONFEDERATED TRIBES OF THE UMATILLA INDIAN RESERVATION
46411 Timine Way
Pendleton, OR 97801
541.429.7010

CTUIR
TUCANNON RIVER
PROJECT AREA 27/28
PHASE 0.5 - 1
COLUMBIA COUNTY, WA

WHS DETAILS 1

REVISION NUMBER

No.	Date	Revision
X	DATE	NOTE

Date	Designed By
07/2021	AJ
Drawn By	Checked By
RW, AJ	MW, AJ

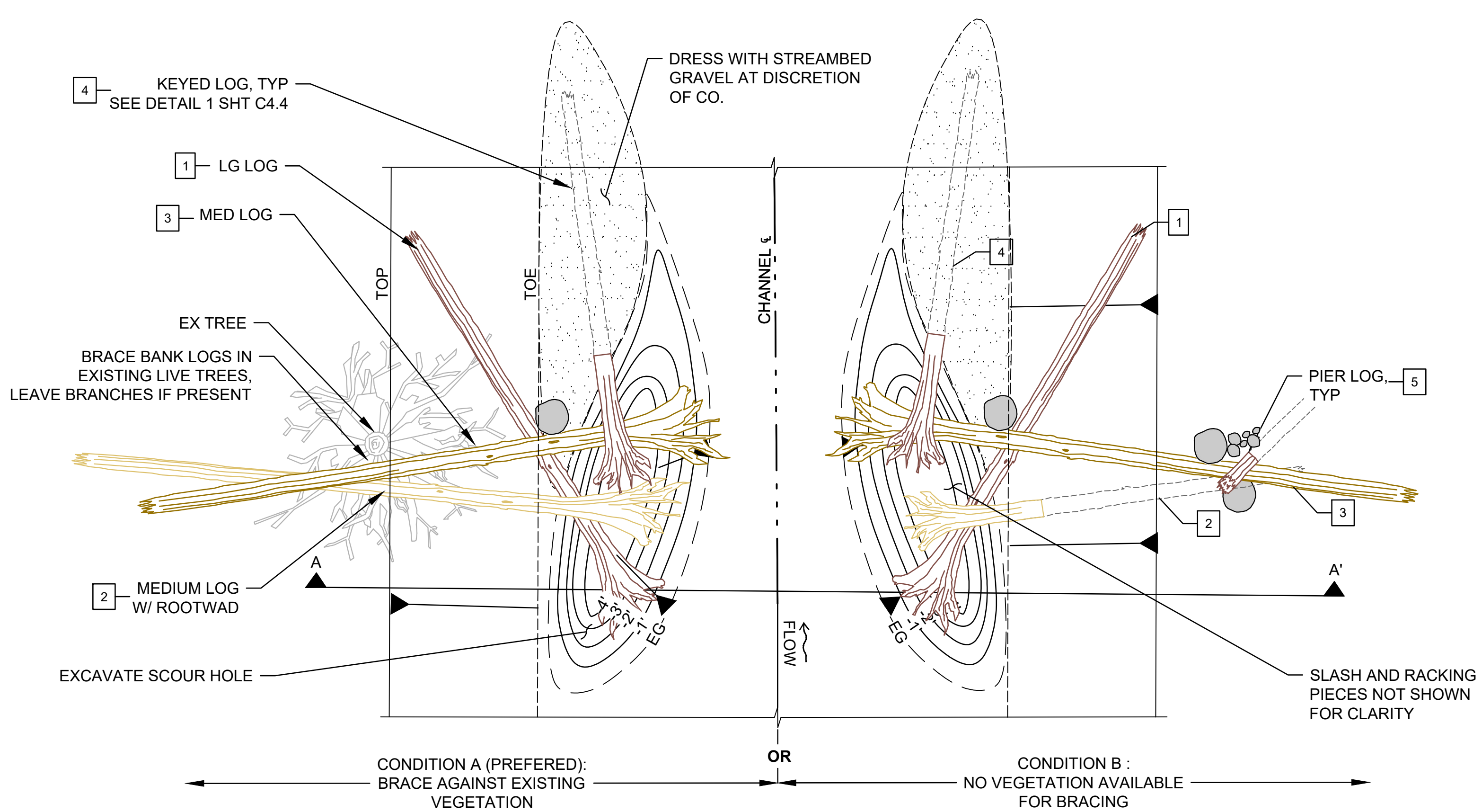
SCALE 0 1"

JOB NO. 20190026

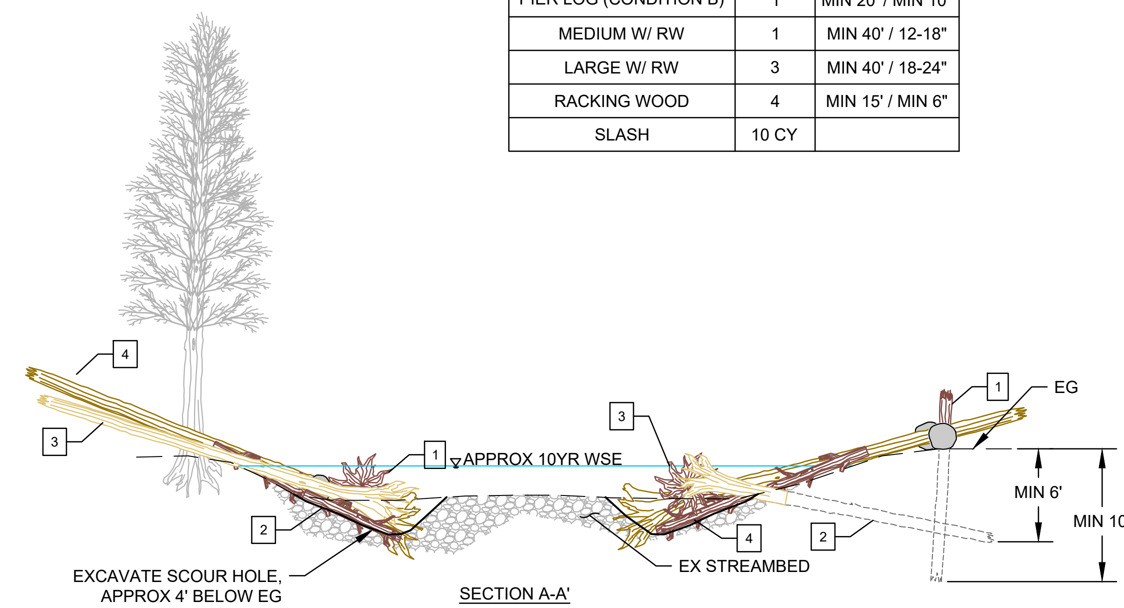
SHEET NO. C4.1

DWG: Z:\Shared\W2r\CAD\20190026-Tucannon\DWG\PHASE 0.5-1 SHEETS\C4.X - HABITAT-WOOD DETAILS.dwg USER: ajones
DATE: Jul 16, 2021 2:08pm XREFS: X-TB-22X34

80% DESIGN
JULY 2021



PLAN



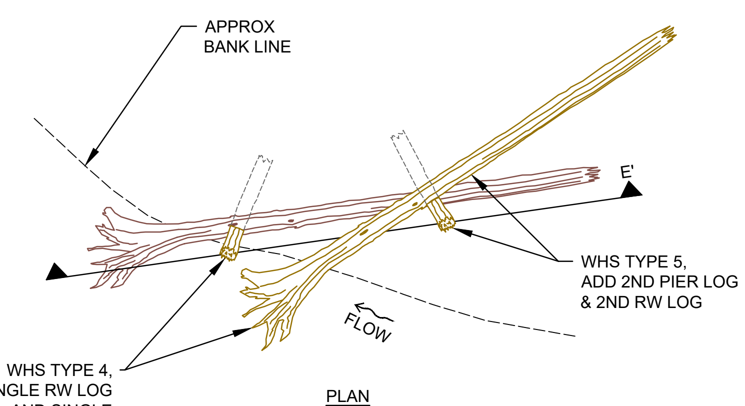
SECTION A-A'

WHS TYPE 3

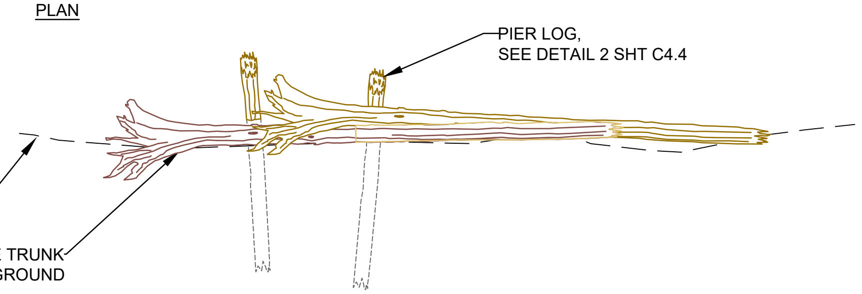
Piece Summary		
Piece	QTY	LENGTH / DBH
PIER LOG (CONDITION B)	1	MIN 20' / MIN 10"
MEDIUM W/ RW	1	MIN 40' / 12-18"
LARGE W/ RW	3	MIN 40' / 18-24"
RACKING WOOD	4	MIN 15' / MIN 6"
SLASH	10 CY	

1 WHS TYPE 3 - MARGIN DEFLECTOR JAM

NOT TO SCALE



PLAN



SECTION E-E'

WHS TYPE 4

Piece Summary		
Piece	QTY	LENGTH / DBH
PIER LOG	1	MIN 20' / MIN 10"
MEDIUM W/ RW	1	MIN 40' / MIN 12-18"

WHS TYPE 5

Piece Summary		
Piece	QTY	LENGTH / DBH
PIER LOG	2	MIN 20' / MIN 10"
MEDIUM W/ RW	2	MIN 40' / MIN 12-18"

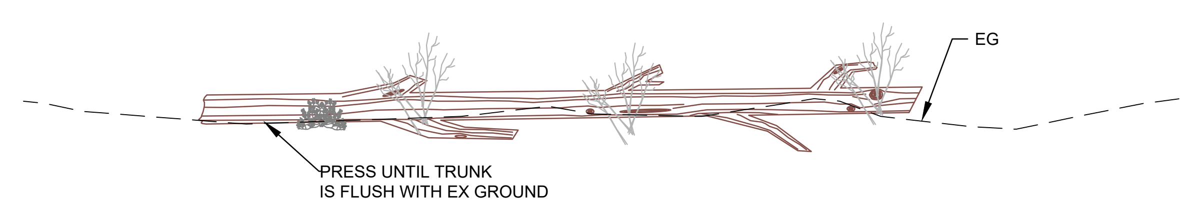
2 WHS TYPE 4 & 5 - FLOODPLAIN WOOD

NOT TO SCALE

LOG INSTALLATION NOTES:

1. NATIVE STREAMBED BACKFILL SHALL BE PLACED IN 12" LIFTS AND COMPACTED TO FIRM UNYIELDING CONDITION.
2. CONTRACTOR TO COORDINATE LOG PLACEMENT WITH ENGINEER PRIOR TO CONSTRUCTION. ENGINEER SHALL APPROVE PLACEMENT BEFORE COMPLETION.
3. WHERE POSSIBLE, LOGS PROTRUDING FROM BANK SHALL BE PLACED CANTILEVERED BETWEEN EXISTING LIVE TREES. THE SUPPORTING TREE NEAREST TO THE BANK SHALL BE ON THE DOWNSTREAM SIDE OF THE LOGS.
4. EMBEDDED LOGS SHALL BE INSTALLED BY EXCAVATING A TRENCH, PLACING THE LOG, BACKFILLING, AND MACHINE COMPACTING BACKFILL PER SPECIFICATIONS. WHERE EXCAVATION IS NOT POSSIBLE LOG ENDS SHALL BE TIED INTO NATIVE MATERIAL AND BURIED WITH NATIVE MATERIAL PER SPECIFICATIONS.
5. SALVAGE ADJACENT BOULDERS FOR USE IN STRUCTURE.
6. FOR BURIED KEYED LOGS EMBED A MINIMUM OF ⅔ THE TOTAL LENGTH OF THE LOG. MIN 6' COVER AT STEM TIP (MEASURED FROM EG).
7. EMBED ROOTWAD AS NEEDED TO ACHIEVE REQUIRED BURIAL DEPTH AND ALLOW FOR FULL CONTACT BETWEEN THE BOTTOM OF THE LOG AND THE BOTTOM OF THE CHANNEL. BACKFILL AROUND ROOTWAD WITH NATIVE STREAMBED MATERIAL.
8. SEE SPECIFICATIONS FOR TREE SPECIES. KEYED LOG DIAMETER MEASURED AT BREAST HEIGHT (DBH) AND LENGTH AS SHOWN ON PLANS.
9. CRUSH ALL EXPOSED SAW-CUT FACES.

# DENOTES PLACEMENT ORDER



SECTION

WHS TYPE 6

Piece Summary		
Piece	QTY	LENGTH / DBH
SMALL W/ OR W/O RW	1	MIN 25' / MIN 8-12"

3 WHS TYPE 6 - HABITAT WOOD

NOT TO SCALE

AMANDA JONES, STATE OF WASHINGTON, 21008109, REGISTERED PROFESSIONAL ENGINEER

RENEWS: 08/28/2021

WOLF WATER RESOURCES, INC.
1001 SE WATER AVE, SUITE #180
PORTLAND, OR 97214
503.207.6688

CONFEDERATED TRIBES OF THE UMATILLA INDIAN RESERVATION
46411 Timine Way
Pendleton, OR 97801
541.429.7010

CTUIR
TUCANNON RIVER
PROJECT AREA 27/28
PHASE 0.5 - 1
COLUMBIA COUNTY, WA

WHS DETAILS 2

REVISION NUMBER

No.	Date	Revision
X	DATE	NOTE

Date 07/2021	Designed By AJ
Drawn By RW, AJ	Checked By MW, AJ

SCALE 0 1"

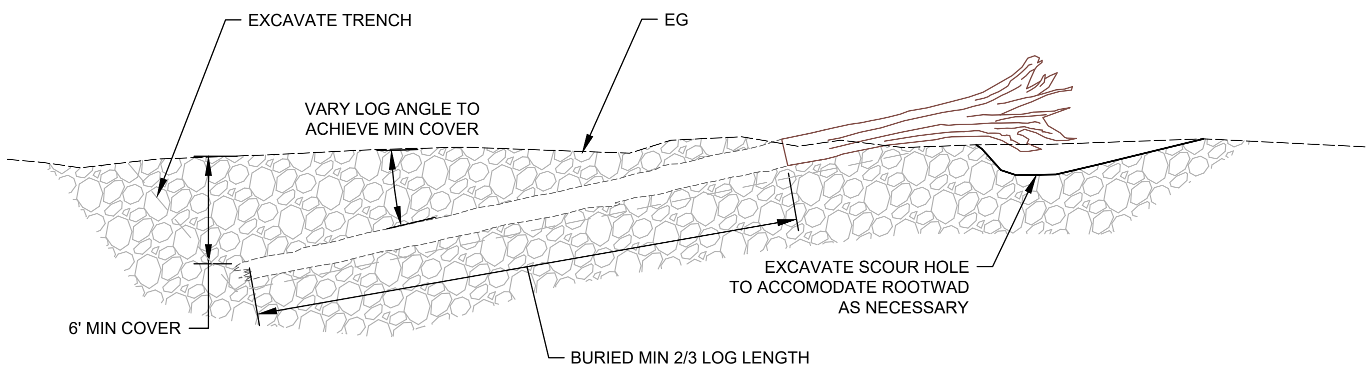
JOB NO. 20190026

SHEET NO. C4.2

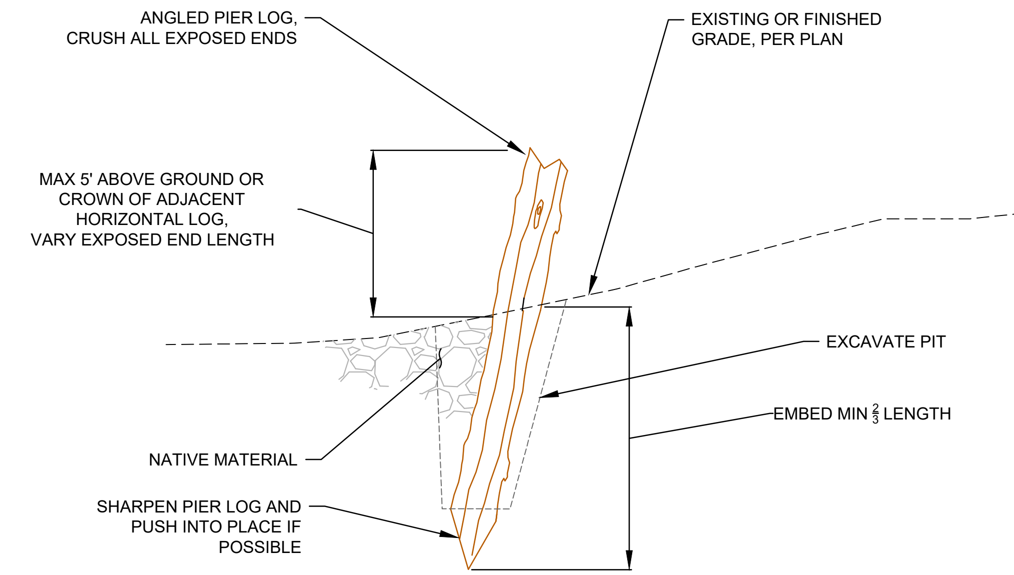
12 OF 17

DWG: Z:\Shared\W2r\CAD\20190024-Tucannon\DWG\PHASE 0.5-1 SHEETS\C4.X - HABITAT-WOOD DETAILS.dwg USER: ajones
DATE: Jul 16, 2021 2:09pm XREFS: X-TB-22X34

80% DESIGN
JULY 2021



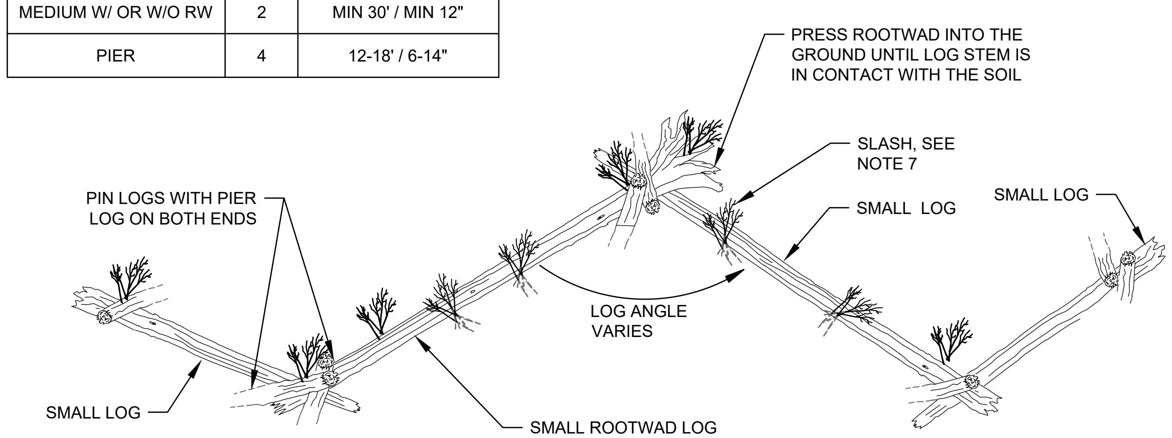
1 SINGLE KEYED LOG
NOT TO SCALE



2 PIER LOG
NOT TO SCALE

WHS TYPE 6A

Piece Summary		
Piece	QTY	LENGTH / DBH
SMALL W/ OR W/O RW	2	MIN 25' / MIN 8-12"
MEDIUM W/ OR W/O RW	2	MIN 30' / MIN 12"
PIER	4	12-18' / 6-14"



3 WHS TYPE 6A - PINNED HABITAT WOOD
NOT TO SCALE

LOG INSTALLATION NOTES:

1. SELECT NATIVE BACKFILL SHALL BE PLACED IN 12" LIFTS AND COMPACTED TO FIRM UNYIELDING CONDITION.
2. CONTRACTOR TO COORDINATE LOG PLACEMENT WITH ENGINEER PRIOR TO CONSTRUCTION. ENGINEER SHALL APPROVE PLACEMENT BEFORE COMPLETION.
3. WHERE POSSIBLE, LOGS PROTRUDING FROM BANK SHALL BE PLACED CANTILEVERED BETWEEN EXISTING LIVE TREES. THE SUPPORTING TREE NEAREST TO THE BANK SHALL BE ON THE DOWNSTREAM SIDE OF THE LOGS.
4. EMBEDDED LOGS SHALL BE INSTALLED BY EXCAVATING A TRENCH, PLACING THE LOG, BACKFILLING, AND MACHINE COMPACTING BACKFILL PER SPECIFICATIONS. WHERE EXCAVATION IS NOT POSSIBLE LOG ENDS SHALL BE TIED INTO NATIVE MATERIAL AND BURIED WITH NATIVE MATERIAL PER SPECIFICATIONS.
5. FOR BURIED KEYED LOGS EMBED A MINIMUM OF ⅔ THE TOTAL LENGTH OF THE LOG.
6. EMBED ROOTWAD AS NEEDED TO ACHIEVE REQUIRED BURIAL DEPTH AND ALLOW FOR FULL CONTACT BETWEEN THE BOTTOM OF THE LOG AND THE BOTTOM OF THE CHANNEL. BACKFILL AROUND ROOTWAD WITH SELECT NATIVE BACKFILL.
7. WEDGE SLASH AND SMALL WOODY DEBRIS BELOW LOGS IN NATURALLY VARYING MANNER, PER FIELD DIRECTION OF ENGINEER.
8. SEE SPECIFICATIONS FOR TREE SPECIES. KEYED LOG DIAMETER MEASURED AT BREAST HEIGHT (DBH) AND LENGTH AS SHOWN ON PLANS.
9. CRUSH ALL EXPOSED SAW-CUT FACES.

AMANDA JONES STATE OF WASHINGTON 21008109 REGISTERED PROFESSIONAL ENGINEER
RENEWS: 08/28/2021

WOLF WATER RESOURCES, INC.
1001 SE WATER AVE, SUITE #180
PORTLAND, OR 97214
503.207.6688

CONFEDERATED TRIBES OF THE UMATILLA INDIAN RESERVATION
46411 Tl'mine Way
Pendleton, OR 97801
541.429.7010

CTUIR
TUCANNON RIVER
PROJECT AREA 27/28
PHASE 0.5 - 1
COLUMBIA COUNTY, WA

WHS DETAILS 3

REVISION NUMBER

No.	Date	Revision
X	DATE	NOTE

Date	Designed By
07/2021	AJ
Drawn By	Checked By
RW, AJ	MW, AJ

SCALE 0 1"

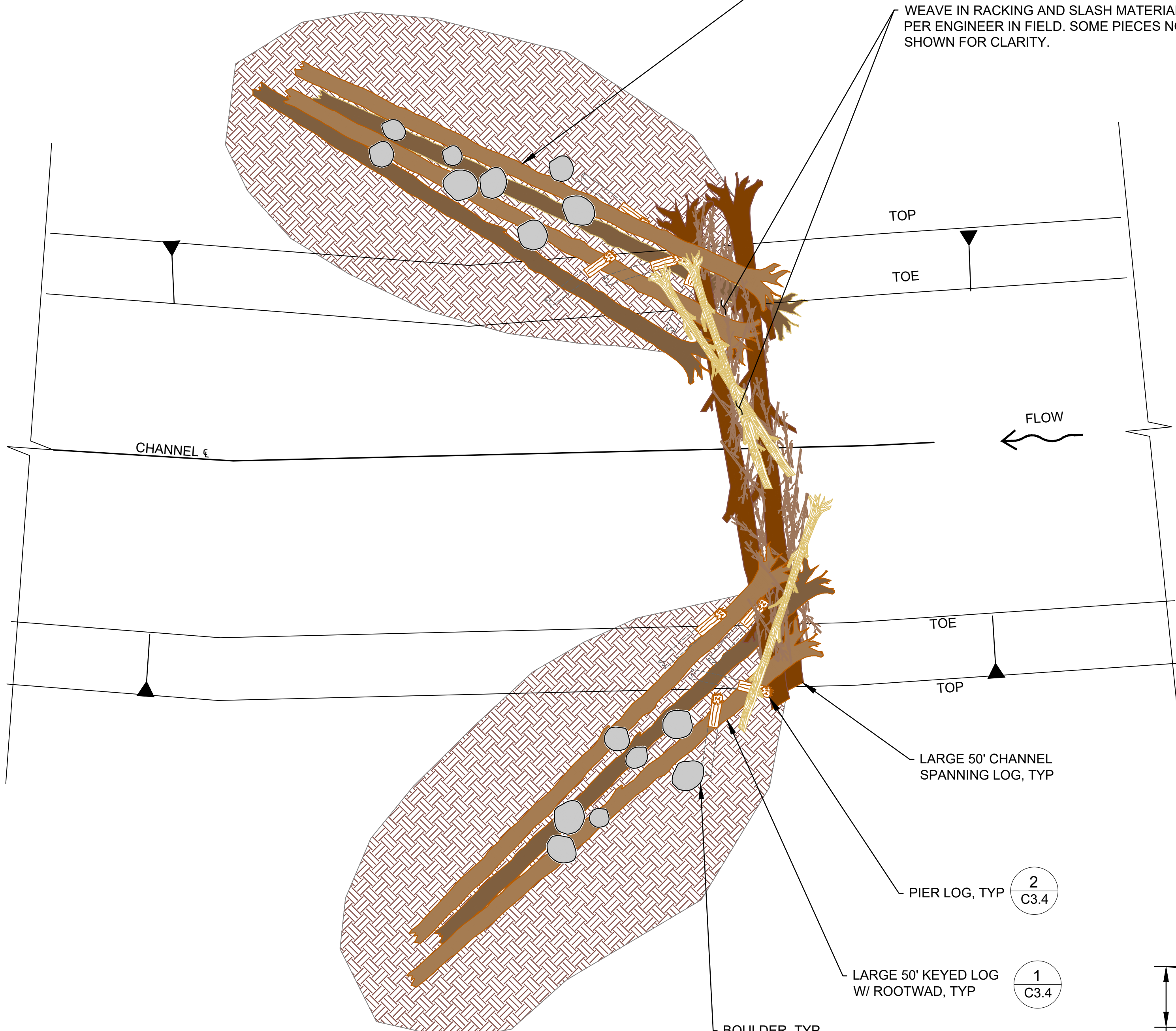
JOB NO. 20190026

SHEET NO. C4.3

13 OF 17

DWG: Z:\Shared\W2\CAD\20190026-Tucannon\DWG\PHASE 0.5-1 SHEETS\C4.X - HABITAT-WOOD DETAILS.dwg USER: ajones
DATE: Jul 16, 2021 2:09pm XREFS: X-TB-22X34

80% DESIGN
JULY 2021



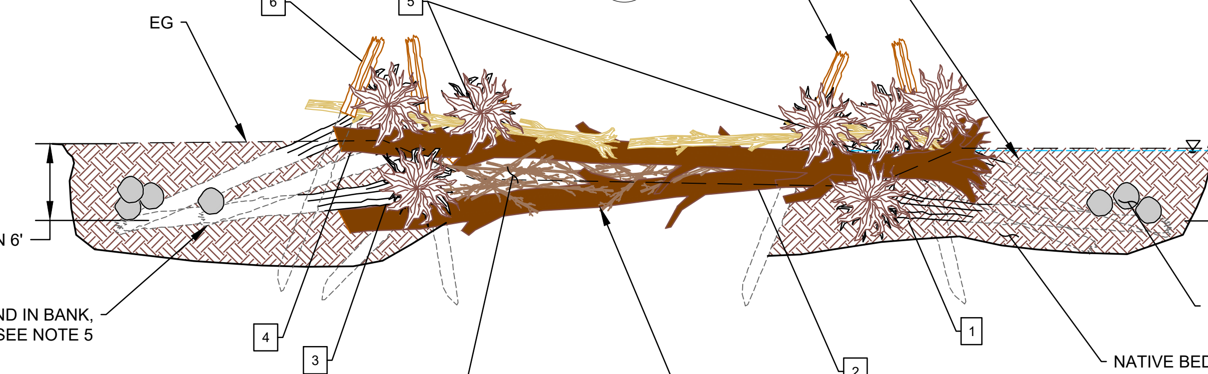
LOG INSTALLATION NOTES:

1. SELECT NATIVE BACKFILL SHALL BE PLACED IN 12" LIFTS AND COMPACTED TO FIRM UNYIELDING CONDITION.
2. CONTRACTOR TO COORDINATE LOG PLACEMENT WITH ENGINEER PRIOR TO CONSTRUCTION. ENGINEER SHALL APPROVE PLACEMENT BEFORE COMPLETION.
3. WHERE POSSIBLE, LOGS PROTRUDING FROM BANK SHALL BE PLACED CANTILEVERED BETWEEN EXISTING LIVE TREES. THE SUPPORTING TREE NEAREST TO THE BANK SHALL BE ON THE DOWNSTREAM SIDE OF THE LOGS.
4. EMBEDDED LOGS SHALL BE INSTALLED BY EXCAVATING A TRENCH, PLACING THE LOG, BACKFILLING, AND MACHINE COMPACTING BACKFILL PER SPECIFICATIONS. WHERE EXCAVATION IS NOT POSSIBLE LOG ENDS SHALL BE TIED INTO NATIVE MATERIAL AND BURIED WITH NATIVE MATERIAL PER SPECIFICATIONS.
5. FOR BURIED KEYED LOGS EMBED TIPS A MINIMUM OF 6 FEET DEEP AND A MINIMUM OF ⅔ THE TOTAL LENGTH OF THE LOG.
6. EMBED ROOTWAD AS NEEDED TO ACHIEVE REQUIRED BURIAL DEPTH AND ALLOW FOR FULL CONTACT BETWEEN THE BOTTOM OF THE LOG AND THE BOTTOM OF THE CHANNEL. BACKFILL AROUND ROOTWAD WITH SELECT NATIVE BACKFILL.
7. SEE SPECIFICATIONS FOR TREE SPECIES. KEYED LOG DIAMETER MEASURED AT BREAST HEIGHT (DBH) AND LENGTH AS SHOWN ON PLANS.
8. CRUSH ALL EXPOSED SAW-CUT FACES.

[#] DENOTES PLACEMENT ORDER

WHS TYPE 7

Piece Summary		
Piece	QTY	LENGTH / DBH
LARGE W/ RW	9	MIN 50' / 18-24"
PIER LOG	8	MIN 18' / MIN 10"
RACKING WOOD	10	VARY / MIN 6"
SLASH	20 CY	-



SECTION A-A'

1 WHS TYPE 7 - CHANNEL SPANNING JAM

NOT TO SCALE

DWG: Z:\Shared\W2r\CAD\20190024-Tucannon\DWG\PHASE 0.5-1 SHEETS\C4.X - HABITAT-WOOD DETAILS.dwg USER: ajones
DATE: Jul 16, 2021 2:45pm XREFS:X-TB-22X34

AMANDA JONES, STATE OF WASHINGTON, 21008109, REGISTERED PROFESSIONAL ENGINEER
RENEWS: 08/28/2021

WOLF WATER RESOURCES, INC.
1001 SE WATER AVE, SUITE #180
PORTLAND, OR 97214
503.207.6688

CONFEDERATED TRIBES OF THE UMATILLA INDIAN RESERVATION
46411 Timine Way
Pendleton, OR 97801
541.429.7010

CTUIR
TUCANNON RIVER
PROJECT AREA 27/28
PHASE 0.5 - 1
COLUMBIA COUNTY, WA

WHS DETAILS 4

REVISION NUMBER

No.	Date	Revision
X	DATE	NOTE

Date	Designed By
07/2021	AJ
Drawn By	Checked By
RW, AJ	MW, AJ

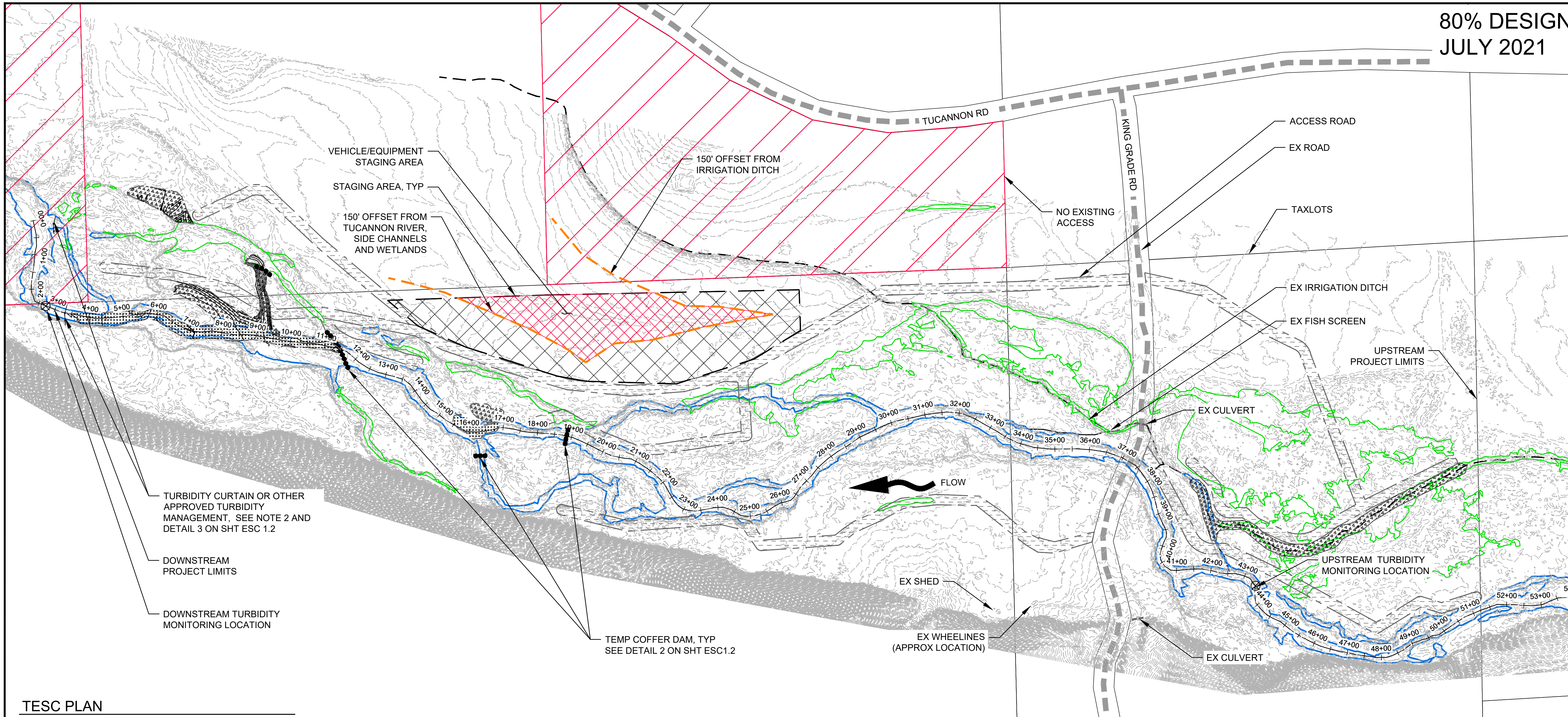
SCALE 0 1"

JOB NO. 20190026

SHEET NO. C4.4

14 OF 17

80% DESIGN
JULY 2021



TESC PLAN

N

SCALE
150 0 75 150 300
SCALE FEET

TEMPORARY EROSION, SEDIMENT, AND POLLUTANT CONTROL (TESC) NOTES

1. EROSION, SEDIMENT AND POLLUTANT CONTROL IS REQUIRED FOR THIS PROJECT. CONTRACTOR SHALL BE RESPONSIBLE FOR IMPLEMENTING ALL TEMPORARY EROSION AND SEDIMENT CONTROL MEASURES.

2. PREPARE A TEMPORARY EROSION AND SEDIMENT CONTROL PLAN (TESC) BEFORE BEGINNING WORK. KEEP A COPY OF THE TESC ON SITE AT ALL TIMES DURING THE PROJECT.

3. PREPARE A SPILL PREVENTION CONTROL AND COUNTERMEASURES (SPCC) PLAN PRIOR TO ANY CONSTRUCTION ACTIVITY, KEEP THIS ON SITE AT ALL TIMES.

6. SELECT BEST MANAGEMENT PRACTICES (BMPs) FROM THE FOLLOWING DOCUMENTS: 1) THE WSDOT TEMPORARY EROSION AND SEDIMENT CONTROL MANUAL (KEEP ON-SITE AT ALL TIMES) 2)THE STANDARD CONSTRUCTION SPECIFICATIONS 3) THE PROJECT SPECIAL PROVISIONS 4) AND VOLUME II OF STORMWATER MANAGEMENT MANUAL FOR EASTERN WASHINGTON.

7. THE TESC FACILITIES SHOWN ON THIS PLAN ARE THE MINIMUM REQUIREMENTS FOR THE ANTICIPATED SITE AND SEASONAL CONDITIONS. UPGRADE THESE FACILITIES TO ADDRESS CHANGING WORK OR WEATHER CONDITIONS.

8. INSTALL, MONITOR, REPLACE AND UPGRADE AS NECESSARY ALL FACILITIES AND MEASURES. PERFORM MAINTENANCE TO ENSURE CONTINUED FUNCTIONING.

9. THE TESC PLAN FACILITIES AND MEASURES MUST BE INSPECTED DAILY BY THE CONTRACTOR AND MAINTAINED AS NECESSARY TO ENSURE THEIR CONTINUED FUNCTION.

10. COMPLETE AN EROSION CONTROL MONITORING FORM AFTER EACH INSPECTION. INCLUDE THE INSPECTION DATE AND TIME. RETAIN THESE COMPLETED FORMS ON SITE AND PROVIDE THEM UPON REQUEST.

11. NO VISIBLE AND MEASURABLE SEDIMENT OR POLLUTANT SHALL EXIT THE SITE, ENTER A PUBLIC RIGHT-OF-WAY OR BE DEPOSITED INTO ANY WATER BODY OR STORM DRAINAGE SYSTEM.

12. FOLLOWING A STORM EVENT, INSPECT AND ADJUST, REPAIR, IMPROVE OR REPLACE ALL DEFICIENT OR FAILING FACILITIES AND MEASURES.

13. PROTECT ALL FUNCTIONING STORM WATER INLETS AND CATCH BASINS FROM RECEIVING UNFILTERED, SEDIMENT-LADEN RUNOFF.

14. THE CONTRACTOR SHALL BE RESPONSIBLE FOR ESTABLISHING AND MAINTAINING A VEHICLE/EQUIPMENT STAGING AREA DESIGNATED FOR ALL REFUELING, EQUIPMENT MAINTENANCE, EQUIPMENT STORAGE AND PARKING. THE VEHICLE/EQUIPMENT STAGING AREA SHALL BE LOCATED OUTSIDE THE 150' OFFSET FROM ANY LIVE WATER OR WETLANDS. CONTRACTOR SHALL INSTALL APPROPRIATE TEMPORARY BMPS TO CONTAIN ANY POTENTIAL POLLUTANTS FROM LEAVING THE VEHICLE/EQUIPMENT STAGING AREA THROUGHOUT THE DURATION OF THE PROJECT.

15. SEED ALL DISTURBED AREAS, INCLUDING ACCESS ROUTES, STAGING AREAS, AND FLOODPLAIN GRADING AREAS PER L1.1 AND OWNER'S REPRESENTATIVE'S APPROVAL.

AMANDA JONES, STATE OF WASHINGTON, 21008109, REGISTERED PROFESSIONAL ENGINEER
RENEWS: 08/28/2021

WOLF WATER RESOURCES, INC.
1001 SE WATER AVE, SUITE #180
PORTLAND, OR 97214
503.207.6688

CONFEDERATED TRIBES OF THE UMATILLA INDIAN RESERVATION
46411 Timine Way
Pendleton, OR 97801
541.429.7010

CTUIR
TUCANNON RIVER
PROJECT AREA 27/28
PHASE 0.5 - 1
COLUMBIA COUNTY, WA

TESC PLAN

REVISION NUMBER

No.	Date	Revision
X	DATE	NOTE

Date	Designed By
07/2021	AJ
Drawn By	Checked By
RW, AJ	MW, AJ

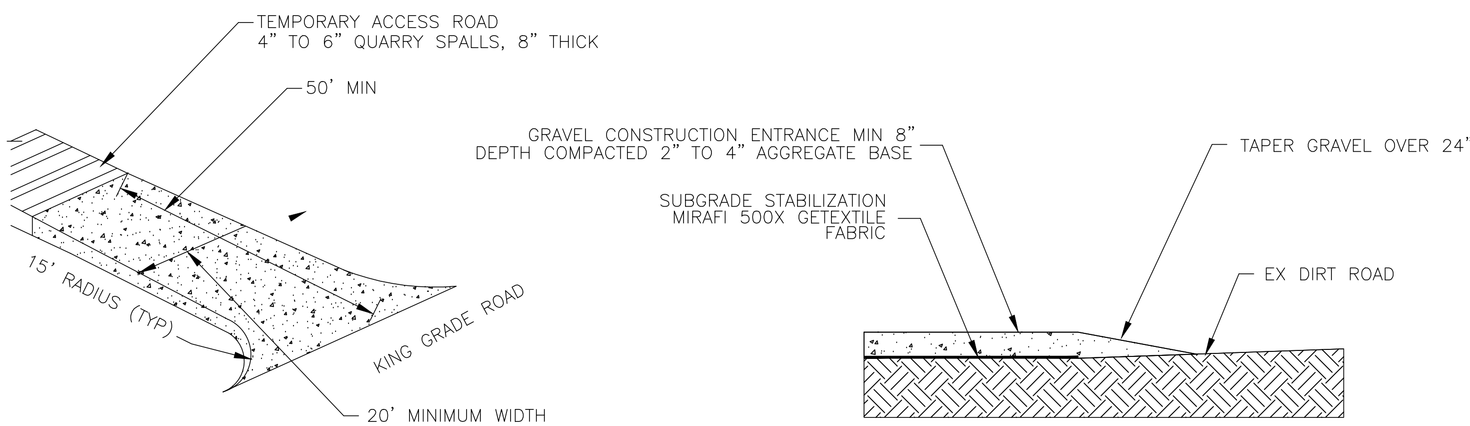
SCALE 0 1"

JOB NO. 20190026

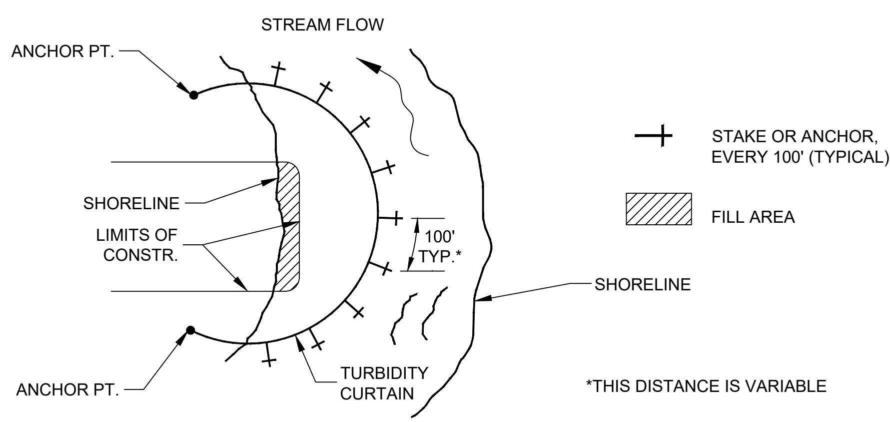
SHEET NO. ESC 1.1

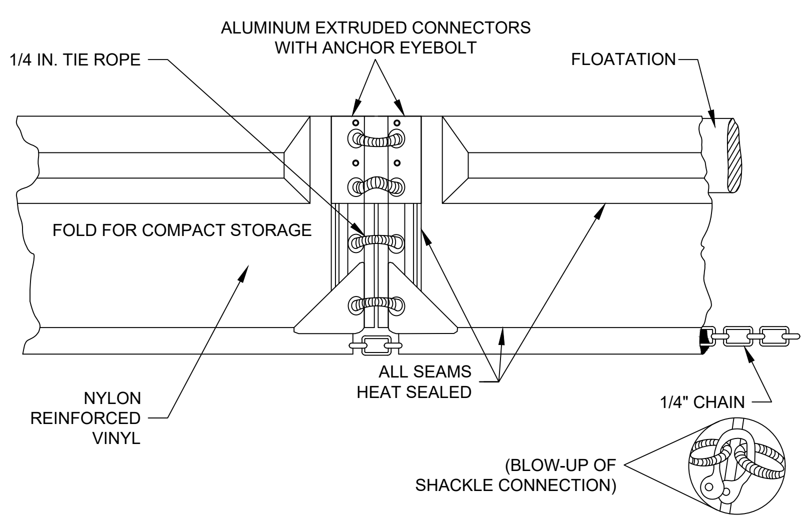
15 OF 17

DWG: Z:\Shared\W2r\CAD\20190026-Tucannon\DWG\PHASE 0.5-1 SHEETS\ESC1.1 - TESC PLAN.dwg USER: ajones
DATE: Jul 16, 2021 2:11pm XREFS:X-DESIGN X-AERIAL_Large X-SURVEY X-WHS X-TB-22X34



1 / -
TEMPORARY CONSTRUCTION ENTRANCE
NOT TO SCALE

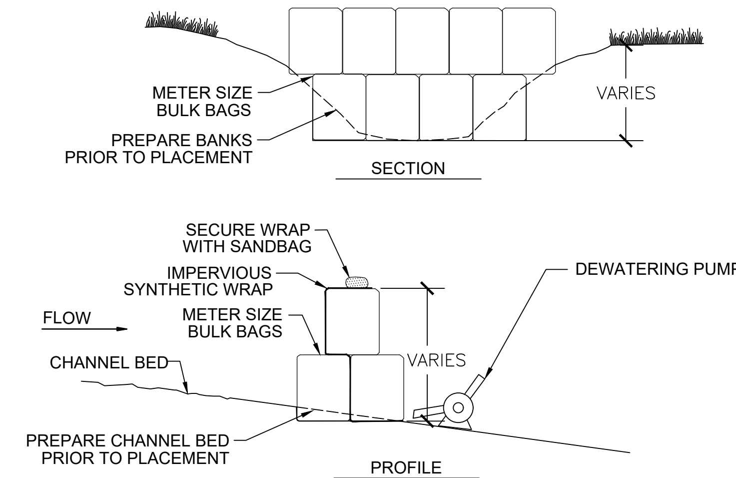


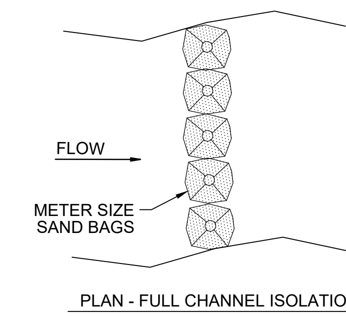


NOTES FOR TURBIDITY CURTAIN:

1. INSTALL TYPE 2 TURBIDITY CURTAIN PER SPECIFICATIONS AND MANUFACTURER INSTRUCTIONS.

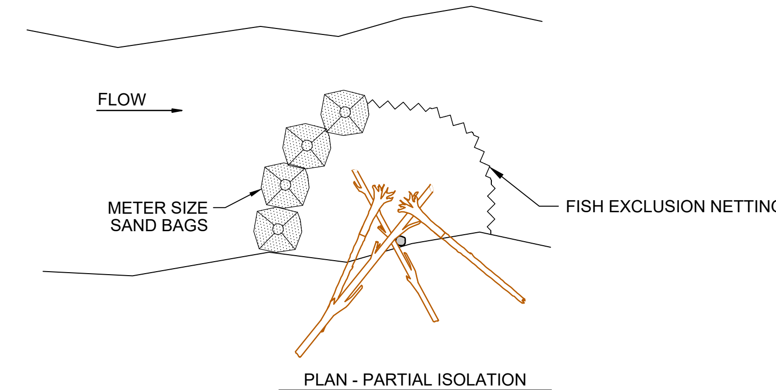
3 / -
TURBIDITY CURTAIN
NOT TO SCALE





NOTE:

1. CONSTRUCTION CREWS SHALL INSTALL BULK BAG COFFER DAMS AS SHOWN ON PLANS OR AS NECESSARY TO ISOLATE THE EXCAVATION AREAS.
2. IN ADDITION TO BULK BAGS, USE AN IMPERVIOUS SYNTHETIC LINER TO REDUCE PERMEABILITY OF BLUK BAG COFFER DAM.
3. HEIGHT OF THE BULK BAG COFFER DAMS SHALL BE HIGH ENOUGH TO PREVENT BYPASS FLOWS FROM ENTERING THE ISOLATED WORK AREA. DAM HEIGHTS AND MATERIALS SHALL BE INCLUDED IN THE CONTRACTOR'S WORK CONTAINMENT AND DEWATERING PLAN.



2 / -
TEMPORARY BULK BAG COFFER DAM
NOT TO SCALE

AMANDA JONES
STATE OF WASHINGTON
21008109
REGISTERED PROFESSIONAL ENGINEER
RENEWS: 08/28/2021

WOLF WATER RESOURCES, INC.
1001 SE WATER AVE, SUITE #180
PORTLAND, OR 97214
503.207.6688

CONFEDERATED TRIBES OF THE
UMATILLA INDIAN RESERVATION
46411 Ti'mine Way
Pendleton, OR 97801
541.429.7010

CTUIR
TUCANNON RIVER
PROJECT AREA 27/28
PHASE 0.5 - 1
COLUMBIA COUNTY, WA

EROSION CONTROL
& TEMP WATER MNGMT DETAILS

REVISION NUMBER

No.	Date	Revision
X	DATE	NOTE

Date	Designed By
07/2021	AJ
Drawn By	**Checked By**
RW, AJ	MW, AJ

SCALE 0 1"

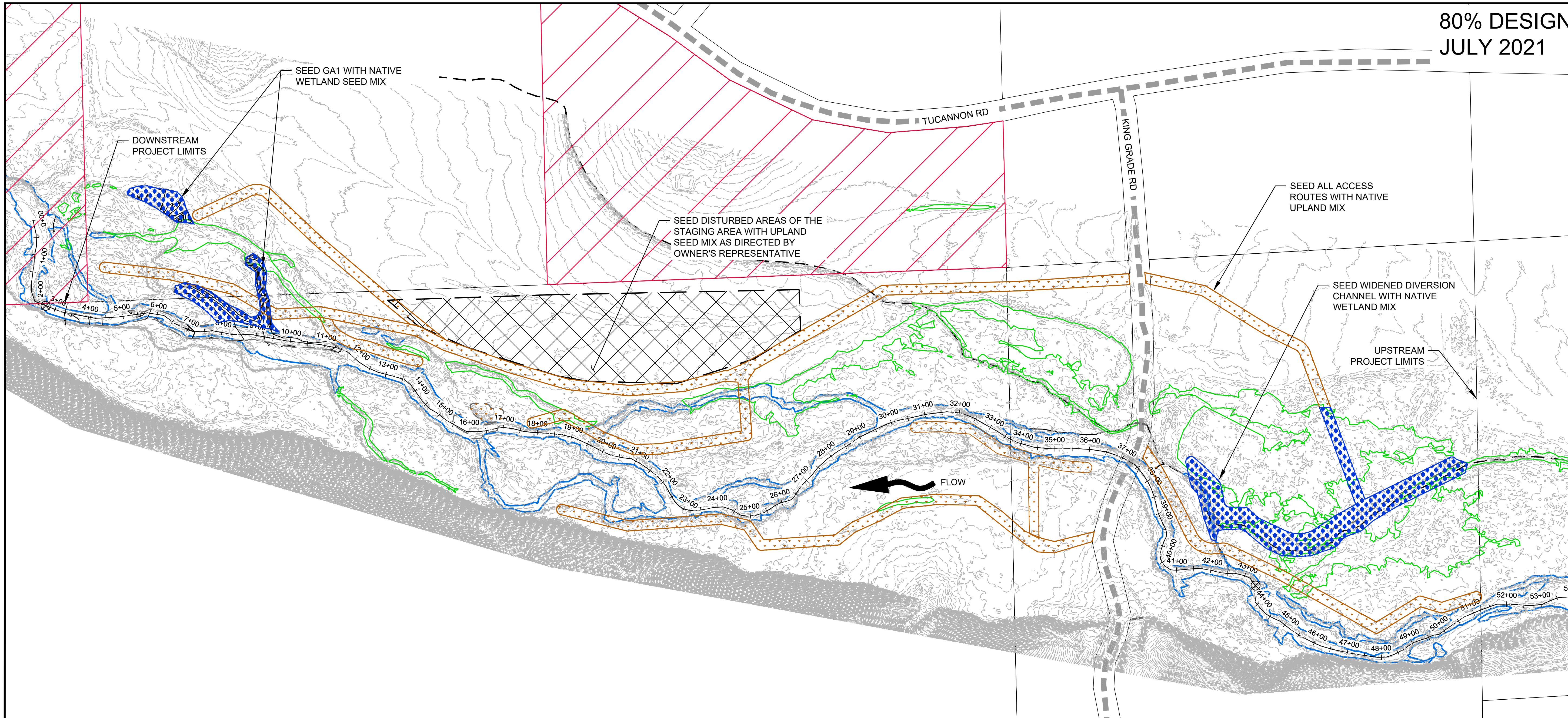
JOB NO. 20190026

SHEET NO. ESC1.2

16 OF 17

DWG: Z:\Shared\W2r\CAD\20190024-Tucannon\DWG\PHASE 0.5-1 SHEETS\ESC1.X - ESC DETAILS.dwg USER: ajones
DATE: Jul 16, 2021 2:11pm XREFS:X-TB-22X34

80% DESIGN
JULY 2021



N

SCALE
150 0 75 150 300
SCALE FEET

SITE RECLAMATION & RESTORATION PLAN

WETLAND SEED MIX	
UPLAND SEED MIX	

TABLE 1: NATIVE WETLAND SEED MIX (3.0 AC)

COMMON NAME	BOTANICAL NAME	COMPOSITION (% OF MIX)
BLUE WILDRYE	*ELYMUS GLAUCUS*	20
TUFTED HAIRGRASS	DESCHAMPSOA CESPITOSA	20
CALIFORNIA BROME	*BROMUS CARINATUS*	10
IDAHO FESCUE	*FESTUCA IDAHOENSIS*	10
TALL MANNAGRASS	*GLYCERIA ELATA*	10
COMMON YARROW	*ACHILIA MILLEFOLIUM*	5

TABLE 2: NATIVE UPLAND SEED MIX (7.0 AC)

COMMON NAME	BOTANICAL NAME	COMPOSITION (% OF MIX)
BLUE WILDRYE	*ELYMUS GLAUCUS*	26
BLUEBUNCH WHEATGRASS	PSEUDOROEGNERIA SPICATA	14
IDAHO FESCUE	*FESTUCA IDAHOENSIS*	18
MOUNTAIN BROME	BROMUS MARGINATUS	18
PRAIRIE JUNEGRASS	KOELERIA MACRANTHA	14

AMANDA JONES
STATE OF WASHINGTON
21008109
REGISTERED PROFESSIONAL ENGINEER
RENEWS: 08/28/2021

WOLF WATER RESOURCES, INC.
1001 SE WATER AVE, SUITE #180
PORTLAND, OR 97214
503.207.6688

CONFEDERATED TRIBES OF THE
UMATILLA INDIAN RESERVATION
46411 Timine Way
Pendleton, OR 97801
541.429.7010

CTUIR
TUCANNON RIVER
PROJECT AREA 27/28
PHASE 0.5 - 1
COLUMBIA COUNTY, WA

SEEDING PLAN

REVISION NUMBER

No.	Date	Revision
X	DATE	NOTE

Date 07/2021 | Designed By AJ
Drawn By RW, AJ | Checked By MW, AJ

SCALE 0 1"

JOB NO. 20190026

SHEET NO. L1.1

17 OF 17

DWG: Z:\Shared\W2r\CAD\20190026-Tucannon\DWG\PHASE 0.5-1 SHEETS\L1.1 - REVEG.dwg USER: ajones
DATE: Jul 16, 2021 2:13pm XREFS:X-DESIGN X-AERIAL_Large X-SURVEY X-WHS X-TB-22X34

Document Path: Z:\Shared\W2r\GIS\GIS Projects\2019\20190026 - Tucannon River\maps\Additional Modeling Maps\Depth_WinterBase_EX.mxd

N

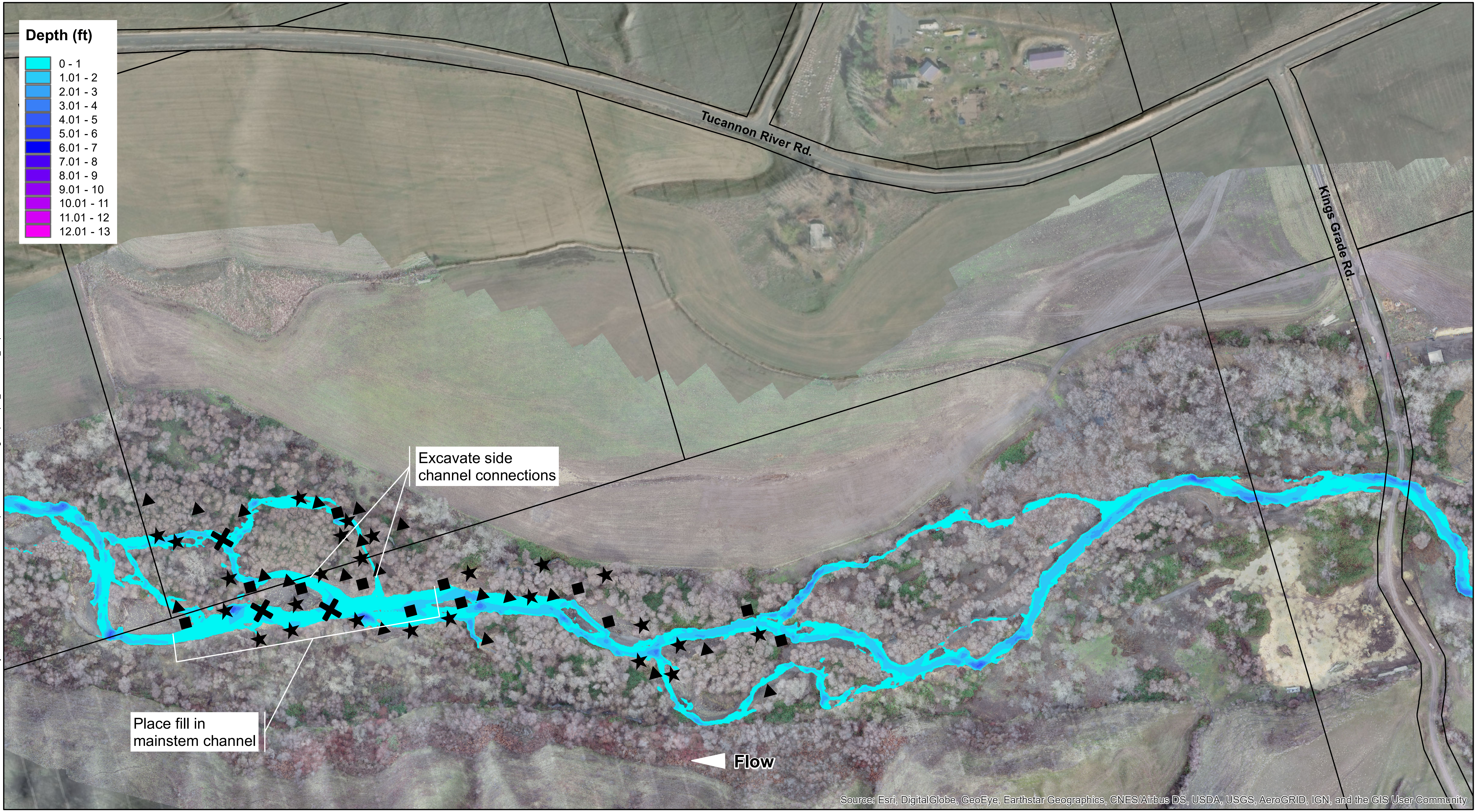
0 125 250 500 Feet

Columbia County Taxlots (2019)

Tucannon River PA 27/28

Depth Modeling Results - Existing

Winter Base Flow (~100 cfs)



Document Path: Z:\Shared\W2r\GIS\GIS Projects\2019\20190026 - Tucannon River\maps\Additional Modeling Maps\Depth_WinterBase_Proposed.mxd

N

0 125 250 500 Feet

Channel Spanner

Apex Jam

Margin Jam

Habitat Log & Floodplain Wood

Columbia County Taxlots (2019)

Tucannon River PA 27/28

Depth Modeling Results - Proposed

Winter Base Flow (~100 cfs)

Document Path: Z:\Shared\W2r\GIS\GIS Projects\2019\20190026 - Tucannon River\maps\Additional Modeling Maps\Depth_2yr_EX.mxd

N

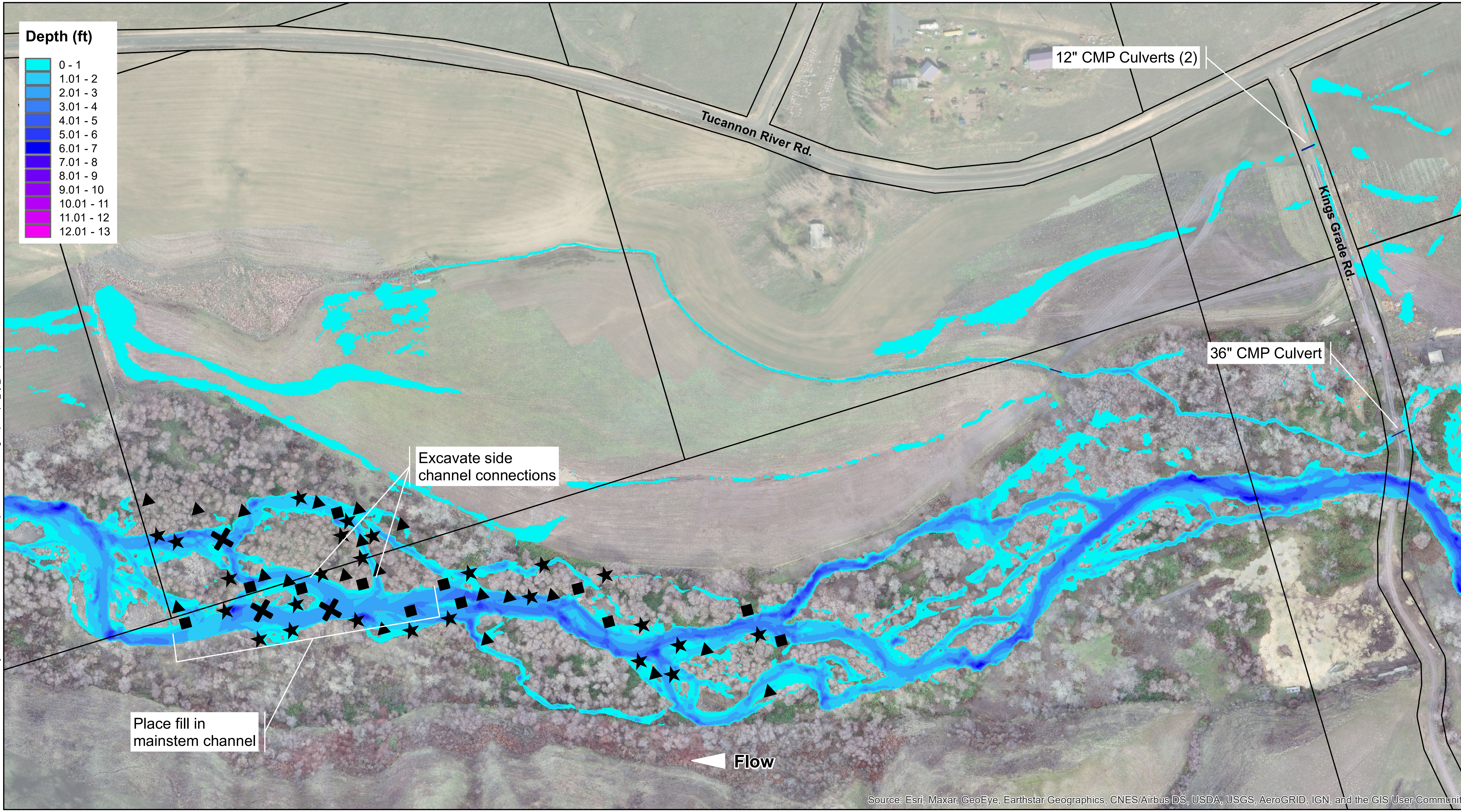
0 125 250 500 Feet

Columbia County Taxlots (2019)

Tucannon River PA 27/28

Depth Modeling Results - Existing

Q2 (~790 cfs)



N

0 125 250 500 Feet

Channel Spanner

Apex Jam

Margin Jam

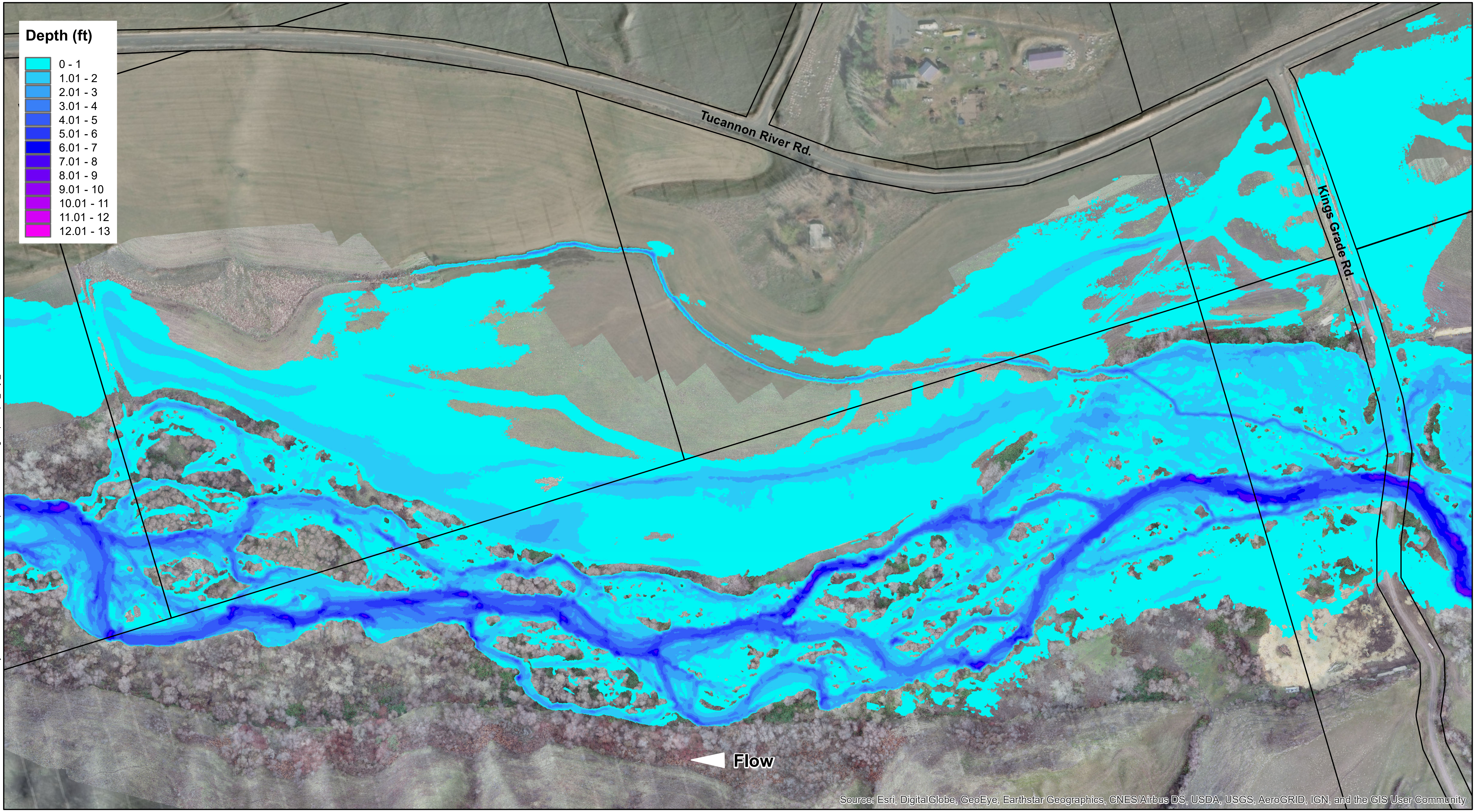
Habitat Log & Floodplain Wood

Columbia County Taxlots (2019)

Tucannon River PA 27/28

Depth Modeling Results - Proposed

Q2 (~790 cfs)



Document Path: Z:\Shared\W2r\GIS\GIS Projects\2019\20190026 - Tucannon River\maps\Additional Modeling Maps\Depth_10yr_EX.mxd

N

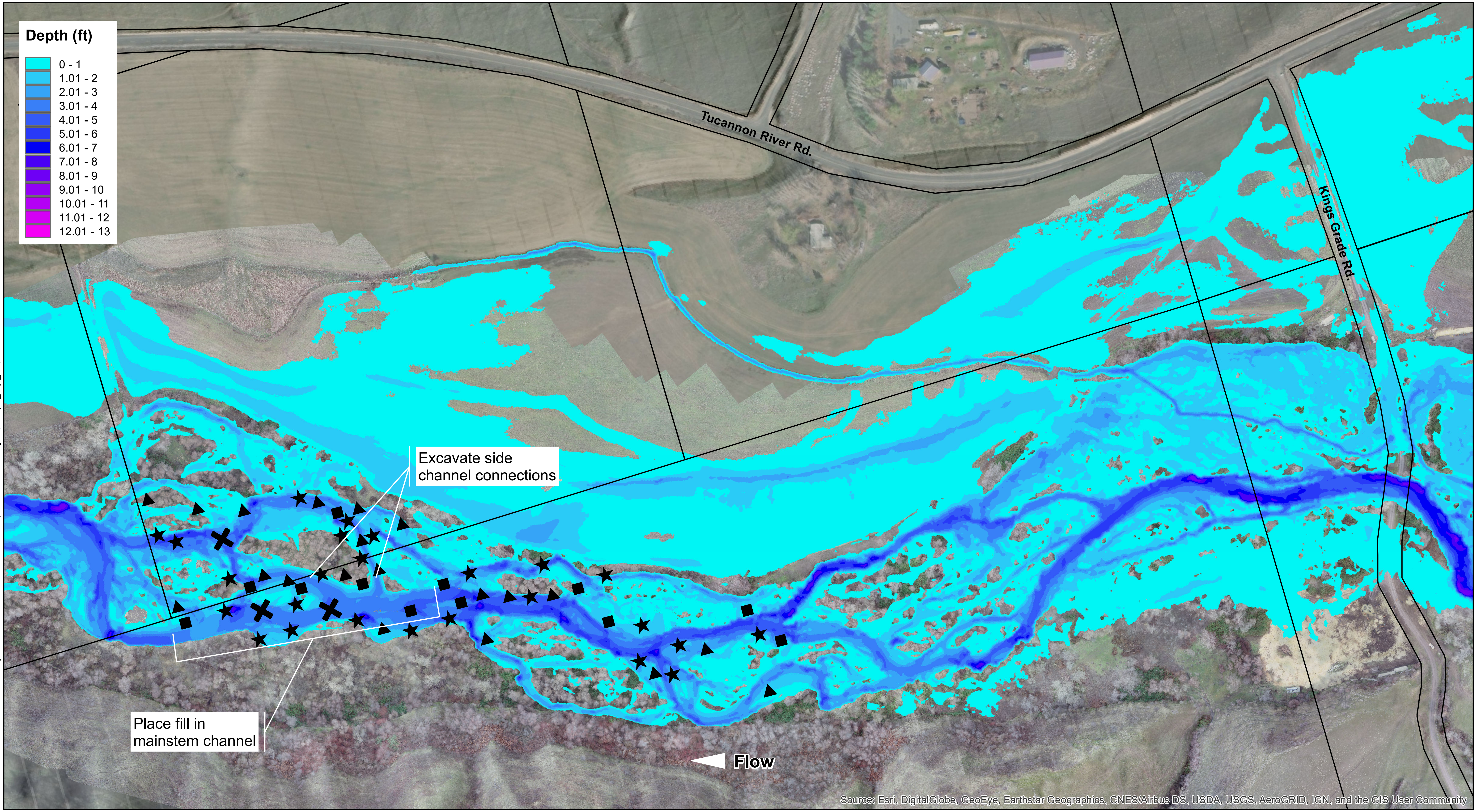
0 125 250 500 Feet

Columbia County Taxlots (2019)

Tucannon River PA 27/28

Depth Modeling Results - Existing

Q10 (~2440 cfs)



Document Path: Z:\Shared\W2r\GIS\GIS Projects\2019\20190026 - Tucannon River\maps\Additional Modeling Maps\Depth_10yr_Proposed.mxd

N

0 125 250 500 Feet

Channel Spanner

Apex Jam

Margin Jam

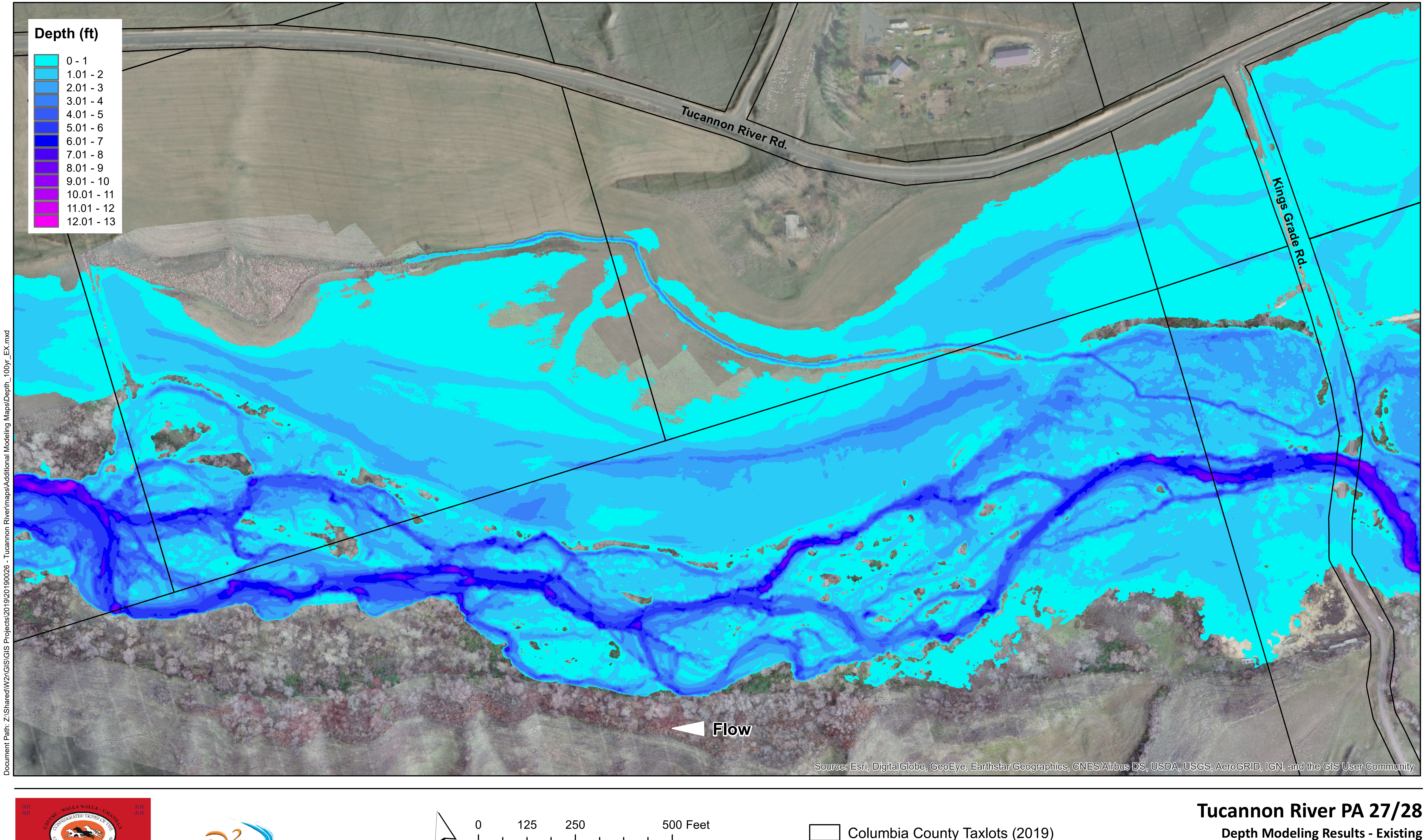
Habitat Log & Floodplain Wood

Columbia County Taxlots (2019)

Tucannon River PA 27/28

Depth Modeling Results - Proposed

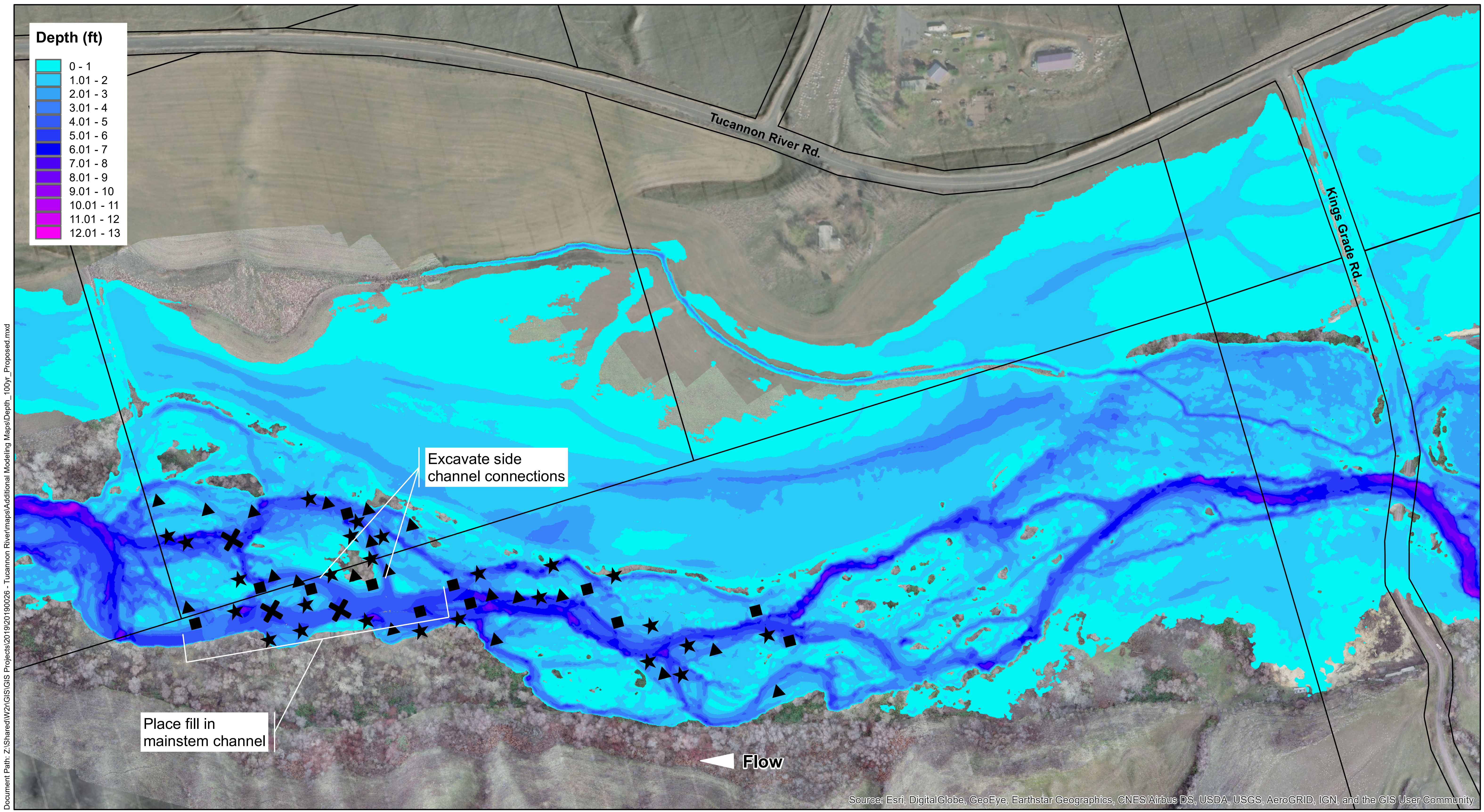
Q10 (~2440 cfs)



Tucannon River PA 27/28

Depth Modeling Results - Existing

Q100 (~5500 cfs)



Tucannon River PA 27/28

Depth Modeling Results - Proposed

Q100 (~5500 cfs)

Document Path: Z:\Shared\W2r\GIS\GIS Projects\2019\20190026 - Tucannon River\maps\Additional Modeling Maps\Velocity_WinterBase_Existing.mxd

N

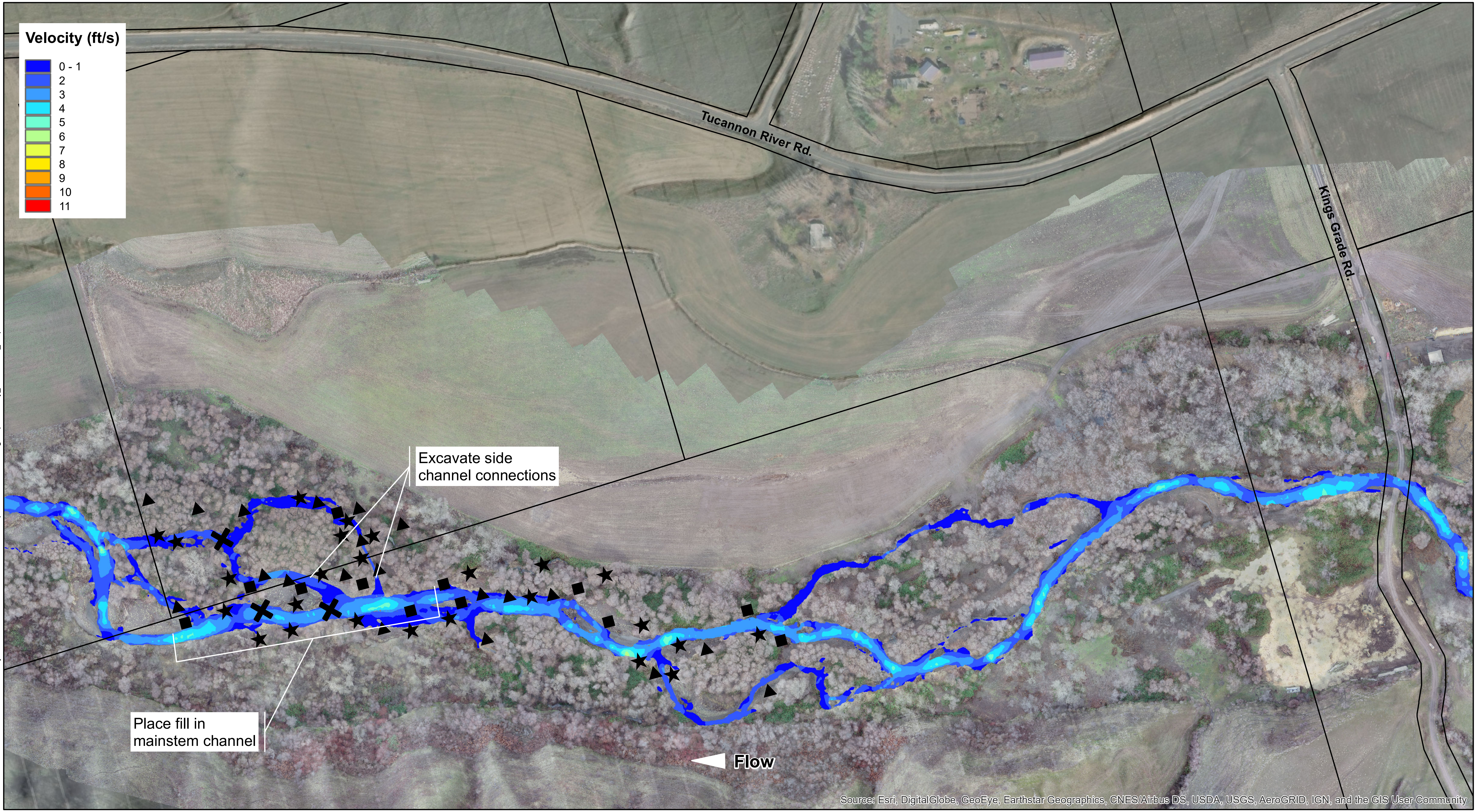
0 125 250 500 Feet

Columbia County Taxlots (2019)

Tucannon River PA 27/28

Velocity Modeling Results - Existing

Winter Base Flow (~100 cfs)



N

0 125 250 500 Feet

Channel Spanner

Apex Jam

Margin Jam

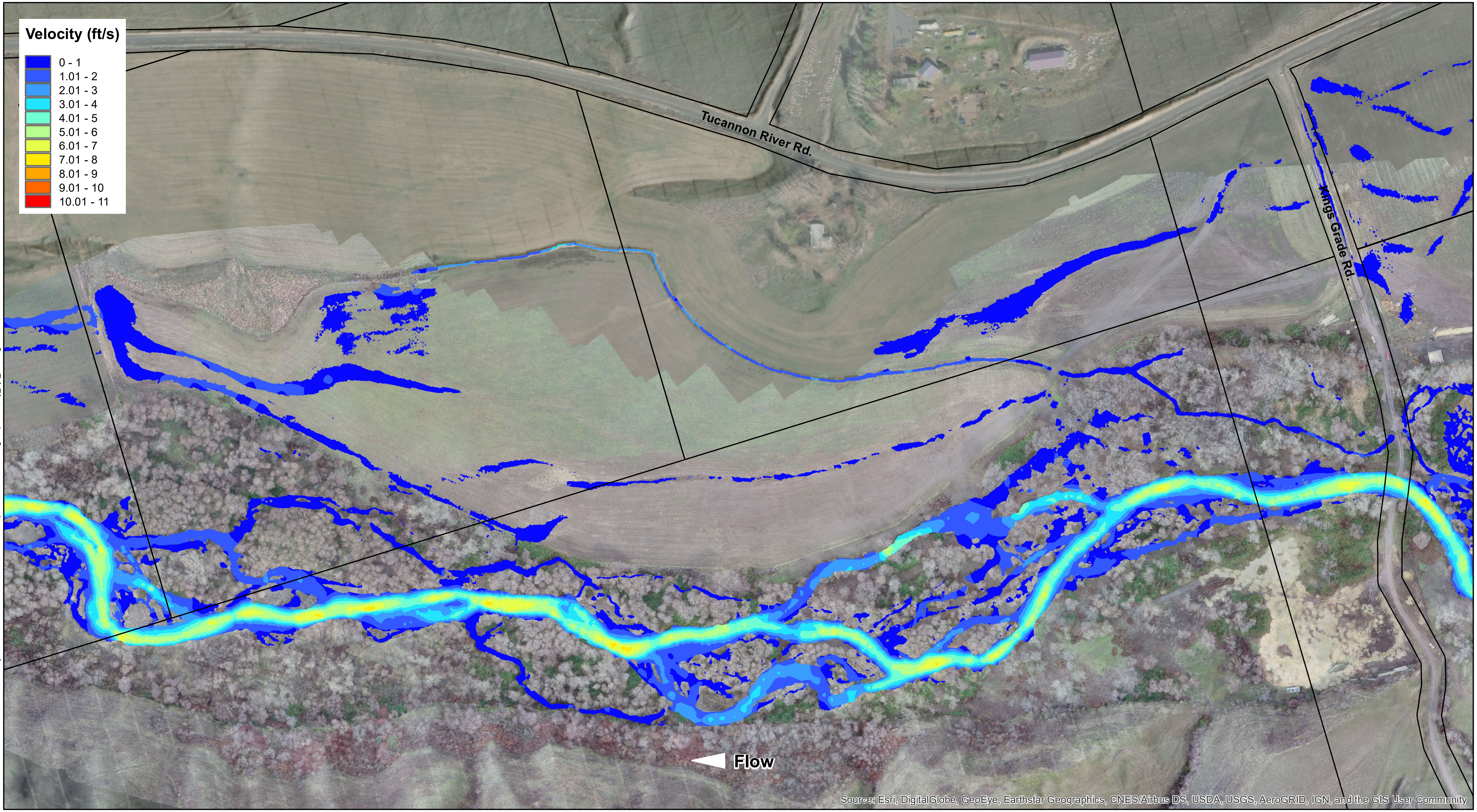
Habitat Log & Floodplain Wood

Columbia County Taxlots (2019)

Tucannon River PA 27/28

Velocity Modeling Results - Proposed

Winter Base Flow (~100 cfs)



N

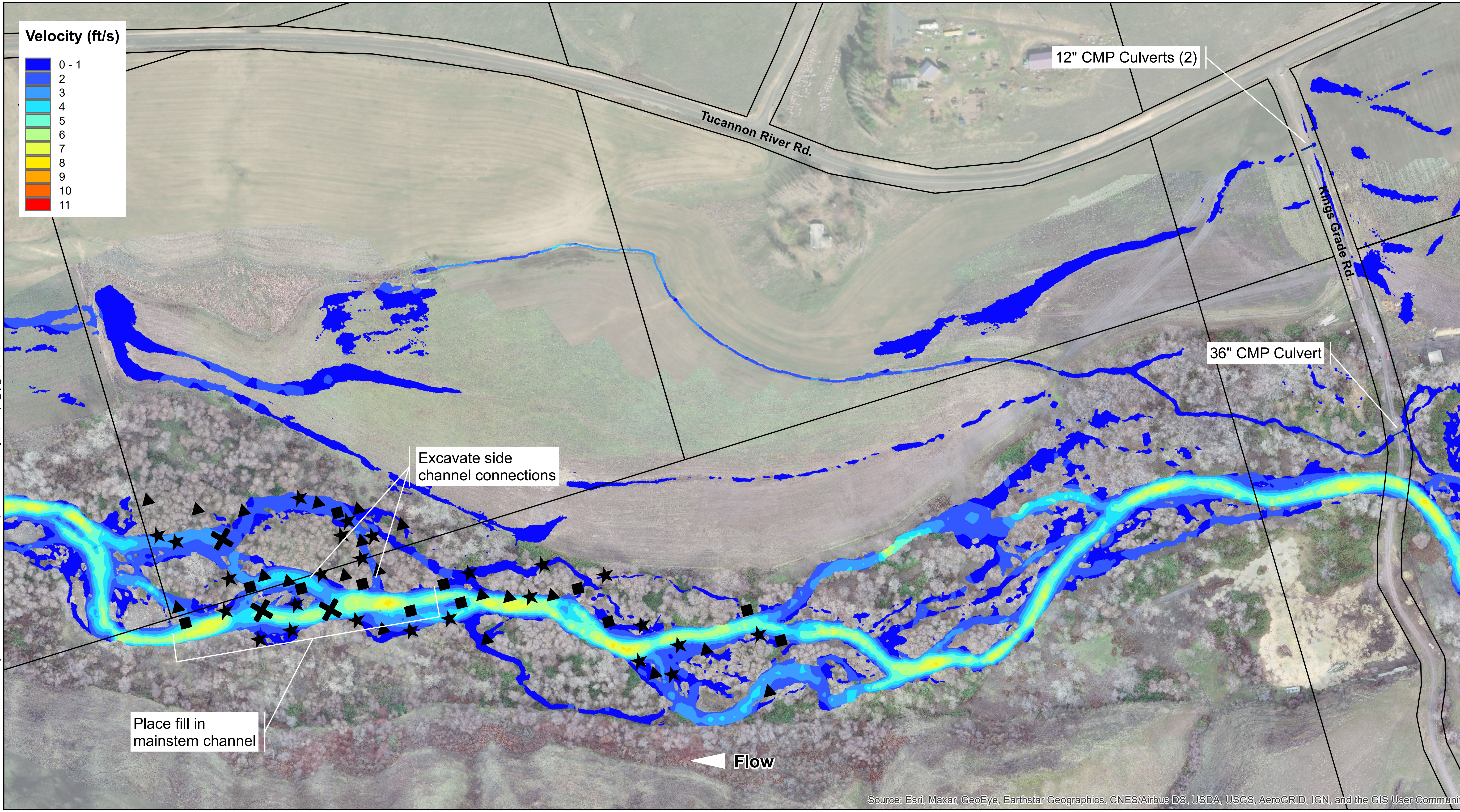
0 125 250 500 Feet

Columbia County Taxlots (2019)

Tucannon River PA 27/28

Velocity Modeling Results - Existing

Q2 (~790 cfs)



Document Path: Z:\Shared\W2r\GIS\GIS Projects\2019\20190026 - Tucannon River\maps\Additional Modeling Maps\Depth_2yr_Proposed.mxd

N

0 125 250 500 Feet

Channel Spanner

Apex Jam

Margin Jam

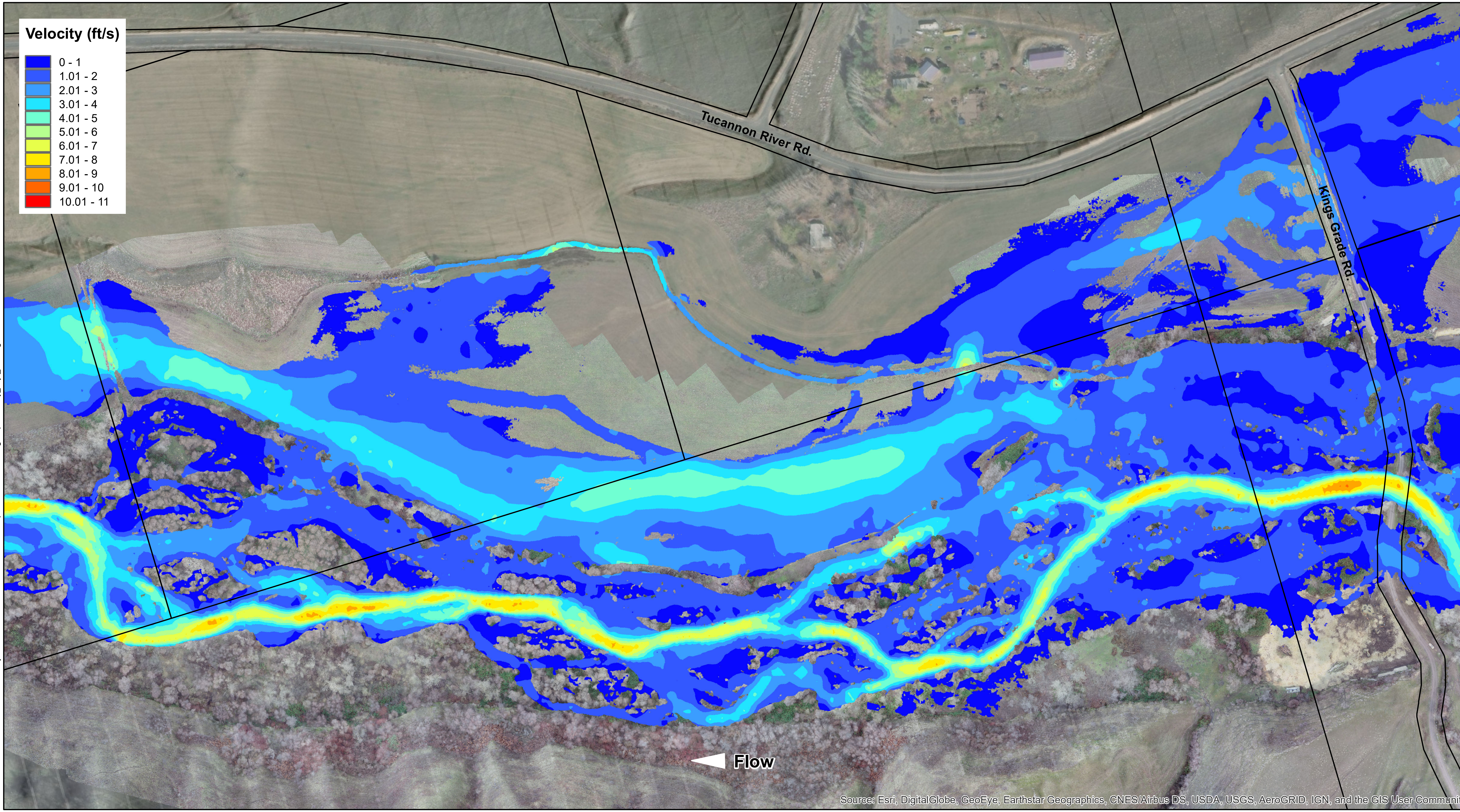
Habitat Log & Floodplain Wood

Columbia County Taxlots (2019)

Tucannon River PA 27/28

Velocity Modeling Results - Proposed

Q2 (~790 cfs)



Document Path: Z:\Shared\W2r\GIS\GIS Projects\2019\20190026 - Tucannon River\maps\Additional Modeling Maps\Velocity_10yr_Existing.mxd

N

0 125 250 500 Feet

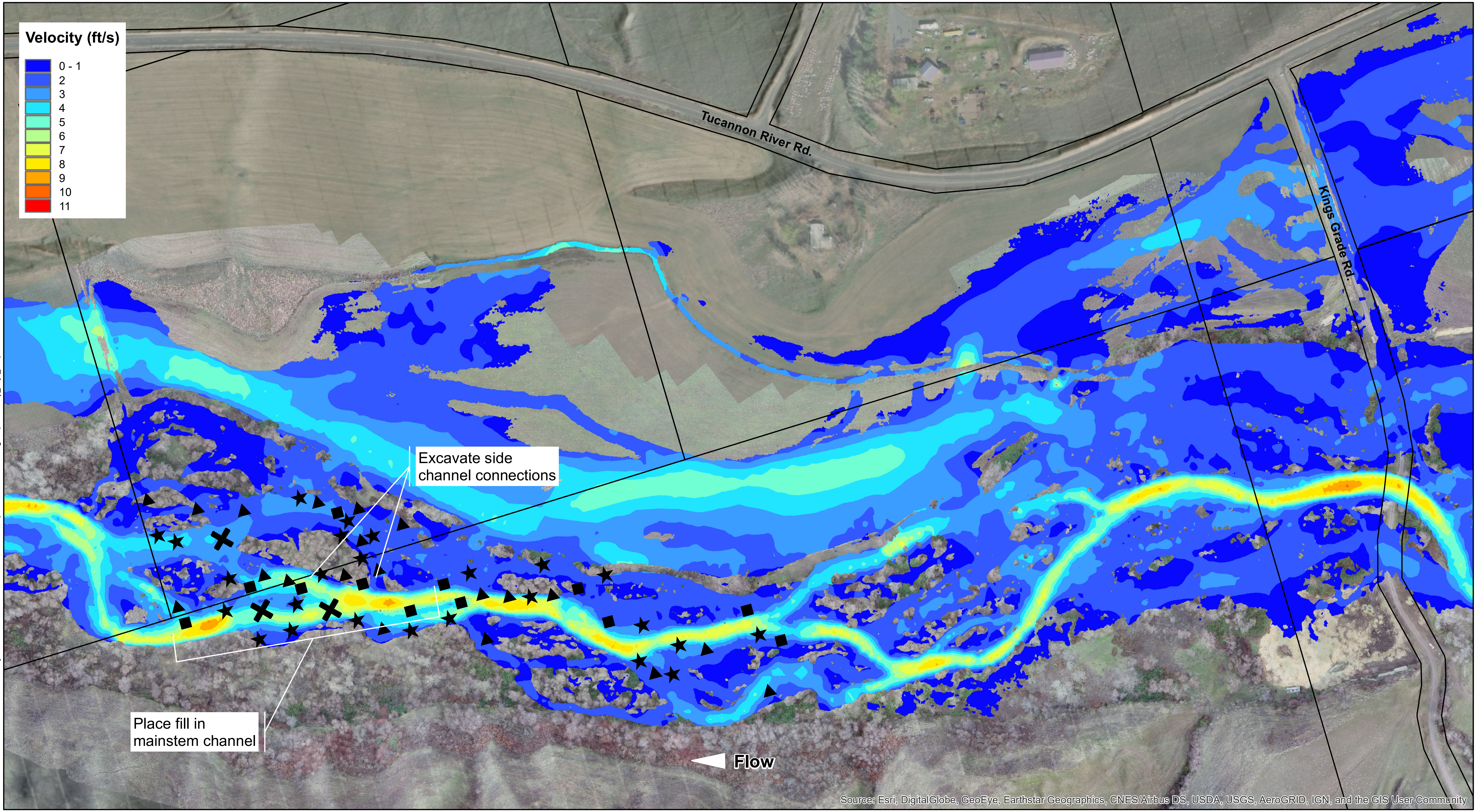
Columbia County Taxlots (2019)

Tucannon River PA 27/28

Velocity Modeling Results - Existing

Q10 (~2440 cfs)

Document Path: Z:\Shared\W2r\GIS\GIS Projects\2019\20190026 - Tucannon River\maps\Additional Modeling Maps\Velocity_10yr_Proposed.mxd



N

0 125 250 500 Feet

Channel Spanner

Apex Jam

Margin Jam

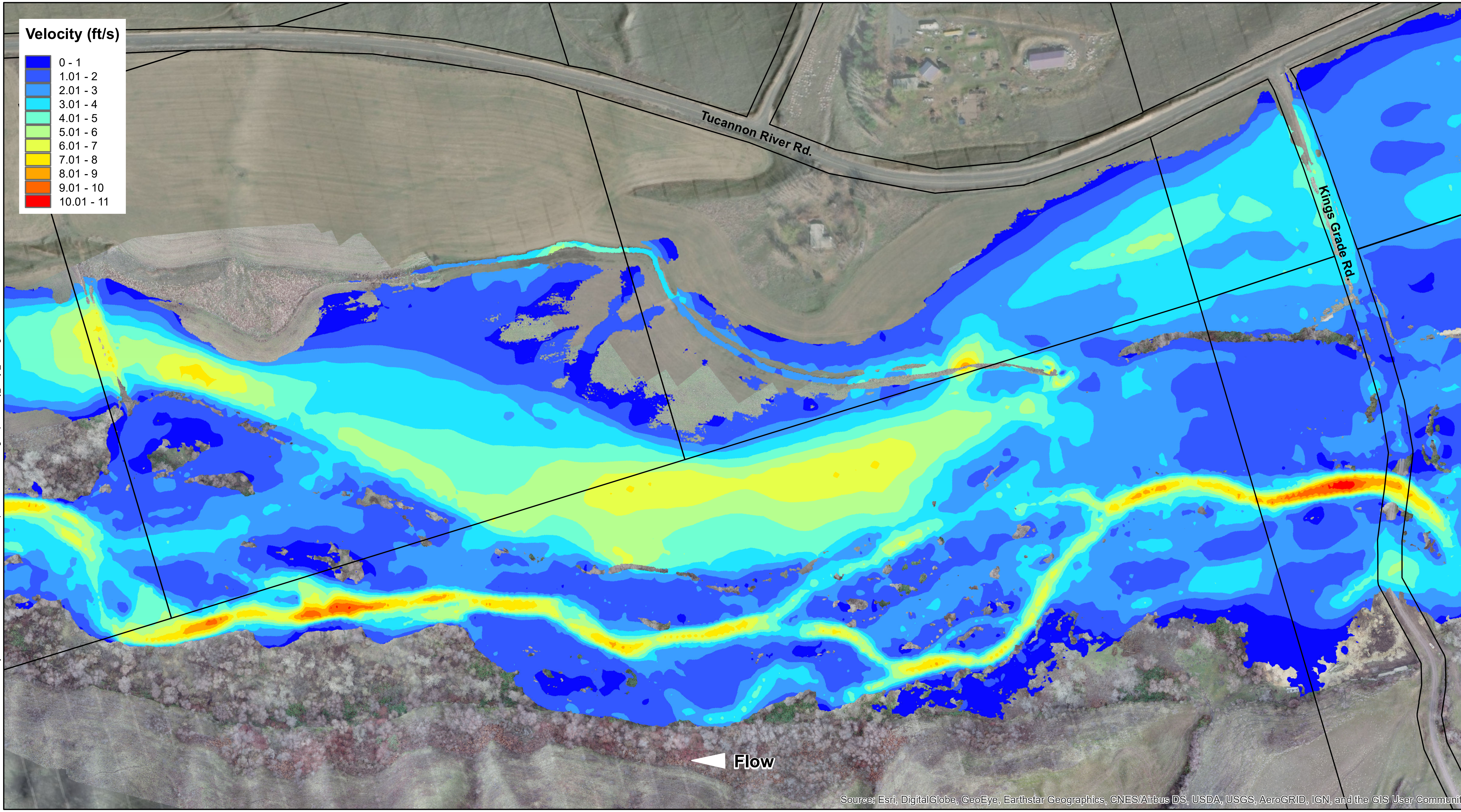
Habitat Log & Floodplain Wood

Columbia County Taxlots (2019)

Tucannon River PA 27/28

Velocity Modeling Results - Proposed

Q10 (~2440 cfs)



Document Path: Z:\Shared\W2r\GIS\GIS Projects\2019\20190026 - Tucannon River\maps\Additional Modeling Maps\Velocity_100yr_Existing.mxd

N

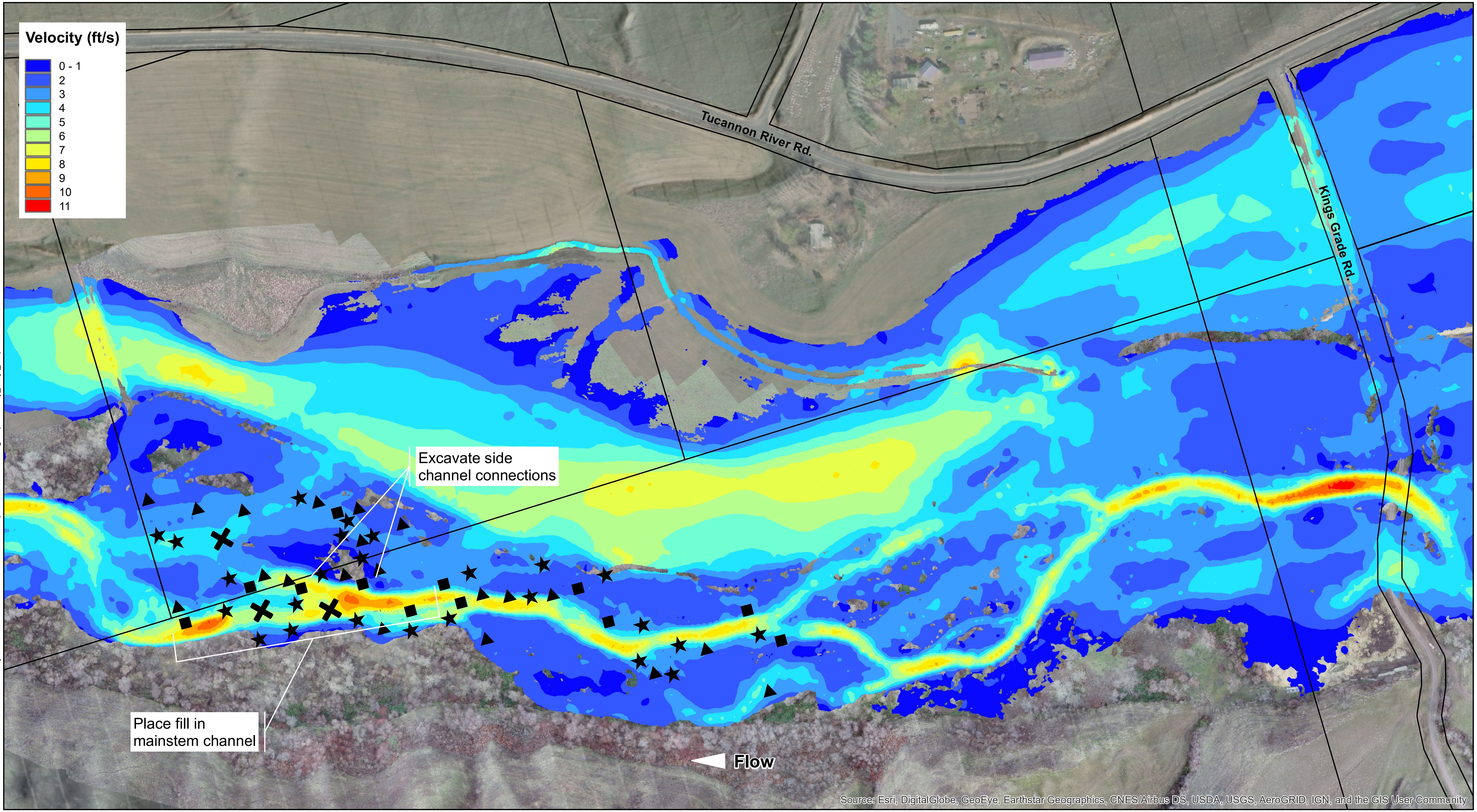
0 125 250 500 Feet

Columbia County Taxlots (2019)

Tucannon River PA 27/28

Velocity Modeling Results - Existing

Q100 (~5500 cfs)



N

0 125 250 500 Feet

Channel Spanner

Apex Jam

Margin Jam

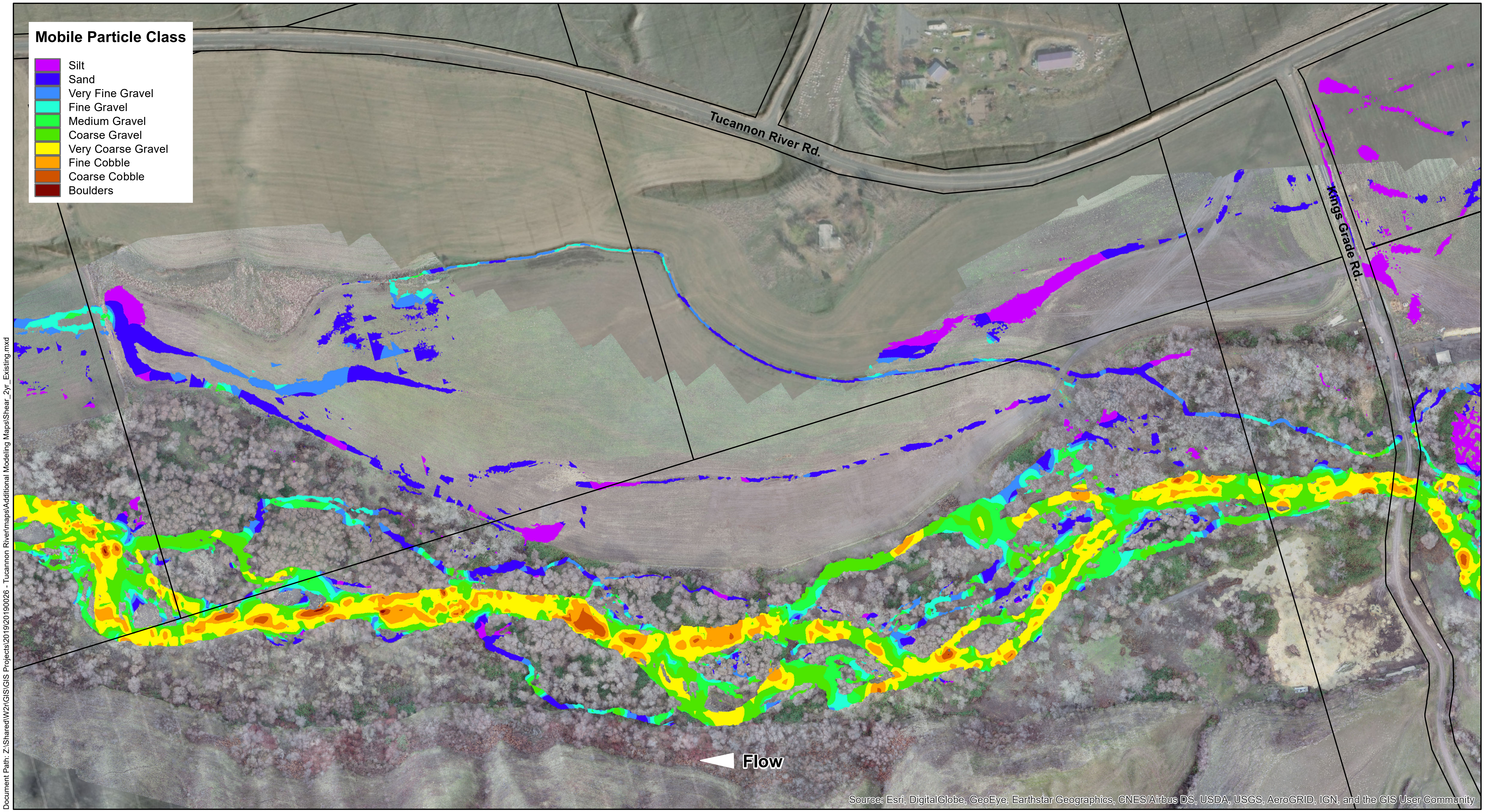
Habitat Log & Floodplain Wood

Columbia County Taxlots (2019)

Tucannon River PA 27/28

Velocity Modeling Results - Proposed

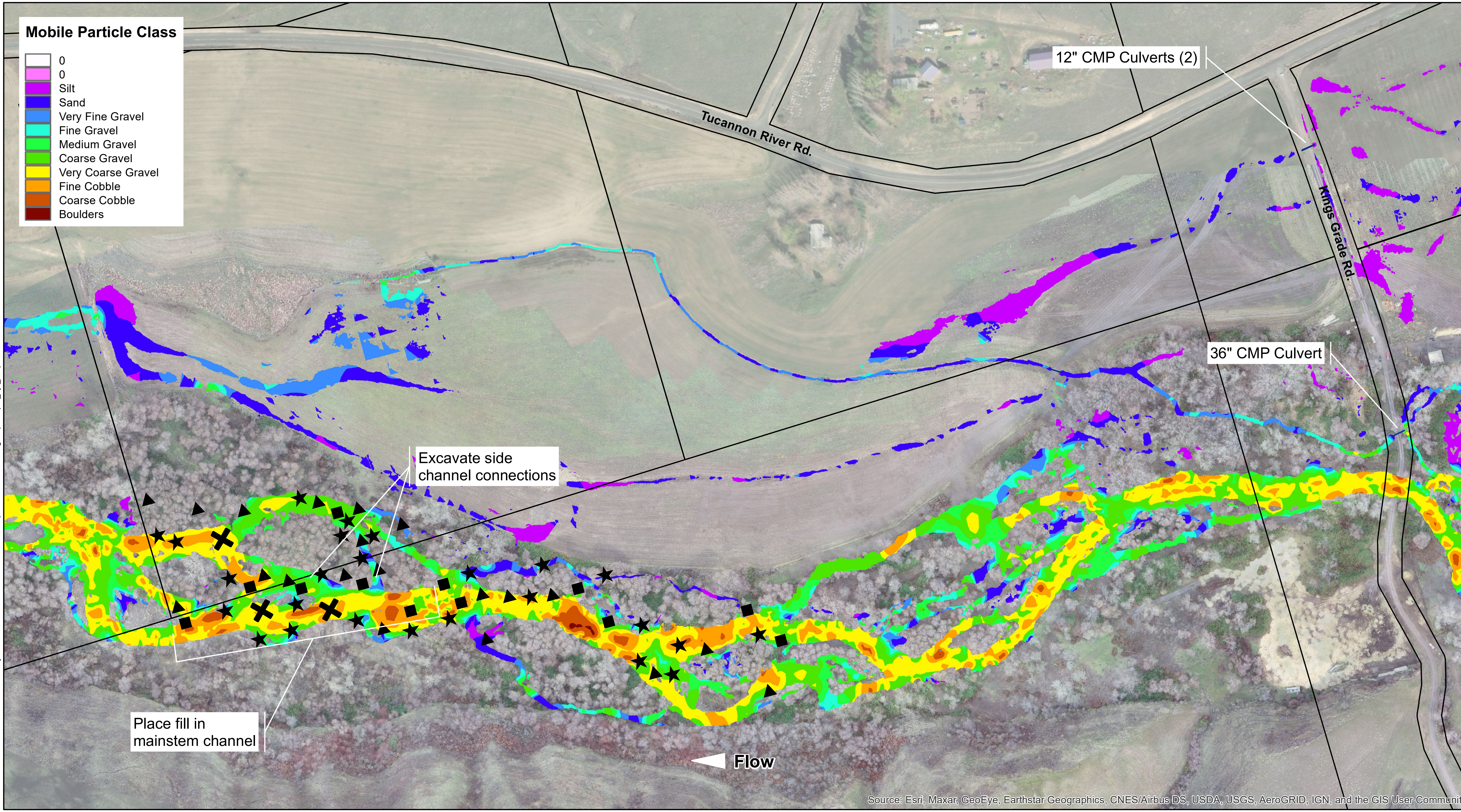
Q100 (~5500 cfs)



Tucannon River PA 27/28

Shear Modeling Results - Existing

Q2 (~790 cfs)



Document Path: Z:\Shared\W2r\GIS\GIS Projects\2019\20190026 - Tucannon River\maps\Additional Modeling Maps\Depth_2yr_Proposed.mxd

N

0 125 250 500 Feet

Channel Spanner

Apex Jam

Margin Jam

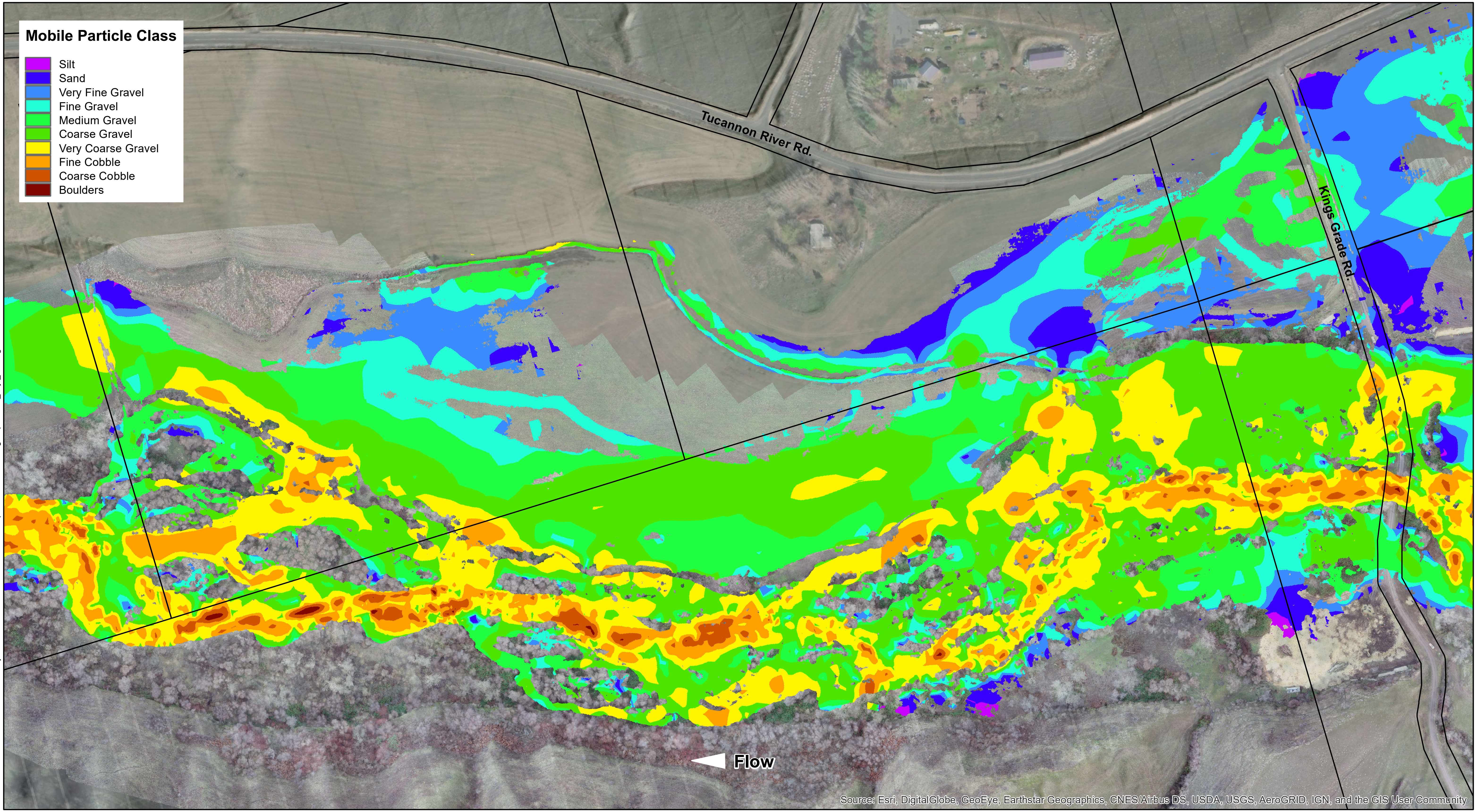
Habitat Log & Floodplain Wood

Columbia County Taxlots (2019)

Tucannon River PA 27/28

Shear Stress Modeling Results - Proposed

Q2 (~790 cfs)



Document Path: Z:\Shared\W2r\GIS\GIS Projects\2019\20190026 - Tucannon River\maps\Additional Modeling Maps\Shear_10yr_Existing.mxd

N

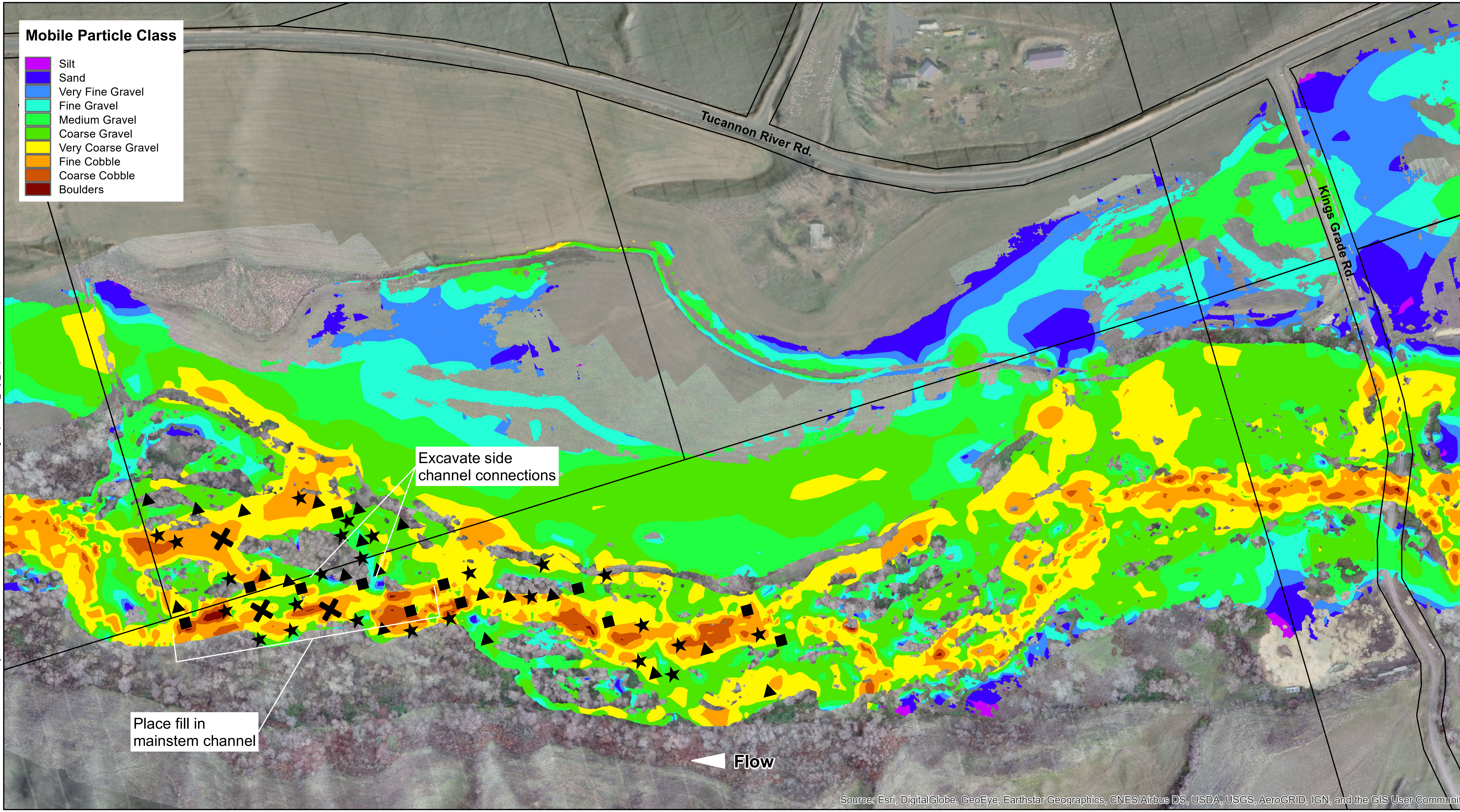
0 125 250 500 Feet

Columbia County Taxlots (2019)

Tucannon River PA 27/28

Shear Modeling Results - Existing

Q10 (~2440 cfs)



Document Path: Z:\Shared\W2r\GIS\GIS Projects\2019\20190026 - Tucannon River\maps\Additional Modeling Maps\Shear_10yr_Proposed.mxd

N

0 125 250 500 Feet

Channel Spanner

Apex Jam

Margin Jam

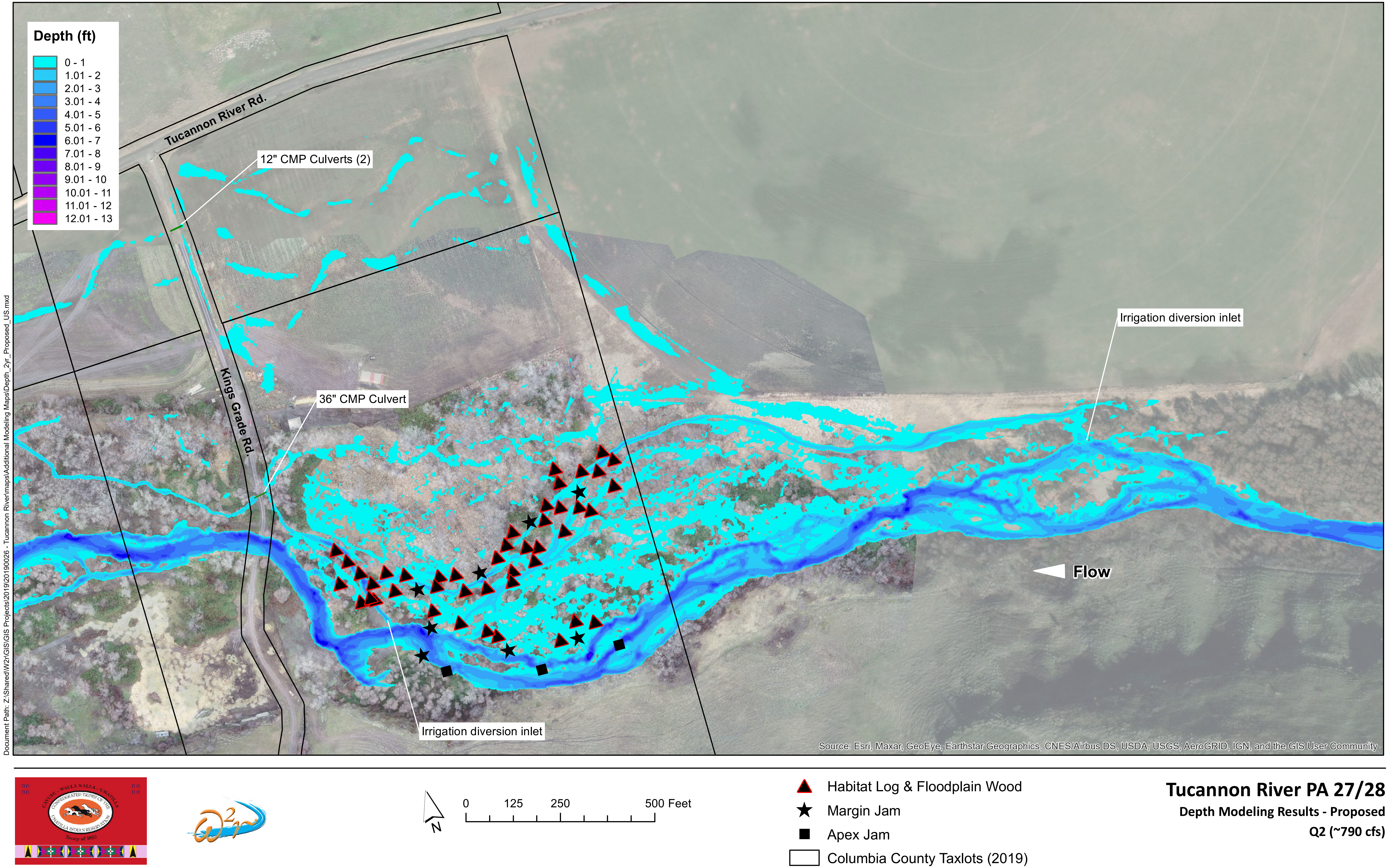
Habitat Log & Floodplain Wood

Columbia County Taxlots (2019)

Tucannon River PA 27/28

Shear Modeling Results - Proposed

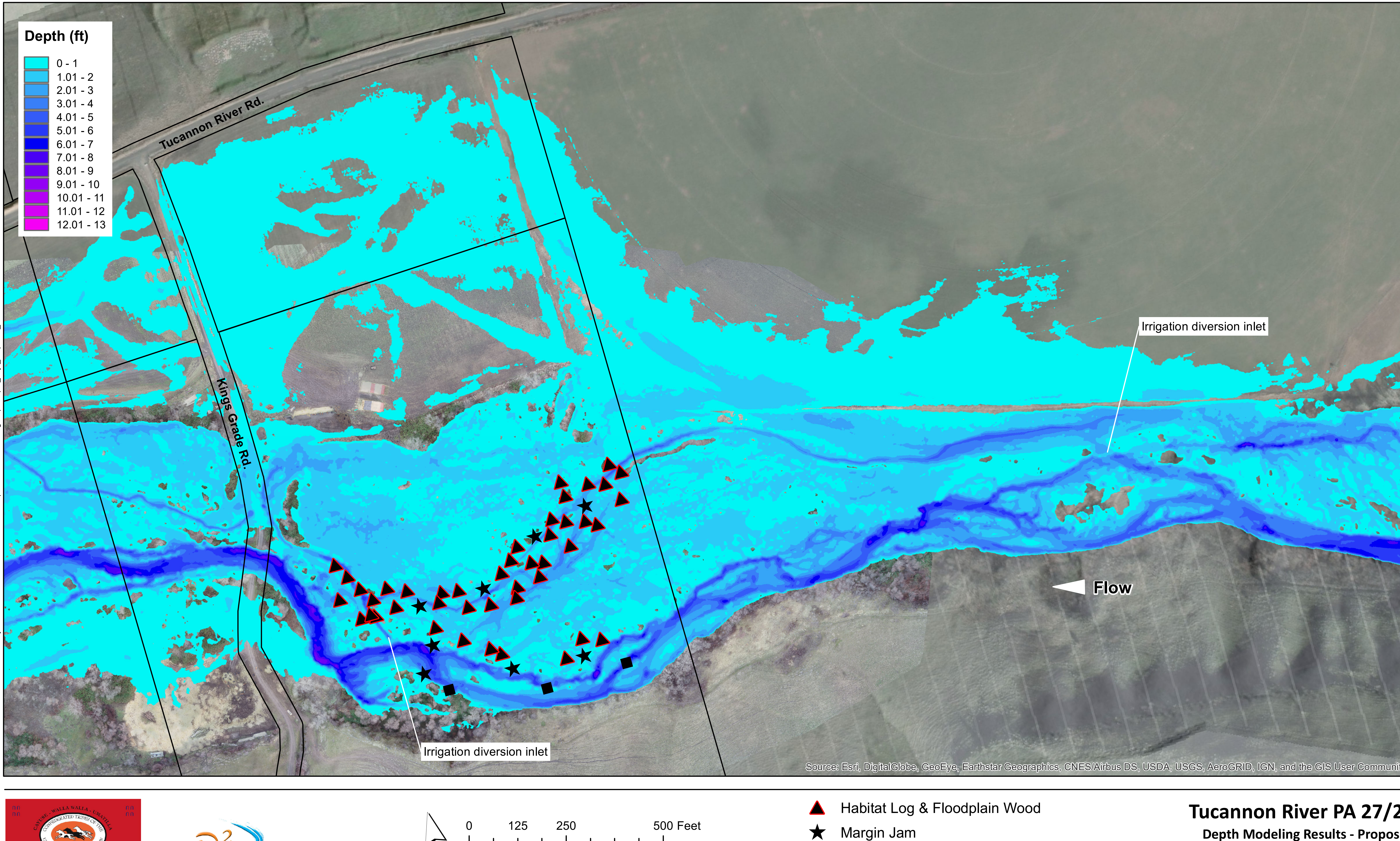
Q10 (~2440 cfs)



Tucannon River PA 27/28

Depth Modeling Results - Proposed

Q2 (~790 cfs)



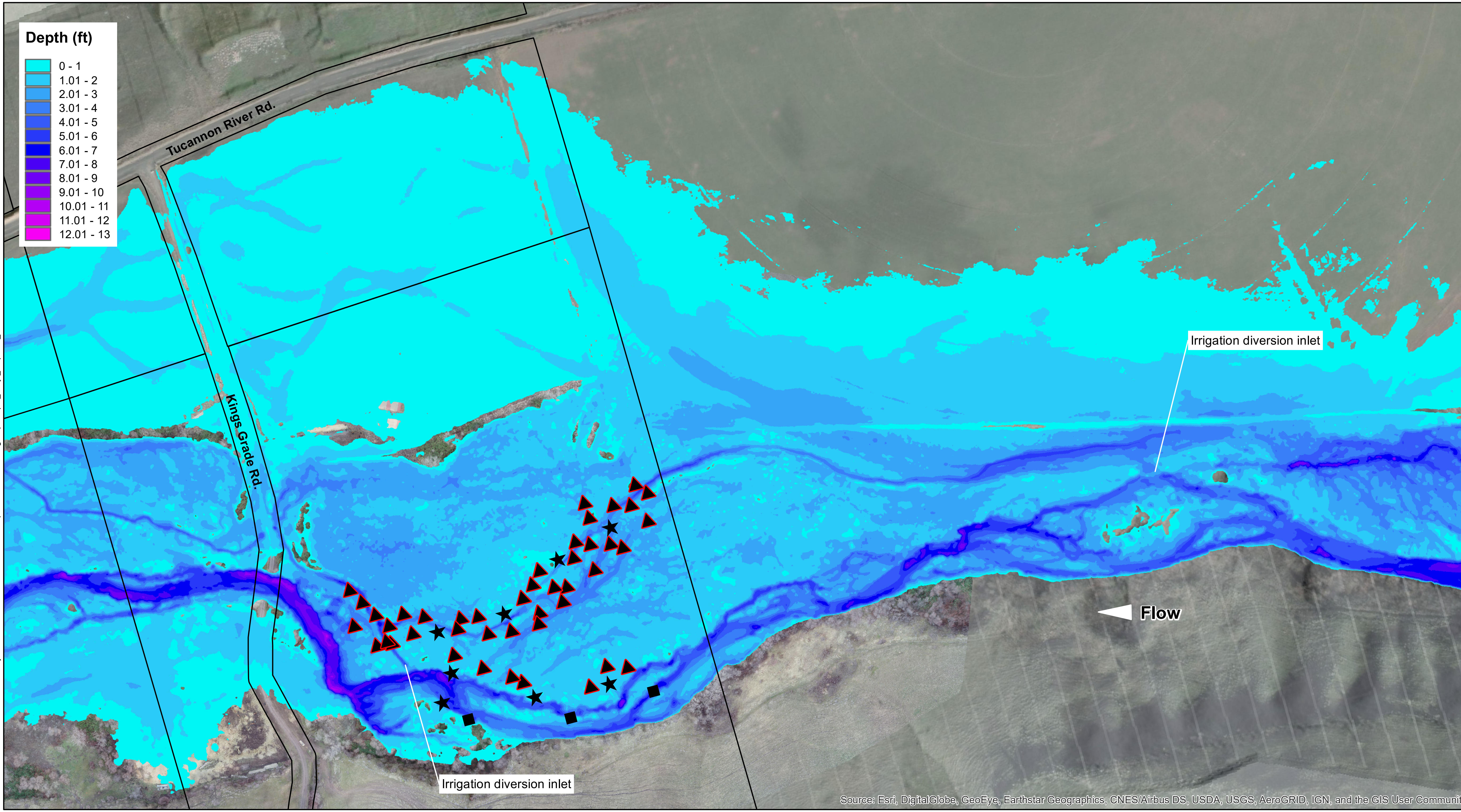
Habitat Log & Floodplain Wood
Margin Jam
Apex Jam
Columbia County Taxlots (2019)

Tucannon River PA 27/28

Depth Modeling Results - Proposed

Q10 (~2440 cfs)

Document Path: Z:\Shared\W2r\GIS\GIS Projects\2019\20190026 - Tucannon River\maps\Additional Modeling Maps\Depth_10yr_Proposed_US.mxd



Document Path: Z:\Shared\W2r\GIS\GIS Projects\2019\20190026 - Tucannon River\maps\Additional Modeling Maps\Depth_100yr_Proposed_US.mxd

N

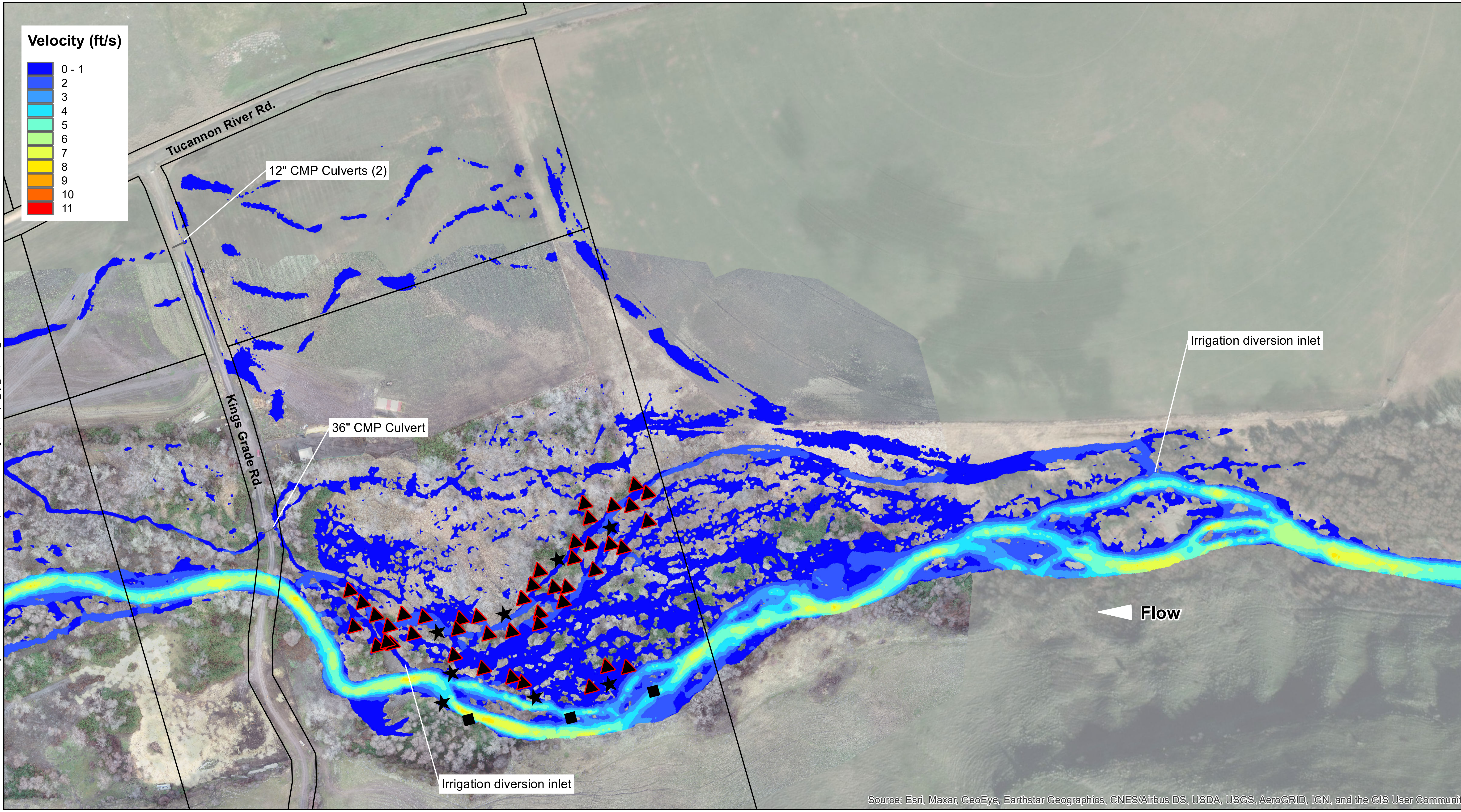
0 125 250 500 Feet

- Habitat Log & Floodplain Wood
- Margin Jam
- Apex Jam
- Columbia County Taxlots (2019)

Tucannon River PA 27/28

Depth Modeling Results - Proposed

Q100 (~5500 cfs)



Document Path: Z:\Shared\W2r\GIS\GIS Projects\2019\20190026 - Tucannon River\maps\Additional Modeling Maps\Depth_2yr_Proposed_US.mxd

N

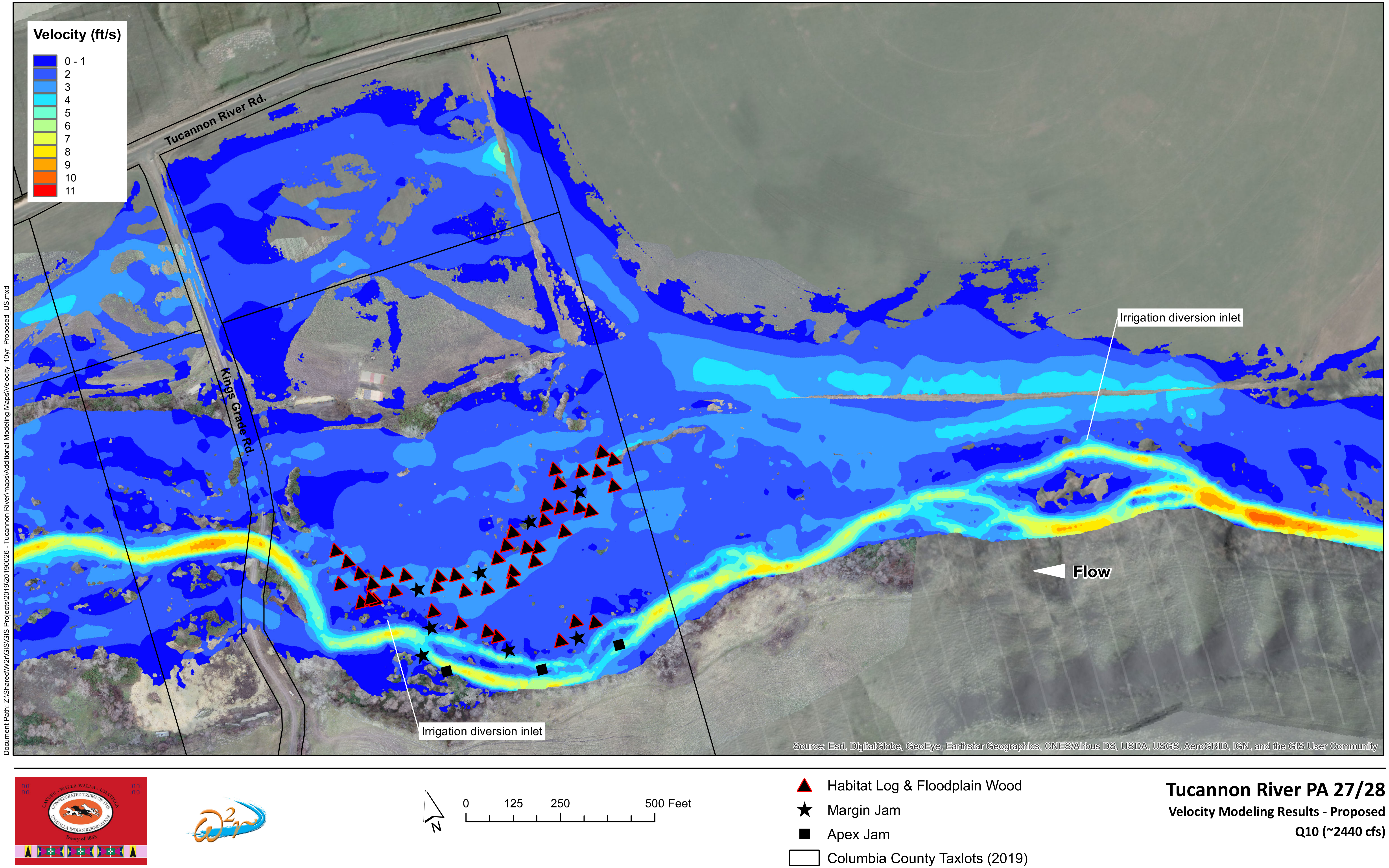
0 125 250 500 Feet

- Habitat Log & Floodplain Wood
- Margin Jam
- Apex Jam
- Columbia County Taxlots (2019)

Tucannon River PA 27/28

Velocity Modeling Results - Proposed

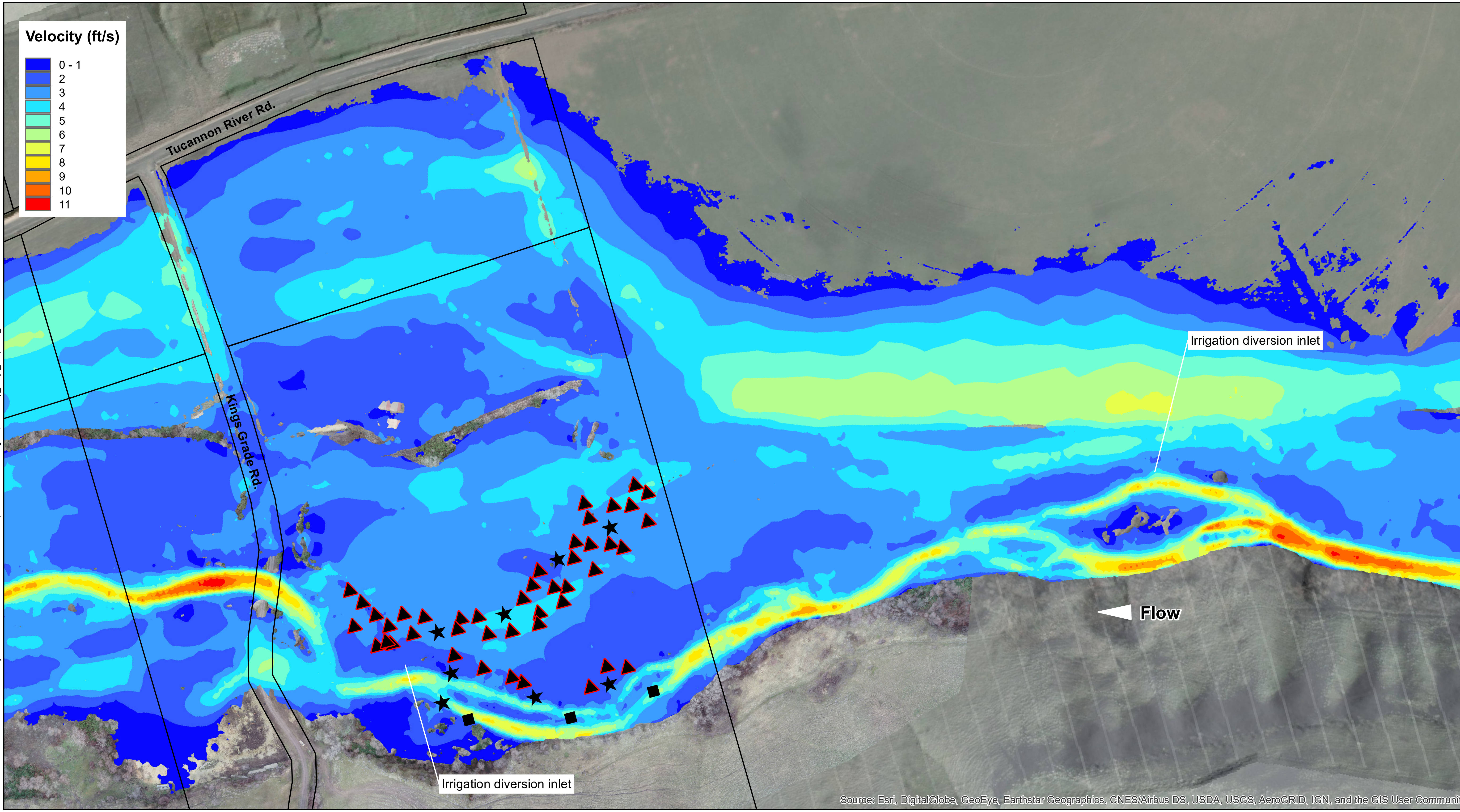
Q2 (~790 cfs)



Tucannon River PA 27/28

Velocity Modeling Results - Proposed

Q10 (~2440 cfs)



Document Path: Z:\Shared\W2r\GIS\GIS Projects\2019\20190026 - Tucannon River\maps\Additional Modeling Maps\Velocity_100yr_Proposed_US.mxd

N

0 125 250 500 Feet

- ▲ Habitat Log & Floodplain Wood
- ★ Margin Jam
- ■ Apex Jam
- ☐ Columbia County Taxlots (2019)

Tucannon River PA 27/28

Velocity Modeling Results - Proposed

Q100 (~5500 cfs)

APPENDIX D.1 BOR Risk Assessment

The method for the reach-scale risk assessment follows the guidance outlined in Step 4 of the Large Woody Material (LWM) Risk-Based Design Guidelines (Reclamation 2014). This evaluation includes assessing Public Safety Risks and Property Damage Risks associated with the placement of LWM in the project reach. Direct outcomes of this risk assessment approach include recommendations on log-jam design, safety factors for stability, and design floods. The risk assessment made use of general information, professional judgement, and information about reach user characteristics provided by the Project Sponsor, CTUIR.

1 Public Safety Risk Matrix

The Public Safety Risk matrix plots two major categories: the structure characteristics of each LWM structure versus the user characteristics for the project area (Reclamation 2014). Each category has a number of factors that are associated with the risk of that characteristic summarized below. The project design team assigned each factor a rating from 0 to 10, which represent low to high levels of public safety risk. For each category, the rating assigned to each factor is summed and then averaged. The average for each category is plotted on the matrix to determine the overall risk to the public of the LWM structure (Figure 1).

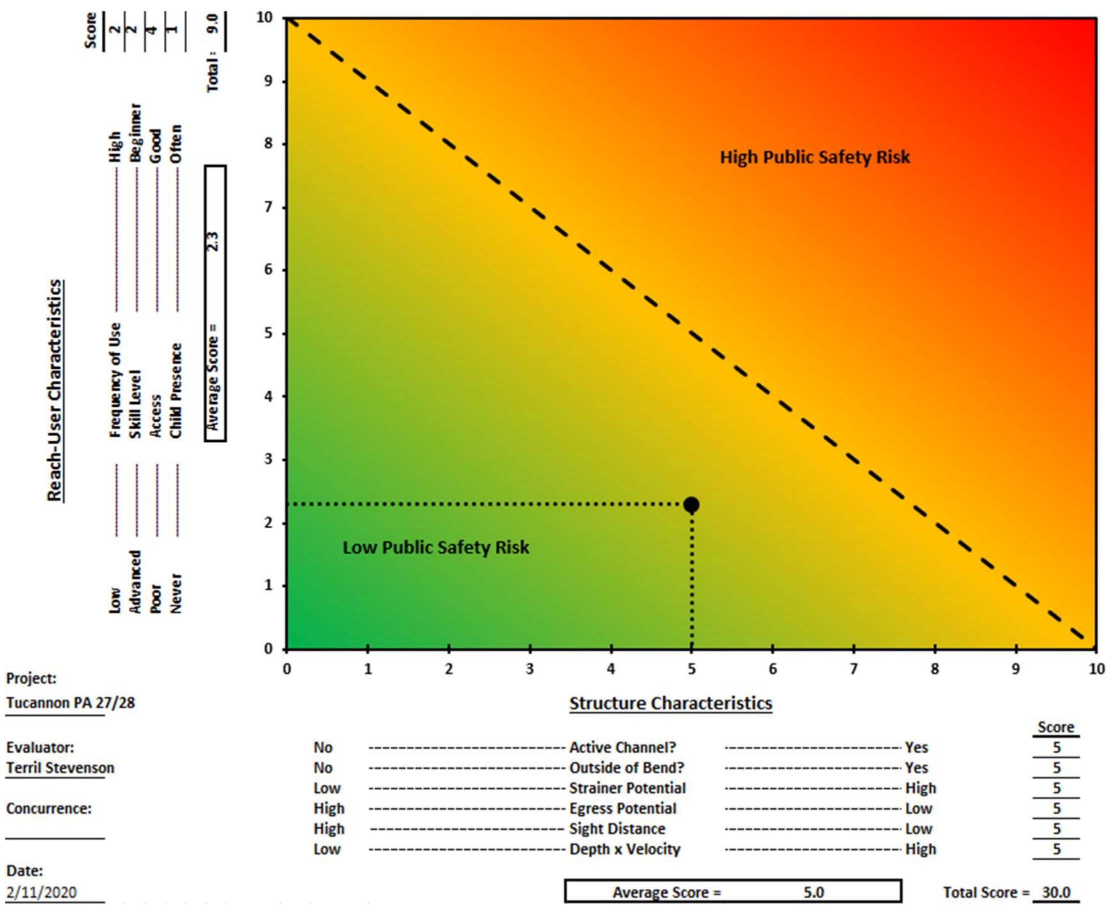


Figure 1 Public Safety Risk Matrix (Reclamation 2014).

1.1 Reach User-Characteristics

The reach user-characteristics are plotted on the Y-axis of Figure 1 and include the following four factors for developing an average categorical risk:

- Frequency of use – This factor rates the level of use that can be expected in the project area by floating, swimming, or other in-river activities. A reach of river that is frequently used by the public would have a higher rating.
- Skill Level – This factor rates the level of skill and knowledge of the river reach that is anticipated by the recreationists using the system. A reach that is frequently used by individuals with proper safety equipment and training would receive a lower risk rating than one that is frequented by low-skilled inner-tube recreationists.
- Access – This factor rates the risk of public safety related to accessibility to the project reach—specifically, LWM structure. The easier the access, the higher the risk.
- Child Presence – This factor rates the risk of the project reach for the presence of children, who are prone to investigating or climbing on LWM structures. A reach that that has easy access for children, or is near children camps or parks, has a higher risk.

The rating evaluation for the reach-user characteristics are summarized in Table 1.

Table 1 Reach-User Characteristic Ratings.

Reach-User Characteristics	Rating	Notes
Frequency of Use	2	The remote area surrounding project reach is used by local visitors during the summer months and during hunting season, but direct use of the creek is likely minimal due to location, ownership, and access. The reach may primarily be used fly-fishers. A search of the American Whitewater database revealed no documentation on rafting or kayaking routes on Tucannon River.
Skill Level	2	If rafting were to occur, it would be highly likely that it would occur during high flows, so users would necessarily have high skill levels.
Access	4	The reach is readily accessible by primarily gravel roads, but far from major population centers. The reach has a County Road bridge on a spur road (King Grade Road) and is paralleled on the north by Tucannon Road.
Child Presence	1	Limited use means child presence is low to non-existent.
Average	2.25	Low overall use and suitability as a floatable river make public safety risk low.

1.2 Structure Characteristics

The structure characteristics include the following six factors for developing an average categorical risk:

- Active Channel – This factor rates the uncertainty of physical channel migration. The magnitude of risk is higher in anticipation of dynamic channel movement.
- Outside of bend – This factor rates the location of the LWM structure design inside or outside of a bend. A person is more likely to be forced into a structure on the outside of a bend; therefore, a higher risk rating is associated with a structure located on the outside of a bend.
- Strainer potential – This factor rates the potential for a structure to pin or entrap a person. The more voids or protrusions a structure has, the higher the risk of entrapping an individual.
- Egress potential – This factor rates the ease of avoiding the LWM structure by floating or swimming around the structure. Structures that protrude into the channel or cause the recreationist to be pushed into deep, quick stream currents have higher ratings.
- Sight distance – This factor rates the ability for recreationist to see the structure from upstream and have enough time to divert away from the structure. Length of approach, slope, width, and stream velocity should all be considered when analyzing risk for this factor. An LWM structure located downstream of a bend in a narrow channel would have a higher risk rating.

- Depth x velocity – This factor rates channel approach velocity and depth to assess the safety of standing and moving, or walking away and around, the structure. A lower rating is applied to stream systems with lower depths and velocities where recreationists can easily avoid a structure.

At this design stage, LWM structure-specific risks were not assessed and all scores were assumed to be 5.

Based on the above, the overall public safety risk category is ranked as low. Structure-specific scoring in future design phases may reveal specific structures with differing risk categories.

2 Property Damage Risk Matrix

The Property Damage Risk matrix evaluates property damage risk potential for all structures within a project reach by weighing the property/project characteristics and stream potential against each other factors (Reclamation 2014). A rating of 0 to 10 is assigned to each of the factors associated with the two property damage risk categories. The average for each category is then plotted on the property damage matrix to determine the overall risk of the LWM structure (Figure 2).

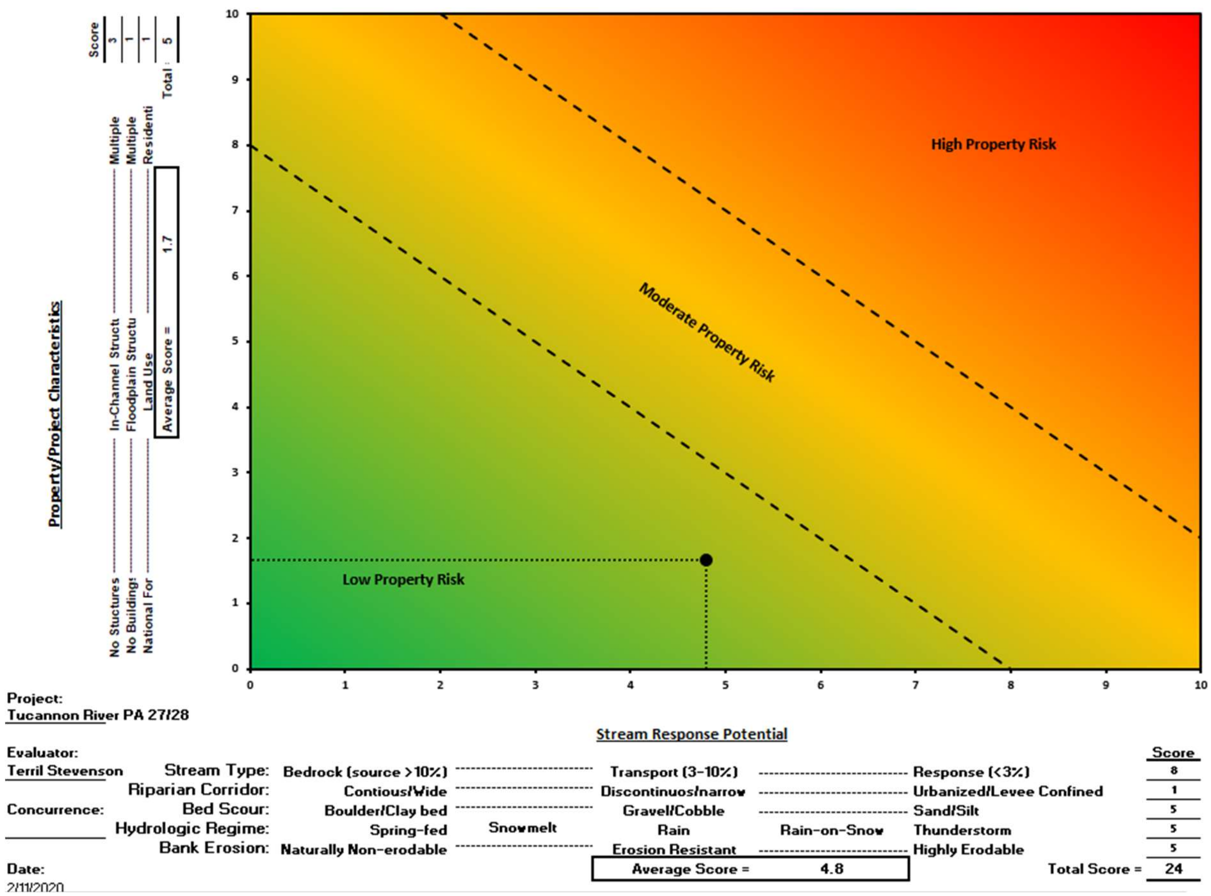


Figure 2 Property Damage Risk Matrix (Reclamation 2014).

2.1 Stream Response Potential

The property/project characteristics are plotted on the X-axis of Figure , and include the following five factors for developing an average categorical risk:

- Stream type – This factor rates the stream's sensitivity to change based on the stream type and slope within a project reach. A project located in a response reach within an alluvial channel may have high sensitivity and receive a high stream type rating.

- Riparian corridor – This factor rates the project reach's ability to absorb disturbances through natural riparian resiliency without causing harm to habitat or property. A project located in a reach with a wide riparian corridor would be rated low compared to a stream with a relatively narrow riparian corridor.
- Bed scour potential – This factor rates the project reach's physical susceptibility to bed changes based on channel material composition. Streams with highly erodible material such as sand or loose gravel may be susceptible to great disturbance and therefore have a higher rating.
- Bank erosion potential – This factor rates the project reach's physical susceptibility to bank erosion based on bank material composition. Channels with banks composed of highly erodible material such as sand or loose gravel are associated with a higher risk rating.
- Dominant Hydrologic Regime – This factor rates the stream's temporal hydrologic variability. Stream systems with evidence of high variability in their hydrograph have a much greater potential for system response and hence a relatively lower channel stability. Higher hydrograph variability equates to higher risk potential.

The evaluation of the five stream response factors for the project reach is provided in Table 2 with notes describing the rationale for each rating.

Table 2 Stream response potential ratings

Stream Response Potential	Rating	Notes
Stream Type	8	The reach is located within an alluvial channel with a moderate slope (0.8%). Although the reach is considered a response reach, it has many characteristics of a transport reach and has a moderate sensitivity to change.
Riparian Corridor	1	Existing riparian corridor is mostly continuous, and wide for significant portions of the reach. Post-project conditions should have increased width and density of riparian corridor, which should increase overall resilience.
Bed Scour Potential	5	The reach is dominated by coarse gravel to cobble-sized sediment. The reach is alluvial in nature and downstream from the project is a natural bedrock grade control which limits overall bed scour and incision potential through the project reach. Additionally, the bed is already somewhat incised, decreasing potential for active rapid incision.
Bank Erosion Potential	5	Bank erosion processes are active but slow. Historical aerials indicate relatively slow rates of channel migration and bank erosion. The well-established riparian corridor also reduces bank erosion potential.
Dominant Hydrologic Regime	5	Snow-melt dominated hydrologic regime with relatively moderate variability in peak flows.
Average	4.8	The average stream response potential risk is low to moderate.

2.2 Property/Project Characteristics

The property/project characteristics are plotted on the Y-axis of Figure , and include the following three factors for developing an average categorical risk:

- In-channel structures – This factor rates the risk of LWM based on the proximity and vulnerability of in channel structures such as bridges, piers, docks, pumps, fish screens, and other features in the channel.
- Floodplain structures – This factor weighs the vulnerability and type of structures within the 100-year floodplain. Projects that have multiple structures within the 100-year floodplain may be rated high.
- Land use – This factor is used to determine the damage potential based on land use. Natural land uses may receive a lower rating than farm land or rural residence based on the judgement of the design team.

The evaluation of the three property/project characteristic factors is provided in Table 3 with notes describing the rationale for each rating.

Plotting of average scores on Figure 2 reveals a low property risk category.

Table 3 Property/Project Characteristics

Property/Project Characteristics	Rating	Notes
In-Channel Structures	3	Tucannon River has one existing bridge within the project reach, and multiple downstream. The bridge within the project reach is upstream of planned activity in Phase I. Bridges downstream are located more than 10-miles downstream, with large segments of unconfined channel and floodplain between, andd therefore they have low potential of being impacted by the project elements.
Floodplain Structures	1	The project reach has no structures within the geomorphic floodplain
Land Use	1	The project reach is within undeveloped private lands used for conservation, recreation, and grazing. These uses mimic those of national forest land.
Average	1.7	The average property risk is low.

3 Risk-Based LWM Design Recommendations

The identified low categories of public safety and property risks have associated recommendations of design flood and factor of safety (FOS) listed in Table 4.

Table 4 LWM risk-based design recommendations (Reclamation, 2014). Yellow highlighting calls-out the project reach.

Public Safety Risk	Property Damage Risk	Stability Design Flow Criteria	FOS Sliding	FOS Buoyancy	FOS Rotation & Overturning
High	High	100-year	1.75	2.0	1.75
High	Moderate	50-year	1.5	1.75	1.5
High	Low	25-year	1.5	1.75	1.5
Low	High	100-year	1.75	2.0	1.75
Low	Moderate	25-year	1.5	1.75	1.5
Low	Low	10-year	1.25	1.5	1.25

Buoyancy Calculations

Project:	Tucannon - Large Apex	**Analyst:**	SJR
Project No.:	Project Number	**Calculations Checked By:**	SJR
		Latest Revision:	5/12/2020

Spreadsheet Description

- The spreadsheet below is used to calculate the Factor of Safety against Buoyant uplift of the LWM

Assumptions:

1) The LWM structure behaves as a single structure under the design load and will not experience any shearing at joints
2) The LWM structure will be submerged during the design event.
3) Negative buoyancy is uplift, positive numbers equals downward.
4) Ballast material remains intact and is not scoured out.
5) The uplift due to racking material is evenly dividing among all layers.

Input (Cells Requiring Input from Structure Detail)
Input (Cells requiring Input from Hydraulic Model)
Input (Cells automatically populated from Input to Interface Tab)
Input (Cells requiring input from a dropdown list)
Output (Cells automatically updated are this color)
Output (Cells automatically updated with previously calculated values are this color)

FBD and Equations:

$$FOS_b = \frac{F_{LWMd} + F_{boulders} + F_{soil} + F_{piles-v}}{|F_{LWMs} + F_L|}$$ **Equation 18**

FOS_b = *buoyancy factor of safety*

*** PROJECT NAME has a "XXXX" Public Safety Risk Factor and a "XXXX" Property Damage Risk Factor. The Design buoyancy factor of safety (FOS_b) for this structure is #.# per Table 4 "*Minimum Recommended Factors of Safety*".**

Table 4. Minimum recommended factors of safety.

Public Safety Risk	Property Damage Risk	Stability Design Flow Criteria	$FOS_{sliding}$	$FOS_{buoyancy}$	$FOS_{rotation}$ $FOS_{overturning}$
High	High	100-year	1.75	2.0	1.75
High	Moderate	50-year	1.5	1.75	1.5
High	Low	25-year	1.5	1.75	1.5
Low	High	100-year	1.75	2.0	1.75
Low	Moderate	25-year	1.5	1.75	1.5
Low	Low	10-year	1.25	1.5	1.25

1. Large Wood Material Force - Dry (F_{LWMd})

$$F_{LWMd} = V_{LWMd} * \gamma_{wood}$$ **Equation 3**

V_{LWMd} = *volume of dry large wood material*

Comment: Assumed to be zero because structure assumed to be submerged during design event.

2. Boulder Ballast Force ($F_{boulder}$)

$N_{bouldersub}$			Number of submerged boulders (from design)
$d_{bouldersub}$	2.5	ft	Effective diameter of submerged boulder (ft, from spec)
$\gamma_{boulder}$	146	lb/ft^3	unit weight of boulders (Table 5)
γ_{water}	62.4	lb/ft^3	unit weight of water
$F_{bouldersub}$		lb	Eqn. 6
$N_{boulderdry}$			Number of dry boulders (from detail)
$d_{boulderdry}$	2.5	ft	Effective diameter of dry boulder (ft, from spec)
$F_{boulderdry}$		lb	Eqn. 7
$F_{boulder}$		**lb**	**Eqn. 5**

$$F_{boulder} = F_{bouldersub} + F_{boulderdry}$$ **Equation 5**

$$F_{bouldersub} = N_{bouldersub} * \frac{\pi}{6} * d_{bouldersub}^3 * (\gamma_{boulder} - \gamma_w)$$ **Equation 6**

$N_{bouldersub}$ = *number of submerged boulders*
$d_{bouldersub}$ = *effective diameter of submerged boulders*
$\gamma_{boulder}$ = *unit weight of boulders*

$$F_{boulderdry} = N_{boulderdry} * \frac{\pi}{6} * d_{boulderdry}^3 * \gamma_{boulder}$$ **Equation 7**

$N_{boulderdry}$ = *number of unsubmerged boulders*
$d_{boulderdry}$ = *effective diameter of unsubmerged boulders*

Comment: The intent is design without the use of boulders so it is assumed no boulders are used.

Buoyancy Calculations

Project: Tucannon - Large Apex
Project No.: Project Number

Analyst: SJR
Calculations Checked By: SJR
Latest Revision: 5/12/2020

3. Soil Backfill Force (F_{soil})

$N_{logssub1}$	2		Number of Type 1 buried logs (from detail)
L_{eb1}	25	ft	Average embedded length of Type 1 logs (from detail)
d_{bole1}	1.25	ft	Average diameter of Type 1 logs (from detail)
$h_{soilsub1}$		ft	Average height of submerged soil above Type 1 log (from detail)
$V_{soilsub1}$		ft^3	Volume of submerged soil above Type 1 log (from detail)
$h_{soildry1}$		ft	Average height of dry soil above Type 1 log (from detail)
$V_{soildry1}$		ft^3	Volume of dry soil above Type 1 log (from detail)
$N_{logssub2}$	5		Number of Type 2 buried logs (from detail)
L_{eb2}	25	ft	Average embedded length of Type 2 logs (from detail)
d_{bole2}	1.75	ft	Average diameter of Type 2 logs (from detail)
$h_{soilsub2}$	2.5	ft	Average height of submerged soil above Type 2 log (from detail)
$V_{soilsub2}$	547	ft^3	Volume of submerged soil above Type 2 log (from detail)
$h_{soildry2}$		ft	Average height of dry soil above Type 2 log (from detail)
$V_{soildry2}$		ft^3	Volume of dry soil above Type 2 log (from detail)
$N_{logssub3}$	1		Number of Type 3 buried logs (from detail)
L_{eb3}	15	ft	Average embedded length of Type 3 logs (from detail)
d_{bole3}	1.75	ft	Average diameter of Type 3 logs (from detail)
$h_{soilsub3}$	2	ft	Average height of submerged soil above Type 3 log (from detail)
$V_{soilsub3}$	53	ft^3	Volume of submerged soil above Type 3 log (from detail)
$h_{soildry3}$		ft	Average height of dry soil above Type 3 log (from detail)
$V_{soildry3}$		ft^3	Volume of dry soil above Type 3 log (from detail)
γ_{soil}	131	lb/ft^3	Specific Gravity of bank/backfill material (Table 5)
γ_{water}	62.4	lb/ft^3	Unit weight of water
SG_{rock}	2.64		Specific Gravity of Rock (Using unit weight of bedrock from Table 5)
e	0.26		Eqn. 14
γ_{sat}	144	lb/ft^3	Eqn. 13
γ'_{soil}	81.4	lb/ft^3	Eqn. 12
F_{soil}	**48,776**	**lb**	**Eqn. 8**

$$F_{soil} = \sum_i^n V_{soilsub_i} * \gamma'_{soil} + V_{soildry_i} * \gamma_{soil}$$ **Equation 8**

$$V_{soilsub_i} = L_{eb_i} d_{bole_i} h_{soilsub_i}$$ **Equation 9**

$V_{soilsubi}$ = volume of submerged soil above log i
L_{ebi} = embedded length of log i
d_{bolei} = bole diameter of log i
$h_{soilsubi}$ = height of submerged soil above log i

$$V_{soildry_i} = L_{eb_i} d_{bole_i} h_{soildry_i}$$ ***Equation 10***

$V_{soildryi}$ = volume of dry soil above log i
$h_{soildryi}$ = height of dry soil above log i

$$\gamma_{soil} = (99.2 + 18.6 * \log(d_{50}))$$ **Equation 11**

d_{50} = median grain size in millimeters

$$\gamma'_{soil} = \gamma_{sat} - \gamma_w$$ **Equation 12**

$$\gamma_{sat} = \frac{(SG_{rock}+e)*\gamma_w}{1+e}$$ **Equation 13**

$$e = \frac{SG_{rock}*\gamma_w}{\gamma_{soil}} - 1$$ **Equation 14**

Buoyancy Calculations

Project: Tucannon - Large Apex
Project No.: Project Number

Analyst: SJR
Calculations Checked By: SJR
Latest Revision: 5/12/2020

4. Pile Skin Friction

N_{piles}	6		Number of piles (Design)
d_{piles}	0.83	ft	Diameter of piles (Design)
L_{piles}	8	ft	Embedded length of piles (Design)
k_s	1		Coefficient of lateral earth pressure (0.5 to 1.5 depending on soil and density)
Placement Method	Excavated		Method of pile placement
Placement Multiplier	0.25		See RBDG (P. 52)
Pile Placement Location	Bed		Bed or Bank
ϕ_{soil}	0.72	rad	Internal angle of friction of soils (Table 5)
γ_{soil}	137	lb/ft^3	Specific Weight of Soil
e	0.20		Eqn. 14
γ_{sat}	148	lb/ft^3	Eqn. 13
γ_{water}	62.4	lb/ft^3	Unit weight of water
σ'	681	lb/ft^2	Eqn 16
γ_{wood}	33	lb/ft^3	Unit weight of wood
$F_{piles-v}$	**10,821**	**lb**	**Eqn 15**

$$F_{piles-v} = N_{piles} * \pi * d_{piles} * L_{piles}(k_s * \tan\frac{2}{3}\emptyset * \sigma' + \frac{d_{piles}}{4} * (\gamma_{wood} - \gamma_w))$$

Equation 15

N_{piles} = number of piles
d_{piles} = diameter of piles
L_{piles} = embedded length of piles
k_s = coefficient of lateral earth pressure (0.5 to 1.5 depending on soil and density)
ϕ = internal angle of friction of soils

$$\sigma' = L_{piles} * (\gamma_{sat} - \gamma_w)$$

Equation 16

$$\gamma_{sat} = \frac{(SG_{rock} + e) * \gamma_w}{1 + e}$$

Equation 13

$$e = \frac{SG_{rock} * \gamma_w}{\gamma_{soil}} - 1$$

Equation 14

Assumptions:
*** k_s = 1**
**** This calculation is based on the assumption that piles are driven or vibrated into place. If piles are drilled or excavated, the associated coefficicient of lateral earth pressures shall be approx. 50% and 25% of the driven value, respectively.**
***** For use in buoyancy calculations, piles must be mechanically fastened.**
****** Top 2' of pile embedment disregarded for calculation to account for vortex shedding.**

Buoyancy Calculations

Project: Tucannon - Large Apex
Project No.: Project Number

Analyst: SJR
Calculations Checked By: SJR
Latest Revision: 5/12/2020

5. Large Wood Material Force - Submerged (F_{LWMs})

$$F_{LWMs} = V_{LWMs} * (\gamma_{wood} - \gamma_w)$$ **Equation 2**

V_{LWMs} = *volume of submerged large wood material*
γ_{wood} = *unit weight of wood*
γ_w = *unit weight of water*

$N_{logssub1}$	2		Number of log type 1 (from detail)
L_{log1}	25	ft	Length of log type 1 (from detail)
d_{bole1}	1.25	ft	Diameter of log type 1 (from detail)
d_{rw1}	3.13	ft	Diameter of rootwad of log type 1 (from detail)
V_{LWMs1}	74	ft^3	Volume of LWM1
$N_{logssub2}$	5		Number of log type 2 (from detail)
L_{eb2}	40	ft	Length of log type 2 (from detail)
d_{bole2}	1.75	ft	Diameter of log type 2 (from detail)
d_{rw2}	4.38	ft	Diameter of rootwad of log type 2 (from detail)
V_{LWMs2}	569	ft^3	Volume of LWM2
$N_{logssub3}$	1		Number of log type 3 (from detail)
L_{eb3}	25	ft	Length of log type 3 (from detail)
d_{bole3}	1.25	ft	Diameter of log type 3 (from detail)
d_{rw3}	3.13	ft	Diameter of rootwad of log type 3 (from detail)
V_{LWMs3}	37	ft^3	Volume of LWM3
V_{LWMs}	680	ft^3	Volume of LWM
γ_{wood}	33.0	lb/ft^3	Unit weight of logs
γ_w	62.4	lb/ft^3	Unit weight of water
F_{LWMs}	**-19,991**	**lb**	**Eqn. 3**

Volume of Rootwad

National Large Wood Manual. 2016
Equation 6-4 (p. 6-38)

$V_{rw} = \pi * t_k * w_k^2 / 3$
$\pi*(2d_{bole}) * (1/2d_{rw})^2 / 3$

t_k = Thickness of rootwad measured in direction parallel to trunk
= 4 times the radius of the log ($4r_k$ or

w_k =
Radius of rootwad
= 2.5 times the radius of the log ($2.5r_k$ or $1.25d_{bole}$) or 1/2 d_{rw} specified

6. Lift Forces (F_L)

$$F_L = -\frac{C_L * A_{LWM} * \gamma_w * U_o^2}{2 * g}$$ **Equation 4**

C_L = *lift coefficient*
A_{LWM} = *area of large woody material perpendicular to flow*
u_o = *upstream channel velocity at design event*
g = *acceleration due to gravity*

C_L	0.45		Lift Coefficient
A_{LWM}	140	ft^2	Calc'd in Drag Forces
γ_w	62.4	lb/ft^3	Unit weight of water
U_o	9.0	ft/s	upstream velocity (from model)
g	32.2	ft/s^2	Unit weight of water
F_L	**-4,945**	**lb**	**Eqn. 4**

Comment: Lift forces neglected per Section 6.4.2 of BOR Risk Based Design Guidelines

Factor of Safety

FOS_b =	*$(F_{LMDd} + F_{boulders} + F_{soil} + F_{piles-v}) / (F_{LWMs} + F_L)$*		
F_{LWMd}		lb	Assumed Zero
$F_{boulder}$		lb	
F_{soil}	48,776	lb	
$F_{piles-v}$	10,821	lb	
F_{LWMs}	-19,991	lb	
F_L	-4,945	lb	
FOS_b	**2.39**		**STABLE FOR BUOYANCY**

Summary Comments:

Sliding Calculations

Project: Tucannon - Large Apex
Project No.: Project Number

Analyst: SJR
Calculations Checked By: SJR
Latest Revision: 5/12/2020

Spreadsheet Description

Purpose: The spreadsheet below is used to calculate the Factor of Safety against LWM sliding.

Assumptions:
1) The LWM structure behaves as a single structure under the design load and will not experience any shearing at joints.
2) The effect of soil in back of the structure is negligible.
3) The structure will be submerged during the design event.
4) Channel velocity (V_c) taken from hydraulic model.
5) This LWM structure experiences the largest loads. All LWM structures on site will be designed based on this LWM structure's loadings.

Input (Cells Requiring Input from Structure Detail)
Input (Cells requiring Input from Hydraulic Model)
Input (Cells requiring input from a dropdown list)
Input (Cells automatically populated from Input to Interface Tab)
Output (Cells automatically updated are this color)
Output (Cells automatically updated with previously calculated values are this color)

FBD and Equations:

$$FOS_{sliding} = \frac{|F_{hd}+F_f+F_{piles-h}+F_{passive}|}{F_d+F_{hu}+F_i}$$ Equation 41

* **PROJECT NAME has a "XXXX" Public Safety Risk Factor and a "XXXX" Property Damage Risk Factor. The Design Sliding Factor of Safety ($FOS_{sliding}$) for this structure is #.# per Table 4 "Minimum Recommended Factors of Safety".**

Table 4. Minimum recommended factors of safety.

Public Safety Risk	Property Damage Risk	Stability Design Flow Criteria	$FOS_{sliding}$	$FOS_{bouyancy}$	$FOS_{rotation}$ $FOS_{overturning}$
High	High	100-year	1.75	2.0	1.75
High	Moderate	50-year	1.5	1.75	1.5
High	Low	25-year	1.5	1.75	1.5
Low	High	100-year	1.75	2.0	1.75
Low	Moderate	25-year	1.5	1.75	1.5
Low	Low	10-year	1.25	1.5	1.25

1. Drag Force (F_d)

$$F_d = \frac{C_D * A_{LWM} * \gamma_w * U_c^2}{2 * g}$$ Equation 19

F_d = drag force
C_d = drag coefficient
A_{LWM} = area of wetted debris based on the upstream water surface elevation projected normal to flow direction and the potential drift accumulation
γ_w = unit weight of water
U_c = velocity in contracted section
g = acceleration due to gravity

Y_u	7.00	ft	Upstream water depth
hdebris	7	ft	Debris height (incl. accumulation)
wdebris	20	ft	Debris width (incl. accumulation)
Debris Shape	Rectangle		
A_{LWM}	140	ft^2	Wetted area of LWM
γ_{water}	62.40	lb/ft^3	Unit weight of water
v_c	9.00	ft/s	Velocity from Model
g	32.20	ft/s^2	Acceleration due to gravity
A_b	140.00	ft^2	Debris area
$w_{channel}$	60	ft	Channel width
c_d	1.50		NLWM Worst Case
F_d	16482	lb	Eqn 19

Cd can be assumed 0.9 when fully submerged, 1.5 when WSEL within

$$C_{d-applied} = \frac{C_d}{(1-B)^2}$$ C_d is typically estimated as 1.0 Equation 27

Sliding Calculations

Project: Tucannon - Large Apex
Project No.: Project Number

Analyst: SJR
Calculations Checked By: SJR
Latest Revision: 5/12/2020

3. Impact Force (F_i)

L_{debris}	30	ft	Length of debris member (Design)
$d_{boledebris}$	1.5	ft	Bole diameter of debris member (Design)
$d_{rwdebris}$	4	ft	Rootwad diameter of debris member (Design)
V_{debris}	66	ft^3	Volume of debris
γ_{wood}	33	lb/ft^3	Unit weight of wood
w_{debris}	2,164	lb	weight of debris
g	32.2	ft/s^2	Acceleration due to gravity
$V_{channel}$	9.0	ft/s	Velocity from Model
Δt	0.03	sec	Impact Interval (0.03 sec recommended)
C_i	0.8		Coefficient of importance (from Table 6)
C_o	0.8		Coefficient of orientation
C_d	1		Figure 11 (need water depth from model)
Degree of Screening or Sheltering Upstream	No upstream screening, flow path wider than 30'		ASCE 7-05
C_b	1		ASCE 7-05
R_{max}	0.8		Response ratio for impulsive loads
F_i	**16,216**	**lb**	**Eqn 30**

$$F_i = \frac{\pi w_{debris} * V_{channel} * C_i * C_o * C_d * C_b * R_{max}}{2 * g * \Delta t}$$ **Equation 30**

F_i = impact force

w_{debris} = weight of debris

g = acceleration constant due to gravity

$V_{channel}$ = water velocity in channel

Δt = time from initial velocity to zero velocity

C_i = coefficient of importance

C_o = coefficient of orientation = 0.8

C_d = coefficient of depth

C_b = coefficient of blockage

R_{max} = response ratio for impulsive loads = 0.8

Assumption:

***Largest impact force would be generated by structure being struck by floating large key member. For impact calculation, assuming 18" diameter, 30' long member with rootwad impacts structure.**
****See Section 6.3.3 of LWM RBDG (P. 44) for debris loading sizing.**

4. Friction Force (F_f)

ϕ_{bed}	0.72	radians	Calculated for streambed material (small cobble)
μ_{bed}	0.87		Eqn 32
F_{LWMd}		lb	Buoyancy Calcs
$F_{boulder}$		lb	Buoyancy Calcs
F_{soil}	48776	lb	Buoyancy Calcs
$F_{piles-v}$	10821	lb	Buoyancy Calcs
F_{LWMs}	-19991	lb	Buoyancy Calcs
F_L	-4945	lb	Buoyancy Calcs
F_b	34,662	lb	Eqn 17
F_f	**-20,725**	**lb**	**Eqn 31**

$$F_f = -\mu_{bed} * (F_b - F_{piles-v})$$ Equation 31

F_f = force due to frictional resistance

F_b-$F_{piles-v}$ >0

$$\mu_{bed} = \tan \emptyset$$ Equation 32

$$F_b = F_{LWMs} + F_{LWMd} + F_L + F_{boulder} + F_{soil} + F_{piles-v}$$ *Equation 17*

Note:
***If buoyancy forces are less than vertical pile forces (Fb-Fpiles-v<0), then friction force = 0.**

Sliding Calculations

Project: Tucannon - Large Apex
Project No.: Project Number

Analyst: SJR
Calculations Checked By: SJR
Latest Revision: 5/12/2020

5. Passive Forces ($F_{passive}$)

ϕ_{bank}	0.70	radians	Calculated for bank material (very course gravel)
K_p	4.60		Eqn 34
γ_{water}	62.4	lb/ft^3	Unit weight of water
γ_{soil}	131	lb/ft^3	Unit weight of soil
γ_{sat}	144	lb/ft^3	Previously calculated for buoyancy calcs
$N_{logssub1}$	2		Number of log type 1 (from detail)
$Orientation_1^{**}$	Perpendicular		Perpendicular or Parallel to flow
L_{eb1}	25	ft	Length of log type 1 (from detail)
d_{bole1}	1.25	ft	Diameter of log type 1 (from detail)
D_{sub1}		ft	Depth of submerged soil above log 1
D_{dry1}		ft	Depth of dry soil above log 1
σ_{v1}		lb/ft^2	
$\sigma_{v1} * L_{eb1} * \gamma_{soil}$		lb	
$N_{logssub2}$	5		Number of log type 2 (from detail)
$Orientation_2^{**}$	Perpendicular		Perpendicular or Parallel to flow
L_{eb2}	25	ft	Length of log type 2 (from detail)
d_{bole2}	1.75	ft	Diameter of log type 2 (from detail)
D_{sub2}	2.5	ft	Depth of submerged soil above log 2
D_{dry2}		ft	Depth of dry soil above log 2
σ_{v2}	203	lb/ft^2	
$\sigma_{v2} * L_{eb2} * \gamma_{soil}$	44,504	lb	
$N_{logssub3}$	1		Number of log type 3(from detail)
$Orientation_3^{**}$	Perpendicular		Perpendicular or Parallel to flow
L_{eb3}	15	ft	Length of log type 3 (from detail)
d_{bole3}	1.75	ft	Diameter of log type 3 (from detail)
D_{sub3}	2	ft	Depth of submerged soil above log 3
D_{dry3}		ft	Depth of dry soil above log 3
σ_{v3}	163	lb/ft^2	
$\sigma_{v3} * L_{eb3} * \gamma_{soil}$	4,272	lb	
$F_{passive}$	**-112,159**	**lb**	**Eqn 31**

**** Eqns 33 through 35 represent the case where passive forces act along**

$$F_{passive} = -0.5 * K_p * \sum_i^n \sigma_{v_i} * L_{em_i} * d_{log_i}$$ E

$$K_p = \frac{1+\sin\emptyset}{1-\sin\emptyset}$$ E

$$\sigma_{v_i} = D_{sub_i} * (\gamma_{sat} - \gamma_{water}) + D_{dry_i} * \gamma_{soil}$$ E

D_{subi} = depth of submerged soil above log i
D_{dryi} = depth of dry soil above log i
L_{emi} = embedded length of log i
d_{logi} = diameter of log i

Sliding Calculations

Project: Tucannon - Large Apex
Project No.: Project Number

Analyst: SJR
Calculations Checked By: SJR
Latest Revision: 5/12/2020

6. Lateral Resistance from Piles ($F_{piles-h}$)

N_{piles}	6		Number of piles (Design)
d_{piles}	0.83	ft	Diameter of piles (Design)
L_{piles}	8	ft	Embedded length of piles below scour (Design)
Placement Method	Excavated		Method of pile placement
Placement Multiplier	0.25		See RBDG (P. 52)
Pile Placement Location	Bed		Bed or Bank
γ_{water}	62.4	lb/ft^3	Unit weight of water
γ_{soil}	137	lb/ft^3	Unit weight of soil
γ_e	74.6	lb/ft^3	Eqn 37
ϕ_{soil}	0.72	radians	Calculated for material pile is located
K_p	4.81		Eqn 38
h_{load}**	3.5	ft	Height above scour depth load is applied
$F_{piles-h}$	**-9,955**	**lb**	**Eqn 15**

*** Top 2' of pile embedment disregarded for calculation to account for vortex shedding.**

**** Analysis also assumes that the resultant force is located at half of the flow depth on the upstream side of the LWM structure to produce a conservative moment on the pile.**

$$F_{piles-h} = -N_{piles} * \frac{L_{pile}^3 * \frac{1}{2} * \gamma_e * d_{pile} * K_p}{h_{load} + L_{pile}}$$ Equation 36

N_{piles} = number of piles
L_{pile} = length of pile embedded below potential scour depth

$$\gamma_e = \gamma_s - \gamma_w$$ *effective unit weight of soil* Equation 37

γ_s = dry unit weight of the soil

γ_w = unit weight of the soil
d_{pile} = diameter of the pile
h_{load} = height above the potential scour depth the load is applied

$$K_p = \frac{1 + \sin \phi}{1 - \sin \phi}$$ Equation 38

Factor of Safety

$FOS_{sliding}$ =	$(F_{hd} + F_f + F_{piles-h} + F_{passive}) / (F_d + F_{hu} + F_i)$		
F_d	16,482	lb	
F_{hu}		lb	
F_{hd}		lb	
F_i	16,216	lb	
F_f	-20,725	lb	
$F_{passive}$	-112,159	lb	
$F_{piles-h}$	-9,955	lb	
$FOS_{sliding}$	**4.37**		**STABLE FOR SLIDING**

Summary Comments:

Rotation Calculations

Project: Tucannon - Large Apex
Project Number: Project Number

Analyst: SJR
Calculations Checked By: SJR
Latest Revision: 5/12/2020

Spreadsheet Description

Purpose: The spreadsheet below is used to calculate the Factor of Safety against LWM structure horizontal rotation.

Assumptions:
1) The LWM structue behaves as a single structure under the design load.
2) The effect of soil in back of the structure is negligible.
3) The structure will be submerged during the design event
4) This LWM structure experiences the largest loads. All LWM structures on site will be designed based on this LWM structure's loadings

Input (Cells Requiring Input from Structure Detail)
Input (Cells requiring Input from Hydraulic Model)
Input (Cells requiring input from a dropdown list)
Input (Cells automatically populated from Input to Interface Tab)
Output (Cells that are automatically updated are this color)
Output (Cells that are automatically updated with previously calculated values are this color)

FBD and Equations:

$$FOS_{rotation} = \frac{MR_{rotation}}{MD_{rotation}}$$ **Equation 45**

*** PROJECT NAME has a "XXXX" Public Safety Risk Factor and a "XXXX" Property Damage Risk Factor. The Design Rotation Factor of Safety ($FOS_{rotation}$) for this structure is #.# per Table 4 "Minimum Recommended Factors of Safety".**

Table 4. Minimum recommended factors of safety.

Public Safety Risk	Property Damage Risk	Stability Design Flow Criteria	$FOS_{sliding}$	$FOS_{bouyancy}$	$FOS_{rotation}$ $FOS_{overturning}$
High	High	100-year	1.75	2.0	1.75
High	Moderate	50-year	1.5	1.75	1.5
High	Low	25-year	1.5	1.75	1.5
Low	High	100-year	1.75	2.0	1.75
Low	Moderate	25-year	1.5	1.75	1.5
Low	Low	10-year	1.25	1.5	1.25

1. Resistance to Rotation ($MR_{rotation}$ and $MD_{rotation}$)

$$MD_{rotation} = (F_i + F_d + F_{hu}) * \left(\frac{L_{sp}+L_{ebp}}{2}\right)$$ **Equation 42**

L_{sp} = length of wood structure from tip to point of rotation measured perpendicular to flow
L_{ebp} = embedded length of wood structure measured perpendicular to flow

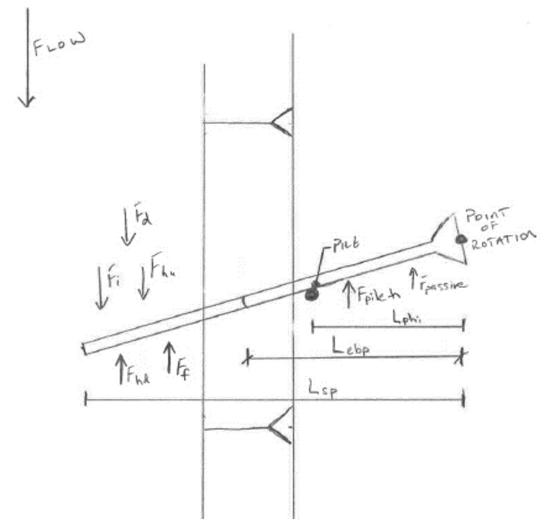
$$MR_{rotation} = \left| F_{hd} * \left(\frac{L_{sp}+L_{ebp}}{2}\right) + F_{passive} * \frac{L_{ebp}}{2} + F_f * \frac{L_{sp}}{2} + \sum_{i}^{n} F_{pile-h_i} * L_{ph_i} \right|$$ **Equation 43**

$$F_{pile-h_i} = \frac{F_{piles-h}}{N_{piles}}$$ **Equation 44**

L_{phi} = distance from pile 'i' to the point of rotation measured perpendicular to flow

Driving:

L_{sp}	40	ft	Length of wood structure from tip to point of rotation measured perpendicular to flow
L_{ebp}	25	ft	Embedded length of wood structure measured perp. to flow
F_i	16,216	lb	Impact Forces (Calc'd in Sliding)
F_d	16,482	lb	Drag Forces (Calc'd in Sliding)
F_{hu}		lb	Upstream Hydrostatic Forces (Calc'd in Sliding)
$MD_{rotation}$	**1,062,679**	**lb*ft**	**Eqn 42**



Resisting:

F_{hd}		lb	Downstream Hydrostatic Forces (Calc'd in Sliding)
$F_{passive}$	-112,159	lb	Passive Forces (Calc'd in Sliding)
F_f	-20,725	lb	Friction Forces (Calc'd in Sliding)
F_{pile-h}	-9,955	lb	Lateral Resistance from Piles (Calc'd in Sliding)
$F_{pile-hi}$	-1,659	lb	Lateral Resistance from Piles (Calc'd in Sliding)
N_{piles}	6		Number of Piles (Design)
L_{phi}	25	ft	Distance from pile to the point of rotation measured perp. to flow
$MR_{rotation}$	**2,065,358**	**lb*ft**	**Eqn 43**

Factor of Safety

$FOS_{rotation}$ =	*$MR_{rotation}$ / $MD_{rotation}$*		
$MD_{rotation}$	1,062,679	lb	
$MR_{rotation}$	2,065,358	lb	
$FOS_{rotation}$	**1.94**		**STABLE FOR ROTATION**

Summary Comments:

Buoyancy Calculations

Project:	Tucannon - Small Apex	**Analyst:**	SJR
Project No.:	Project Number	**Calculations Checked By:**	SJR
		Latest Revision:	5/12/2020

Spreadsheet Description

- The spreadsheet below is used to calculate the Factor of Safety against Buoyant uplift of the LWM

Assumptions:

1) The LWM structure behaves as a single structure under the design load and will not experience any shearing at joints
2) The LWM structure will be submerged during the design event.
3) Negative buoyancy is uplift, positive numbers equals downward.
4) Ballast material remains intact and is not scoured out.
5) The uplift due to racking material is evenly dividing among all layers.

Input (Cells Requiring Input from Structure Detail)
Input (Cells requiring Input from Hydraulic Model)
Input (Cells automatically populated from Input to Interface Tab)
Input (Cells requiring input from a dropdown list)
Output (Cells automatically updated are this color)
Output (Cells automatically updated with previously calculated values are this color)

FBD and Equations:

$$FOS_b = \frac{F_{LWMd} + F_{boulders} + F_{soil} + F_{piles-v}}{|F_{LWMs} + F_L|}$$ **Equation 18**

FOS_b = *buoyancy factor of safety*

*** PROJECT NAME has a "XXXX" Public Safety Risk Factor and a "XXXX" Property Damage Risk Factor. The Design buoyancy factor of safety (FOS_b) for this structure is #.# per Table 4 "*Minimum Recommended Factors of Safety*".**

Table 4. Minimum recommended factors of safety.

Public Safety Risk	Property Damage Risk	Stability Design Flow Criteria	$FOS_{sliding}$	$FOS_{buoyancy}$	$FOS_{rotation}$ $FOS_{overturning}$
High	High	100-year	1.75	2.0	1.75
High	Moderate	50-year	1.5	1.75	1.5
High	Low	25-year	1.5	1.75	1.5
Low	High	100-year	1.75	2.0	1.75
Low	Moderate	25-year	1.5	1.75	1.5
Low	Low	10-year	1.25	1.5	1.25

1. Large Wood Material Force - Dry (F_{LWMd})

$$F_{LWMd} = V_{LWMd} * \gamma_{wood}$$ **Equation 3**

V_{LWMd} = *volume of dry large wood material*

Comment: Assumed to be zero because structure assumed to be submerged during design event.

2. Boulder Ballast Force ($F_{boulder}$)

$N_{bouldersub}$			Number of submerged boulders (from design)
$d_{bouldersub}$	2.5	ft	Effective diameter of submerged boulder (ft, from spec)
$\gamma_{boulder}$	146	lb/ft^3	unit weight of boulders (Table 5)
γ_{water}	62.4	lb/ft^3	unit weight of water
$F_{bouldersub}$		lb	Eqn. 6
$N_{boulderdry}$			Number of dry boulders (from detail)
$d_{boulderdry}$	2.5	ft	Effective diameter of dry boulder (ft, from spec)
$F_{boulderdry}$		lb	Eqn. 7
$F_{boulder}$		**lb**	**Eqn. 5**

$$F_{boulder} = F_{bouldersub} + F_{boulderdry}$$ **Equation 5**

$$F_{bouldersub} = N_{bouldersub} * \frac{\pi}{6} * d_{bouldersub}^3 * (\gamma_{boulder} - \gamma_w)$$ **Equation 6**

$N_{bouldersub}$ = *number of submerged boulders*
$d_{bouldersub}$ = *effective diameter of submerged boulders*
$\gamma_{boulder}$ = *unit weight of boulders*

$$F_{boulderdry} = N_{boulderdry} * \frac{\pi}{6} * d_{boulderdry}^3 * \gamma_{boulder}$$ **Equation 7**

$N_{boulderdry}$ = *number of unsubmerged boulders*
$d_{boulderdry}$ = *effective diameter of unsubmerged boulders*

Comment: The intent is design without the use of boulders so it is assumed no boulders are used.

Buoyancy Calculations

Project: Tucannon - Small Apex
Project No.: Project Number

Analyst: SJR
Calculations Checked By: SJR
Latest Revision: 5/12/2020

3. Soil Backfill Force (F_{soil})

$N_{logssub1}$	1		Number of Type 1 buried logs (from detail)
L_{eb1}	20	ft	Average embedded length of Type 1 logs (from detail)
d_{bole1}	1.25	ft	Average diameter of Type 1 logs (from detail)
$h_{soilsub1}$		ft	Average height of submerged soil above Type 1 log (from detail)
$V_{soilsub1}$		ft^3	Volume of submerged soil above Type 1 log (from detail)
$h_{soildry1}$		ft	Average height of dry soil above Type 1 log (from detail)
$V_{soildry1}$		ft^3	Volume of dry soil above Type 1 log (from detail)
$N_{logssub2}$	2		Number of Type 2 buried logs (from detail)
L_{eb2}	27	ft	Average embedded length of Type 2 logs (from detail)
d_{bole2}	1.75	ft	Average diameter of Type 2 logs (from detail)
$h_{soilsub2}$	3	ft	Average height of submerged soil above Type 2 log (from detail)
$V_{soilsub2}$	284	ft^3	Volume of submerged soil above Type 2 log (from detail)
$h_{soildry2}$		ft	Average height of dry soil above Type 2 log (from detail)
$V_{soildry2}$		ft^3	Volume of dry soil above Type 2 log (from detail)
$N_{logssub3}$			Number of Type 3 buried logs (from detail)
L_{eb3}	25	ft	Average embedded length of Type 3 logs (from detail)
d_{bole3}	1.75	ft	Average diameter of Type 3 logs (from detail)
$h_{soilsub3}$		ft	Average height of submerged soil above Type 3 log (from detail)
$V_{soilsub3}$		ft^3	Volume of submerged soil above Type 3 log (from detail)
$h_{soildry3}$		ft	Average height of dry soil above Type 3 log (from detail)
$V_{soildry3}$		ft^3	Volume of dry soil above Type 3 log (from detail)
γ_{soil}	131	lb/ft^3	Specific Gravity of bank/backfill material (Table 5)
γ_{water}	62.4	lb/ft^3	Unit weight of water
SG_{rock}	2.64		Specific Gravity of Rock (Using unit weight of bedrock from Table 5)
e	0.26		Eqn. 14
γ_{sat}	144	lb/ft^3	Eqn. 13
γ'_{soil}	81.4	lb/ft^3	Eqn. 12
F_{soil}	**23,071**	**lb**	**Eqn. 8**

$$F_{soil} = \sum_i^n V_{soilsub_i} * \gamma'_{soil} + V_{soildry_i} * \gamma_{soil}$$ **Equation 8**

$$V_{soilsub_i} = L_{eb_i} d_{bole_i} h_{soilsub_i}$$ **Equation 9**

$V_{soilsubi}$ = volume of submerged soil above log i
L_{ebi} = embedded length of log i
d_{bolei} = bole diameter of log i
$h_{soilsubi}$ = height of submerged soil above log i

$$V_{soildry_i} = L_{eb_i} d_{bole_i} h_{soildry_i}$$ ***Equation 10***

$V_{soildryi}$ = volume of dry soil above log i
$h_{soildryi}$ = height of dry soil above log i

$$\gamma_{soil} = (99.2 + 18.6 * \log(d_{50}))$$ **Equation 11**

d_{50} = median grain size in millimeters

$$\gamma'_{soil} = \gamma_{sat} - \gamma_w$$ **Equation 12**

$$\gamma_{sat} = \frac{(SG_{rock} + e) * \gamma_w}{1 + e}$$ **Equation 13**

$$e = \frac{SG_{rock} * \gamma_w}{\gamma_{soil}} - 1$$ **Equation 14**

Buoyancy Calculations

Project: Tucannon - Small Apex
Project No.: Project Number

Analyst: SJR
Calculations Checked By: SJR
Latest Revision: 5/12/2020

4. Pile Skin Friction

N_{piles}			Number of piles (Design)
d_{piles}	0.83	ft	Diameter of piles (Design)
L_{piles}	8	ft	Embedded length of piles (Design)
k_s	1		Coefficient of lateral earth pressure (0.5 to 1.5 depending on soil and density)
Placement Method	Excavated		Method of pile placement
Placement Multiplier	0.25		See RBDG (P. 52)
Pile Placement Location	Bed		Bed or Bank
ϕ_{soil}	0.72	rad	Internal angle of friction of soils (Table 5)
γ_{soil}	137	lb/ft^3	Specific Weight of Soil
e	0.20		Eqn. 14
γ_{sat}	148	lb/ft^3	Eqn. 13
γ_{water}	62.4	lb/ft^3	Unit weight of water
σ'	681	lb/ft^2	Eqn 16
γ_{wood}	33	lb/ft^3	Unit weight of wood
$F_{piles-v}$		**lb**	**Eqn 15**

Assumptions:
*** k_s = 1**
**** This calculation is based on the assumption that piles are driven or vibrated into place. If piles are drilled or excavated, the associated coefficicient of lateral earth pressures shall be approx. 50% and 25% of the driven value, respectively.**
***** For use in buoyancy calculations, piles must be mechanically fastened.**
****** Top 2' of pile embedment disregarded for calculation to account for vortex shedding.**

$$F_{piles-v} = N_{piles} * \pi * d_{piles} * L_{piles}(k_s * \tan\frac{2}{3}\emptyset * \sigma' + \frac{d_{piles}}{4} * (\gamma_{wood} - \gamma_w))$$

Equation 15

N_{piles} = number of piles
d_{piles} = diameter of piles
L_{piles} = embedded length of piles
k_s = coefficient of lateral earth pressure (0.5 to 1.5 depending on soil and density)
ϕ = internal angle of friction of soils

$$\sigma' = L_{piles} * (\gamma_{sat} - \gamma_w)$$

Equation 16

$$\gamma_{sat} = \frac{(SG_{rock}+e)*\gamma_w}{1+e}$$

Equation 13

$$e = \frac{SG_{rock}*\gamma_w}{\gamma_{soil}} - 1$$

Equation 14

Buoyancy Calculations

Project: Tucannon - Small Apex
Project No.: Project Number

Analyst: SJR
Calculations Checked By: SJR
Latest Revision: 5/12/2020

5. Large Wood Material Force - Submerged (F_{LWMs})

$$F_{LWMs} = V_{LWMs} * (\gamma_{wood} - \gamma_w)$$ Equation 2

V_{LWMs} = volume of submerged large wood material
γ_{wood} = unit weight of wood
γ_w = unit weight of water

$N_{logssub1}$	1		Number of log type 1 (from detail)
L_{log1}	20	ft	Length of log type 1 (from detail)
d_{bole1}	1.25	ft	Diameter of log type 1 (from detail)
d_{rw1}	3.13	ft	Diameter of rootwad of log type 1 (from detail)
V_{LWMs1}	31	ft^3	Volume of LWM1
$N_{logssub2}$	2		Number of log type 2 (from detail)
L_{eb2}	40	ft	Length of log type 2 (from detail)
d_{bole2}	1.75	ft	Diameter of log type 2 (from detail)
d_{rw2}	4.38	ft	Diameter of rootwad of log type 2 (from detail)
V_{LWMs2}	227	ft^3	Volume of LWM2
$N_{logssub3}$			Number of log type 3 (from detail)
L_{eb3}	40	ft	Length of log type 3 (from detail)
d_{bole3}	1.75	ft	Diameter of log type 3 (from detail)
d_{rw3}		ft	Diameter of rootwad of log type 3 (from detail)
V_{LWMs3}		ft^3	Volume of LWM3
V_{LWMs}	258	ft^3	Volume of LWM
γ_{wood}	33.0	lb/ft^3	Unit weight of logs
γ_w	62.4	lb/ft^3	Unit weight of water
F_{LWMs}	**-7,598**	**lb**	**Eqn. 3**

Volume of Rootwad

National Large Wood Manual. 2016
Equation 6-4 (p. 6-38)

$V_{rw} = \pi * t_k * w_k^2 / 3$
$\pi*(2d_{bole}) * (1/2d_{rw})^2 / 3$

t_k = Thickness of rootwad measured in direction parallel to trunk
= 4 times the radius of the log ($4r_k$ or

w_k =
Radius of rootwad
= 2.5 times the radius of the log ($2.5r_k$ or $1.25d_{bole}$) or 1/2 d_{rw} specified

6. Lift Forces (F_L)

$$F_L = -\frac{C_L * A_{LWM} * \gamma_w * U_o^2}{2*g}$$ Equation 4

C_L = lift coefficient
A_{LWM} = area of large woody material perpendicular to flow
u_o = upstream channel velocity at design event
g = acceleration due to gravity

C_L	0.45		Lift Coefficient
A_{LWM}	75	ft^2	Calc'd in Drag Forces
γ_w	62.4	lb/ft^3	Unit weight of water
U_o	9.0	ft/s	upstream velocity (from model)
g	32.2	ft/s^2	Unit weight of water
F_L	**-2,649**	**lb**	**Eqn. 4**

Comment: Lift forces neglected per Section 6.4.2 of BOR Risk Based Design Guidelines

Factor of Safety

FOS_b =	$(F_{LMDd} + F_{boulders} + F_{soil} + F_{piles-v}) / (F_{LWMs} + F_L)$		
F_{LWMd}		lb	Assumed Zero
$F_{boulder}$		lb	
F_{soil}	23,071	lb	
$F_{piles-v}$		lb	
F_{LWMs}	-7,598	lb	
F_L	-2,649	lb	
FOS_b	**2.25**		**STABLE FOR BUOYANCY**

Summary Comments:

Sliding Calculations

Project:	Tucannon - Small Apex	**Analyst:**	SJR
Project No.:	Project Number	**Calculations Checked By:**	SJR
		Latest Revision:	5/12/2020

Spreadsheet Description

Purpose: The spreadsheet below is used to calculate the Factor of Safety against LWM sliding.

Assumptions:
1) The LWM structure behaves as a single structure under the design load and will not experience any shearing at joints.
2) The effect of soil in back of the structure is negligible.
3) The structure will be submerged during the design event.
4) Channel velocity (V_c) taken from hydraulic model.
5) This LWM structure experiences the largest loads. All LWM structures on site will be designed based on this LWM structure's loadings.

Input (Cells Requiring Input from Structure Detail)
Input (Cells requiring Input from Hydraulic Model)
Input (Cells requiring input from a dropdown list)
Input (Cells automatically populated from Input to Interface Tab)
Output (Cells automatically updated are this color)
Output (Cells automatically updated with previously calculated values are this color)

FBD and Equations:

$$FOS_{sliding} = \frac{|F_{hd}+F_f+F_{piles-h}+F_{passive}|}{F_d+F_{hu}+F_i}$$ **Equation 41**

*** PROJECT NAME has a "XXXX" Public Safety Risk Factor and a "XXXX" Property Damage Risk Factor. The Design Sliding Factor of Safety ($FOS_{sliding}$) for this structure is #.# per Table 4 "Minimum Recommended Factors of Safety".**

Table 4. Minimum recommended factors of safety.

Public Safety Risk	Property Damage Risk	Stability Design Flow Criteria	$FOS_{sliding}$	$FOS_{bouyancy}$	$FOS_{rotation}$ $FOS_{overturning}$
High	High	100-year	1.75	2.0	1.75
High	Moderate	50-year	1.5	1.75	1.5
High	Low	25-year	1.5	1.75	1.5
Low	High	100-year	1.75	2.0	1.75
Low	Moderate	25-year	1.5	1.75	1.5
Low	Low	10-year	1.25	1.5	1.25

1. Drag Force (F_d)

Y_u	7.00	ft	Upstream water depth
hdebris	5	ft	Debris height (incl. accumulation)
wdebris	15	ft	Debris width (incl. accumulation)
Debris Shape	Rectangle		
A_{LWM}	75	ft^2	Wetted area of LWM
γ_{water}	62.40	lb/ft^3	Unit weight of water
v_c	9.00	ft/s	Velocity from Model
g	32.20	ft/s^2	Acceleration due to gravity
A_b	75.00	ft^2	Debris area
$w_{channel}$	60	ft	Channel width
c_d	1.50		NLWM Worst Case
F_d	8830	lb	Eqn 19

$$F_d = \frac{C_D * A_{LWM} * \gamma_w * U_c^2}{2 * g}$$ **Equation 19**

F_d = drag force
C_d = drag coefficient
A_{LWM} = area of wetted debris based on the upstream water surface elevation projected normal to flow direction and the potential drift accumulation
γ_w = unit weight of water
U_c = velocity in contracted section
g = acceleration due to gravity

Cd can be assumed 0.9 when fully submerged, 1.5 when WSEL within

$$C_{d-applied} = \frac{C_d}{(1-B)^2}$$ C_d is typically estimated as 1.0 **Equation 27**

Sliding Calculations

Project: Tucannon - Small Apex
Project No.: Project Number

Analyst: SJR
Calculations Checked By: SJR
Latest Revision: 5/12/2020

3. Impact Force (F_i)

L_{debris}	30	ft	Length of debris member (Design)
$d_{boledebris}$	1.5	ft	Bole diameter of debris member (Design)
$d_{rwdebris}$	4	ft	Rootwad diameter of debris member (Design)
V_{debris}	66	ft^3	Volume of debris
γ_{wood}	33	lb/ft^3	Unit weight of wood
w_{debris}	2,164	lb	weight of debris
g	32.2	ft/s^2	Acceleration due to gravity
$V_{channel}$	9.0	ft/s	Velocity from Model
Δt	0.03	sec	Impact Interval (0.03 sec recommended)
C_i	0.8		Coefficient of importance (from Table 6)
C_o	0.8		Coefficient of orientation
C_d	1		Figure 11 (need water depth from model)
Degree of Screening or Sheltering Upstream	Limited upstream screening, flow path 20' wide		ASCE 7-05
C_b	0.6		ASCE 7-05
R_{max}	0.8		Response ratio for impulsive loads
F_i	**9,730**	**lb**	**Eqn 30**

$$F_i = \frac{\pi w_{debris} * V_{channel} * C_i * C_o * C_d * C_b * R_{max}}{2 * g * \Delta t}$$ **Equation 30**

F_i = impact force

w_{debris} = weight of debris

g = acceleration constant due to gravity

$V_{channel}$ = water velocity in channel

Δt = time from initial velocity to zero velocity

C_i = coefficient of importance

C_o = coefficient of orientation = 0.8

C_d = coefficient of depth

C_b = coefficient of blockage

R_{max} = response ratio for impulsive loads = 0.8

Assumption:

***Largest impact force would be generated by structure being struck by floating large key member. For impact calculation, assuming 18" diameter, 30' long member with rootwad impacts structure.**
****See Section 6.3.3 of LWM RBDG (P. 44) for debris loading sizing.**

4. Friction Force (F_f)

ϕ_{bed}	0.72	radians	Calculated for streambed material (small cobble)
μ_{bed}	0.87		Eqn 32
F_{LWMd}		lb	Buoyancy Calcs
$F_{boulder}$		lb	Buoyancy Calcs
F_{soil}	23071	lb	Buoyancy Calcs
$F_{piles-v}$		lb	Buoyancy Calcs
F_{LWMs}	-7598	lb	Buoyancy Calcs
F_L	-2649	lb	Buoyancy Calcs
F_b	12,824	lb	Eqn 17
F_f	**-11,148**	**lb**	**Eqn 31**

$$F_f = -\mu_{bed} * (F_b - F_{piles-v})$$ **Equation 31**

F_f = force due to frictional resistance

$F_b - F_{piles-v} > 0$

$$\mu_{bed} = \tan \emptyset$$ **Equation 32**

$$F_b = F_{LWMs} + F_{LWMd} + F_L + F_{boulder} + F_{soil} + F_{piles-v}$$ ***Equation 17***

Note:
***If buoyancy forces are less than vertical pile forces (Fb-Fpiles-v<0), then friction force = 0.**

Sliding Calculations

Project: Tucannon - Small Apex
Project No.: Project Number

Analyst: SJR
Calculations Checked By: SJR
Latest Revision: 5/12/2020

5. Passive Forces ($F_{passive}$)

ϕ_{bank}	0.70	radians	Calculated for bank material (very course gravel)	
K_p	4.60		Eqn 34	4.59890993
γ_{water}	62.4	lb/ft^3	Unit weight of water	
γ_{soil}	131	lb/ft^3	Unit weight of soil	
γ_{sat}	144	lb/ft^3	Previously calculated for buoyancy calcs	
$N_{logssub1}$	1		Number of log type 1 (from detail)	
Orientation$_1$**	Perpendicular		Perpendicular or Parallel to flow	
L_{eb1}	20	ft	Length of log type 1 (from detail)	
d_{bole1}	1.25	ft	Diameter of log type 1 (from detail)	
D_{sub1}		ft	Depth of submerged soil above log 1	
D_{dry1}		ft	Depth of dry soil above log 1	
σ_{v1}		lb/ft^2		
$\sigma_{v1}*L_{eb1}*\gamma_{soil}$		lb		
$N_{logssub2}$	2		Number of log type 2 (from detail)	
Orientation$_2$**	Perpendicular		Perpendicular or Parallel to flow	
L_{eb2}	27	ft	Length of log type 2 (from detail)	
d_{bole2}	1.75	ft	Diameter of log type 2 (from detail)	
D_{sub2}	3	ft	Depth of submerged soil above log 2	
D_{dry2}		ft	Depth of dry soil above log 2	
σ_{v2}	244	lb/ft^2		
$\sigma_{v2}*L_{eb2}*\gamma_{soil}$	23,071	lb		
$N_{logssub3}$			Number of log type 3(from detail)	
Orientation$_3$**	Perpendicular		Perpendicular or Parallel to flow	
L_{eb3}	25	ft	Length of log type 3 (from detail)	
d_{bole3}	1.75	ft	Diameter of log type 3 (from detail)	
D_{sub3}		ft	Depth of submerged soil above log 3	
D_{dry3}		ft	Depth of dry soil above log 3	
σ_{v3}		lb/ft^2		
$\sigma_{v3}*L_{eb3}*\gamma_{soil}$		lb		
$F_{passive}$	**-53,050**	**lb**	**Eqn 31**	

**** Eqns 33 through 35 represent the case where passive forces act along**

$$F_{passive} = -0.5 * K_p * \sum_i^n \sigma_{v_i} * L_{em_i} * d_{log_i}$$ E

$$K_p = \frac{1+\sin\emptyset}{1-\sin\emptyset}$$ E

$$\sigma_{v_i} = D_{sub_i} * (\gamma_{sat} - \gamma_{water}) + D_{dry_i} * \gamma_{soil}$$ E

D_{subi} = depth of submerged soil above log i
D_{dryi} = depth of dry soil above log i
L_{emi} = embedded length of log i
d_{logi} = diameter of log i

Sliding Calculations

Project:	Tucannon - Small Apex	**Analyst:**	SJR
Project No.:	Project Number	**Calculations Checked By:**	SJR
		Latest Revision:	5/12/2020

6. Lateral Resistance from Piles ($F_{piles\text{-}h}$)

N_{piles}			Number of piles (Design)
d_{piles}	0.83	ft	Diameter of piles (Design)
L_{piles}	8	ft	Embedded length of piles below scour (Design)
Placement Method	Excavated		Method of pile placement
Placement Multiplier	0.25		See RBDG (P. 52)
Pile Placement Location	Bed		Bed or Bank
γ_{water}	62.4	lb/ft^3	Unit weight of water
γ_{soil}	137	lb/ft^3	Unit weight of soil
γ_e	74.6	lb/ft^3	Eqn 37
ϕ_{soil}	0.72	radians	Calculated for material pile is located
K_p	4.81		Eqn 38
h_{load}**	2.5	ft	Height above scour depth load is applied
$F_{piles\text{-}h}$		**lb**	**Eqn 15**

*** Top 2' of pile embedment disregarded for calculation to account for vortex shedding.**

**** Analysis also assumes that the resultant force is located at half of the flow depth on the upstream side of the LWM structure to produce a conservative moment on the pile.**

$$F_{piles-h} = -N_{piles} * \frac{L_{pile}^3 * \frac{1}{2} * \gamma_e * d_{pile} * K_p}{h_{load} + L_{pile}}$$ Equation 36

N_{piles} = number of piles

L_{pile} = length of pile embedded below potential scour depth

$$\gamma_e = \gamma_s - \gamma_w$$ *effective unit weight of soil* Equation 37

γ_s = dry unit weight of the soil

γ_w = unit weight of the soil

d_{pile} = diameter of the pile

h_{load} = height above the potential scour depth the load is applied

$$K_p = \frac{1+\sin\phi}{1-\sin\phi}$$ Equation 38

Factor of Safety

$FOS_{sliding}$ =	*$(F_{hd} + F_f + F_{piles\text{-}h} + F_{passive}) / (F_d + F_{hu} + F_i)$*		
F_d	8,830	lb	
F_{hu}		lb	
F_{hd}		lb	
F_i	9,730	lb	
F_f	-11,148	lb	
$F_{passive}$	-53,050	lb	
$F_{piles\text{-}h}$		lb	
$FOS_{sliding}$	**3.46**		**STABLE FOR SLIDING**

Summary Comments:

Rotation Calculations

Project: Tucannon - Small Apex
Project Number: Project Number

Analyst: SJR
Calculations Checked By: SJR
Latest Revision: 5/12/2020

Spreadsheet Description

Purpose: The spreadsheet below is used to calculate the Factor of Safety against LWM structure horizontal rotation.

Assumptions:
1) The LWM structue behaves as a single structure under the design load.
2) The effect of soil in back of the structure is negligible.
3) The structure will be submerged during the design event
4) This LWM structure experiences the largest loads. All LWM structures on site will be designed based on this LWM structure's loadings

Input (Cells Requiring Input from Structure Detail)
Input (Cells requiring Input from Hydraulic Model)
Input (Cells requiring input from a dropdown list)
Input (Cells automatically populated from Input to Interface Tab)
Output (Cells that are automatically updated are this color)
Output (Cells that are automatically updated with previously calculated values are this color)

FBD and Equations:

$$FOS_{rotation} = \frac{MR_{rotation}}{MD_{rotation}}$$ **Equation 45**

*** PROJECT NAME has a "XXXX" Public Safety Risk Factor and a "XXXX" Property Damage Risk Factor. The Design Rotation Factor of Safety ($FOS_{rotation}$) for this structure is #.# per Table 4 "Minimum Recommended Factors of Safety".**

Table 4. Minimum recommended factors of safety.

Public Safety Risk	Property Damage Risk	Stability Design Flow Criteria	$FOS_{sliding}$	$FOS_{bouyancy}$	$FOS_{rotation}$ $FOS_{overturning}$
High	High	100-year	1.75	2.0	1.75
High	Moderate	50-year	1.5	1.75	1.5
High	Low	25-year	1.5	1.75	1.5
Low	High	100-year	1.75	2.0	1.75
Low	Moderate	25-year	1.5	1.75	1.5
Low	Low	10-year	1.25	1.5	1.25

1. Resistance to Rotation ($MR_{rotation}$ and $MD_{rotation}$)

$$MD_{rotation} = (F_i + F_d + F_{hu}) * \left(\frac{L_{sp}+L_{ebp}}{2}\right)$$ **Equation 42**

L_{sp} = length of wood structure from tip to point of rotation measured perpendicular to flow

L_{ebp} = embedded length of wood structure measured perpendicular to flow

$$MR_{rotation} = \left| F_{hd} * \left(\frac{L_{sp} + L_{ebp}}{2}\right) + F_{passive} * \frac{L_{ebp}}{2} + F_f * \frac{L_{sp}}{2} + \sum_{i}^{n} F_{pile-h_i} * L_{ph_i} \right|$$

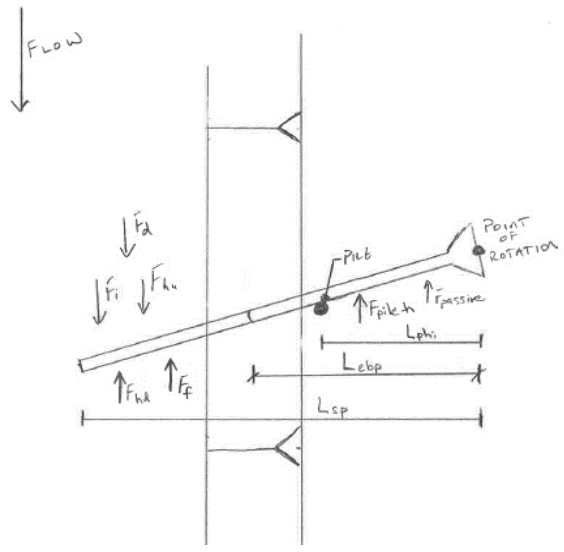
Equation 43

$$F_{pile-h_i} = \frac{F_{piles-h}}{N_{piles}}$$ **Equation 44**

L_{phi} = distance from pile 'i' to the point of rotation measured perpendicular to flow

Driving:

L_{sp}	40	ft	Length of wood structure from tip to point of rotation measured perpendicular to flow
L_{ebp}	27	ft	Embedded length of wood structure measured perp. to flow
F_i	9,730	lb	Impact Forces (Calc'd in Sliding)
F_d	8,830	lb	Drag Forces (Calc'd in Sliding)
F_{hu}		lb	Upstream Hydrostatic Forces (Calc'd in Sliding)
$MD_{rotation}$	**621,731**	**lb*ft**	**Eqn 42**



Resisting:

F_{hd}		lb	Downstream Hydrostatic Forces (Calc'd in Sliding)
$F_{passive}$	-53,050	lb	Passive Forces (Calc'd in Sliding)
F_f	-11,148	lb	Friction Forces (Calc'd in Sliding)
F_{pile-h}		lb	Lateral Resistance from Piles (Calc'd in Sliding)
$F_{pile-hi}$		lb	Lateral Resistance from Piles (Calc'd in Sliding)
N_{piles}			Number of Piles (Design)
L_{phi}	25	ft	Distance from pile to the point of rotation measured perp. to flow
$MR_{rotation}$	**939,137**	**lb*ft**	**Eqn 43**

Factor of Safety

$FOS_{rotation}$ =	$MR_{rotation}$ / $MD_{rotation}$		
$MD_{rotation}$	621,731	lb	
$MR_{rotation}$	939,137	lb	
$FOS_{rotation}$	**1.51**		**STABLE FOR ROTATION**

Summary Comments:

Buoyancy Calculations

Project: Tucannon - Margin Deflector
Project No.: Project Number

Analyst: SJR
Calculations Checked By: SJR
Latest Revision: 5/12/2020

Spreadsheet Description

- The spreadsheet below is used to calculate the Factor of Safety against Buoyant uplift of the LWM

Assumptions:

1) The LWM structure behaves as a single structure under the design load and will not experience any shearing at joints
2) The LWM structure will be submerged during the design event.
3) Negative buoyancy is uplift, positive numbers equals downward.
4) Ballast material remains intact and is not scoured out.
5) The uplift due to racking material is evenly dividing among all layers.

Input (Cells Requiring Input from Structure Detail)
Input (Cells requiring Input from Hydraulic Model)
Input (Cells automatically populated from Input to Interface Tab)
Input (Cells requiring input from a dropdown list)
Output (Cells automatically updated are this color)
Output (Cells automatically updated with previously calculated values are this color)

FBD and Equations:

$$FOS_b = \frac{F_{LWMd}+F_{boulders}+F_{soil}+F_{piles-v}}{|F_{LWMs}+F_L|}$$ **Equation 18**

FOS_b = *buoyancy factor of safety*

*** PROJECT NAME has a "XXXX" Public Safety Risk Factor and a "XXXX" Property Damage Risk Factor. The Design buoyancy factor of safety (FOS_b) for this structure is #.# per Table 4 "*Minimum Recommended Factors of Safety*".**

Table 4. Minimum recommended factors of safety.

Public Safety Risk	Property Damage Risk	Stability Design Flow Criteria	$FOS_{sliding}$	$FOS_{buoyancy}$	$FOS_{rotation}$ $FOS_{overturning}$
High	High	100-year	1.75	2.0	1.75
High	Moderate	50-year	1.5	1.75	1.5
High	Low	25-year	1.5	1.75	1.5
Low	High	100-year	1.75	2.0	1.75
Low	Moderate	25-year	1.5	1.75	1.5
Low	Low	10-year	1.25	1.5	1.25

1. Large Wood Material Force - Dry (F_{LWMd})

$$F_{LWMd} = V_{LWMd} * \gamma_{wood}$$ **Equation 3**

V_{LWMd} = *volume of dry large wood material*

Comment: Assumed to be zero because structure assumed to be submerged during design event.

2. Boulder Ballast Force ($F_{boulder}$)

$N_{bouldersub}$			Number of submerged boulders (from design)
$d_{bouldersub}$	2.5	ft	Effective diameter of submerged boulder (ft, from spec)
$\gamma_{boulder}$	146	lb/ft^3	unit weight of boulders (Table 5)
γ_{water}	62.4	lb/ft^3	unit weight of water
$F_{bouldersub}$		lb	Eqn. 6
$N_{boulderdry}$			Number of dry boulders (from detail)
$d_{boulderdry}$	2.5	ft	Effective diameter of dry boulder (ft, from spec)
$F_{boulderdry}$		lb	Eqn. 7
$F_{boulder}$		**lb**	**Eqn. 5**

$$F_{boulder} = F_{bouldersub} + F_{boulderdry}$$ **Equation 5**

$$F_{bouldersub} = N_{bouldersub} * \frac{\pi}{6} * d_{bouldersub}^3 * (\gamma_{boulder} - \gamma_w)$$ **Equation 6**

$N_{bouldersub}$ = *number of submerged boulders*
$d_{bouldersub}$ = *effective diameter of submerged boulders*
$\gamma_{boulder}$ = *unit weight of boulders*

$$F_{boulderdry} = N_{boulderdry} * \frac{\pi}{6} * d_{boulderdry}^3 * \gamma_{boulder}$$ **Equation 7**

$N_{boulderdry}$ = *number of unsubmerged boulders*
$d_{boulderdry}$ = *effective diameter of unsubmerged boulders*

Comment: The intent is design without the use of boulders so it is assumed no boulders are used.

Buoyancy Calculations

Project: Tucannon - Margin Deflector
Project No.: Project Number

Analyst: SJR
Calculations Checked By: SJR
Latest Revision: 5/12/2020

3. Soil Backfill Force (F_{soil})

$N_{logssub1}$	2		Number of Type 1 buried logs (from detail)
L_{eb1}	25	ft	Average embedded length of Type 1 logs (from detail)
d_{bole1}	1.5	ft	Average diameter of Type 1 logs (from detail)
$h_{soilsub1}$	3	ft	Average height of submerged soil above Type 1 log (from detail)
$V_{soilsub1}$	225	ft^3	Volume of submerged soil above Type 1 log (from detail)
$h_{soildry1}$		ft	Average height of dry soil above Type 1 log (from detail)
$V_{soildry1}$		ft^3	Volume of dry soil above Type 1 log (from detail)
$N_{logssub2}$	1		Number of Type 2 buried logs (from detail)
L_{eb2}	25	ft	Average embedded length of Type 2 logs (from detail)
d_{bole2}	1.5	ft	Average diameter of Type 2 logs (from detail)
$h_{soilsub2}$		ft	Average height of submerged soil above Type 2 log (from detail)
$V_{soilsub2}$		ft^3	Volume of submerged soil above Type 2 log (from detail)
$h_{soildry2}$		ft	Average height of dry soil above Type 2 log (from detail)
$V_{soildry2}$		ft^3	Volume of dry soil above Type 2 log (from detail)
$N_{logssub3}$	1		Number of Type 3 buried logs (from detail)
L_{eb3}	30	ft	Average embedded length of Type 3 logs (from detail)
d_{bole3}	1.25	ft	Average diameter of Type 3 logs (from detail)
$h_{soilsub3}$		ft	Average height of submerged soil above Type 3 log (from detail)
$V_{soilsub3}$		ft^3	Volume of submerged soil above Type 3 log (from detail)
$h_{soildry3}$		ft	Average height of dry soil above Type 3 log (from detail)
$V_{soildry3}$		ft^3	Volume of dry soil above Type 3 log (from detail)
γ_{soil}	131	lb/ft^3	Specific Gravity of bank/backfill material (Table 5)
γ_{water}	62.4	lb/ft^3	Unit weight of water
SG_{rock}	2.64		Specific Gravity of Rock (Using unit weight of bedrock from Table 5)
e	0.26		Eqn. 14
γ_{sat}	144	lb/ft^3	Eqn. 13
γ'_{soil}	81.4	lb/ft^3	Eqn. 12
F_{soil}	**18,310**	**lb**	**Eqn. 8**

$$F_{soil} = \sum_i^n V_{soilsub_i} * \gamma'_{soil} + V_{soildry_i} * \gamma_{soil}$$ **Equation 8**

$$V_{soilsub_i} = L_{eb_i} d_{bole_i} h_{soilsub_i}$$ **Equation 9**

$V_{soilsubi}$ = volume of submerged soil above log i
L_{ebi} = embedded length of log i
d_{bolei} = bole diameter of log i
$h_{soilsubi}$ = height of submerged soil above log i

$$V_{soildry_i} = L_{eb_i} d_{bole_i} h_{soildry_i}$$ ***Equation 10***

$V_{soildryi}$ = volume of dry soil above log i
$h_{soildryi}$ = height of dry soil above log i

$$\gamma_{soil} = (99.2 + 18.6 * \log(d_{50}))$$ **Equation 11**

d_{50} = median grain size in millimeters

$$\gamma'_{soil} = \gamma_{sat} - \gamma_w$$ **Equation 12**

$$\gamma_{sat} = \frac{(SG_{rock} + e) * \gamma_w}{1 + e}$$ **Equation 13**

$$e = \frac{SG_{rock} * \gamma_w}{\gamma_{soil}} - 1$$ **Equation 14**

Buoyancy Calculations

Project: Tucannon - Margin Deflector
Project No.: Project Number

Analyst: SJR
Calculations Checked By: SJR
Latest Revision: 5/12/2020

4. Pile Skin Friction

N_{piles}	2		Number of piles (Design)
d_{piles}	0.83	ft	Diameter of piles (Design)
L_{piles}	10	ft	Embedded length of piles (Design)
k_s	1		Coefficient of lateral earth pressure (0.5 to 1.5 depending on soil and density)
Placement Method	Excavated		Method of pile placement
Placement Multiplier	0.25		See RBDG (P. 52)
Pile Placement Location	Bed		Bed or Bank
ϕ_{soil}	0.72	rad	Internal angle of friction of soils (Table 5)
γ_{soil}	137	lb/ft^3	Specific Weight of Soil
e	0.20		Eqn. 14
γ_{sat}	148	lb/ft^3	Eqn. 13
γ_{water}	62.4	lb/ft^3	Unit weight of water
σ'	851	lb/ft^2	Eqn 16
γ_{wood}	33	lb/ft^3	Unit weight of wood
$F_{piles-v}$	**5,656**	**lb**	**Eqn 15**

Assumptions:
*** k_s = 1**
**** This calculation is based on the assumption that piles are driven or vibrated into place. If piles are drilled or excavated, the associated coefficicient of lateral earth pressures shall be approx. 50% and 25% of the driven value, respectively.**
***** For use in buoyancy calculations, piles must be mechanically fastened.**
****** Top 2' of pile embedment disregarded for calculation to account for vortex shedding.**

$$F_{piles-v} = N_{piles} * \pi * d_{piles} * L_{piles}(k_s * \tan\frac{2}{3}\emptyset * \sigma' + \frac{d_{piles}}{4} * (\gamma_{wood} - \gamma_w))$$

Equation 15

N_{piles} = number of piles
d_{piles} = diameter of piles
L_{piles} = embedded length of piles
k_s = coefficient of lateral earth pressure (0.5 to 1.5 depending on soil and density)
ϕ = internal angle of friction of soils

$$\sigma' = L_{piles} * (\gamma_{sat} - \gamma_w)$$

Equation 16

$$\gamma_{sat} = \frac{(SG_{rock} + e) * \gamma_w}{1 + e}$$

Equation 13

$$e = \frac{SG_{rock} * \gamma_w}{\gamma_{soil}} - 1$$

Equation 14

Buoyancy Calculations

Project: Tucannon - Margin Deflector
Project No.: Project Number

Analyst: SJR
Calculations Checked By: SJR
Latest Revision: 5/12/2020

5. Large Wood Material Force - Submerged (F_{LWMs})

$$F_{LWMs} = V_{LWMs} * (\gamma_{wood} - \gamma_w)$$ **Equation 2**

V_{LWMs} = volume of submerged large wood material
γ_{wood} = unit weight of wood
γ_w = unit weight of water

$N_{logssub1}$	2		Number of log type 1 (from detail)
L_{log1}	40	ft	Length of log type 1 (from detail)
d_{bole1}	1.5	ft	Diameter of log type 1 (from detail)
d_{rw1}	3.75	ft	Diameter of rootwad of log type 1 (from detail)
V_{LWMs1}	163	ft^3	Volume of LWM1
$N_{logssub2}$	1		Number of log type 2 (from detail)
L_{eb2}	40	ft	Length of log type 2 (from detail)
d_{bole2}	1.5	ft	Diameter of log type 2 (from detail)
d_{rw2}	3.75	ft	Diameter of rootwad of log type 2 (from detail)
V_{LWMs2}	82	ft^3	Volume of LWM2
$N_{logssub3}$	1		Number of log type 3 (from detail)
L_{eb3}	30	ft	Length of log type 3 (from detail)
d_{bole3}	1.25	ft	Diameter of log type 3 (from detail)
d_{rw3}	3.13	ft	Diameter of rootwad of log type 3 (from detail)
V_{LWMs3}	43	ft^3	Volume of LWM3
V_{LWMs}	288	ft^3	Volume of LWM
γ_{wood}	33.0	lb/ft^3	Unit weight of logs
γ_w	62.4	lb/ft^3	Unit weight of water
F_{LWMs}	**-8,479**	**lb**	**Eqn. 3**

Volume of Rootwad

National Large Wood Manual. 2016

Equation 6-4 (p. 6-38)

$V_{rw} = \pi * t_k * w_k^2 / 3$

$\pi * (2d_{bole}) * (1/2d_{rw})^2 / 3$

t_k = Thickness of rootwad measured in direction parallel to trunk

= 4 times the radius of the log ($4r_k$ or

w_k =

Radius of rootwad

= 2.5 times the radius of the log ($2.5r_k$ or $1.25d_{bole}$) or 1/2 d_{rw} specified

6. Lift Forces (F_L)

$$F_L = -\frac{C_L * A_{LWM} * \gamma_w * U_o^2}{2 * g}$$ **Equation 4**

C_L = lift coefficient
A_{LWM} = area of large woody material perpendicular to flow
u_o = upstream channel velocity at design event
g = acceleration due to gravity

C_L	0.45		Lift Coefficient
A_{LWM}	72	ft^2	Calc'd in Drag Forces
γ_w	62.4	lb/ft^3	Unit weight of water
U_o	9.0	ft/s	upstream velocity (from model)
g	32.2	ft/s^2	Unit weight of water
F_L	**-2,543**	**lb**	**Eqn. 4**

Comment: Lift forces neglected per Section 6.4.2 of BOR Risk Based Design Guidelines

Factor of Safety

FOS_b =	*$(F_{LMDd} + F_{boulders} + F_{soil} + F_{piles\text{-}v}) / (F_{LWMs} + F_L)$*		
F_{LWMd}		lb	Assumed Zero
$F_{boulder}$		lb	
F_{soil}	18,310	lb	
$F_{piles\text{-}v}$	5,656	lb	
F_{LWMs}	-8,479	lb	
F_L	-2,543	lb	
FOS_b	**2.17**		**STABLE FOR BUOYANCY**

Summary Comments:

Sliding Calculations

Project:	Tucannon - Margin Deflector	**Analyst:**	SJR
Project No.:	Project Number	**Calculations Checked By:**	SJR
		Latest Revision:	5/12/2020

Spreadsheet Description

Purpose: The spreadsheet below is used to calculate the Factor of Safety against LWM sliding.

Assumptions:
1) The LWM structure behaves as a single structure under the design load and will not experience any shearing at joints.
2) The effect of soil in back of the structure is negligible.
3) The structure will be submerged during the design event.
4) Channel velocity (V_c) taken from hydraulic model.
5) This LWM structure experiences the largest loads. All LWM structures on site will be designed based on this LWM structure's loadings.

Input (Cells Requiring Input from Structure Detail)
Input (Cells requiring Input from Hydraulic Model)
Input (Cells requiring input from a dropdown list)
Input (Cells automatically populated from Input to Interface Tab)
Output (Cells automatically updated are this color)
Output (Cells automatically updated with previously calculated values are this color)

FBD and Equations:

$$FOS_{sliding} = \frac{|F_{hd}+F_f+F_{piles-h}+F_{passive}|}{F_d+F_{hu}+F_l}$$ Equation 41

*** PROJECT NAME has a "XXXX" Public Safety Risk Factor and a "XXXX" Property Damage Risk Factor. The Design Sliding Factor of Safety ($FOS_{sliding}$) for this structure is #.# per Table 4 "Minimum Recommended Factors of Safety".**

Table 4. Minimum recommended factors of safety.

Public Safety Risk	Property Damage Risk	Stability Design Flow Criteria	$FOS_{sliding}$	$FOS_{bouyancy}$	$FOS_{rotation}$ $FOS_{overturning}$
High	High	100-year	1.75	2.0	1.75
High	Moderate	50-year	1.5	1.75	1.5
High	Low	25-year	1.5	1.75	1.5
Low	High	100-year	1.75	2.0	1.75
Low	Moderate	25-year	1.5	1.75	1.5
Low	Low	10-year	1.25	1.5	1.25

1. Drag Force (F_d)

Y_u	6.00	ft	Upstream water depth
hdebris	6	ft	Debris height (incl. accumulation)
wdebris	12	ft	Debris width (incl. accumulation)
Debris Shape	Rectangle		
A_{LWM}	72	ft^2	Wetted area of LWM
γ_{water}	62.40	lb/ft^3	Unit weight of water
v_c	9.00	ft/s	Velocity from Model
g	32.20	ft/s^2	Acceleration due to gravity
A_b	72.00	ft^2	Debris area
$w_{channel}$	60	ft	Channel width
c_d	1.50		NLWM Worst Case
F_d	8476	lb	Eqn 19

$$F_d = \frac{C_D * A_{LWM} * \gamma_w * U_c^2}{2 * g}$$ **Equation 19**

$F_d = drag\ force$
$C_d = drag\ coefficient$
A_{LWM} = *area of wetted debris based on the upstream water surface elevation projected normal to flow direction and the potential drift accumulation*
$\gamma_w = unit\ weight\ of\ water$
$U_c = velocity\ in\ contracted\ section$
$g = acceleration\ due\ to\ gravity$

Cd can be assumed 0.9 when fully submerged, 1.5 when WSEL within

$$C_{d-applied} = \frac{C_d}{(1-B)^2}$$ C_d is typically estimated as 1.0 **Equation 27**

Sliding Calculations

Project: Tucannon - Margin Deflector
Project No.: Project Number

Analyst: SJR
Calculations Checked By: SJR
Latest Revision: 5/12/2020

3. Impact Force (F_i)

L_{debris}	30	ft	Length of debris member (Design)
$d_{boledebris}$	1.5	ft	Bole diameter of debris member (Design)
$d_{rwdebris}$	4	ft	Rootwad diameter of debris member (Design)
V_{debris}	66	ft^3	Volume of debris
γ_{wood}	33	lb/ft^3	Unit weight of wood
w_{debris}	2,164	lb	weight of debris
g	32.2	ft/s^2	Acceleration due to gravity
$V_{channel}$	9.0	ft/s	Velocity from Model
Δt	0.03	sec	Impact Interval (0.03 sec recommended)
C_i	0.5		Coefficient of importance (from Table 6)
C_o	0.8		Coefficient of orientation
C_d	1		Figure 11 (need water depth from model)
Degree of Screening or Sheltering Upstream	Limited upstream screening, flow path 20' wide		ASCE 7-05
C_b	0.6		ASCE 7-05
R_{max}	0.8		Response ratio for impulsive loads
F_i	**6,081**	**lb**	**Eqn 30**

$$F_i = \frac{\pi w_{debris} * V_{channel} * C_i * C_o * C_d * C_b * R_{max}}{2 * g * \Delta t}$$ **Equation 30**

F_i = impact force

w_{debris} = weight of debris

g = acceleration constant due to gravity

$V_{channel}$ = water velocity in channel

Δt = time from initial velocity to zero velocity

C_i = coefficient of importance

C_o = coefficient of orientation = 0.8

C_d = coefficient of depth

C_b = coefficient of blockage

R_{max} = response ratio for impulsive loads = 0.8

Assumption:

***Largest impact force would be generated by structure being struck by floating large key member. For impact calculation, assuming 18" diameter, 30' long member with rootwad impacts structure.**
****See Section 6.3.3 of LWM RBDG (P. 44) for debris loading sizing.**

4. Friction Force (F_f)

ϕ_{bed}	0.72	radians	Calculated for streambed material (small cobble)
μ_{bed}	0.87		Eqn 32
F_{LWMd}		lb	Buoyancy Calcs
$F_{boulder}$		lb	Buoyancy Calcs
F_{soil}	18310	lb	Buoyancy Calcs
$F_{piles\text{-}v}$	5656	lb	Buoyancy Calcs
F_{LWMs}	-8479	lb	Buoyancy Calcs
F_L	-2543	lb	Buoyancy Calcs
F_b	12,944	lb	Eqn 17
F_f	**-6,336**	**lb**	**Eqn 31**

$$F_f = -\mu_{bed} * (F_b - F_{piles-v})$$ **Equation 31**

F_f = force due to frictional resistance

$F_b - F_{piles\text{-}v} > 0$

$$\mu_{bed} = \tan \emptyset$$ **Equation 32**

$$F_b = F_{LWMs} + F_{LWMd} + F_L + F_{boulder} + F_{soil} + F_{piles-v}$$ ***Equation 17***

Note:
***If buoyancy forces are less than vertical pile forces (Fb-Fpiles-v<0), then friction force = 0.**

Sliding Calculations

Project: Tucannon - Margin Deflector
Project No.: Project Number

Analyst: SJR
Calculations Checked By: SJR
Latest Revision: 5/12/2020

5. Passive Forces ($F_{passive}$)

ϕ_{bank}	0.70	radians	Calculated for bank material (very course gravel)
K_p	4.60		Eqn 34
γ_{water}	62.4	lb/ft^3	Unit weight of water
γ_{soil}	131	lb/ft^3	Unit weight of soil
γ_{sat}	144	lb/ft^3	Previously calculated for buoyancy calcs
$N_{logssub1}$	2		Number of log type 1 (from detail)
Orientation$_1$**	Perpendicular		Perpendicular or Parallel to flow
L_{eb1}	25	ft	Length of log type 1 (from detail)
d_{bole1}	1.5	ft	Diameter of log type 1 (from detail)
D_{sub1}	3	ft	Depth of submerged soil above log 1
D_{dry1}		ft	Depth of dry soil above log 1
σ_{v1}	244	lb/ft^2	
$\sigma_{v1}*L_{eb1}*\gamma_{soil}$	18,310	lb	
$N_{logssub2}$	1		Number of log type 2 (from detail)
Orientation$_2$**	Perpendicular		Perpendicular or Parallel to flow
L_{eb2}	25	ft	Length of log type 2 (from detail)
d_{bole2}	1.5	ft	Diameter of log type 2 (from detail)
D_{sub2}		ft	Depth of submerged soil above log 2
D_{dry2}		ft	Depth of dry soil above log 2
σ_{v2}		lb/ft^2	
$\sigma_{v2}*L_{eb2}*\gamma_{soil}$		lb	
$N_{logssub3}$	1		Number of log type 3(from detail)
Orientation$_3$**	Parallel		Perpendicular or Parallel to flow
L_{eb3}	30	ft	Length of log type 3 (from detail)
d_{bole3}	1.25	ft	Diameter of log type 3 (from detail)
D_{sub3}		ft	Depth of submerged soil above log 3
D_{dry3}		ft	Depth of dry soil above log 3
σ_{v3}		lb/ft^2	
$\sigma_{v3}*L_{eb3}*\gamma_{soil}$		lb	
$F_{passive}$	**-42,104**	**lb**	**Eqn 31**

**** Eqns 33 through 35 represent the case where passive forces act along**

$$F_{passive} = -0.5 * K_p * \sum_i^n \sigma_{v_i} * L_{em_i} * d_{log_i} \qquad \text{Equation 33}$$

$$K_p = \frac{1+\sin\phi}{1-\sin\phi} \qquad \text{Equation 34}$$

$$\sigma_{v_i} = D_{sub_i} * (\gamma_{sat} - \gamma_{water}) + D_{dry_i} * \gamma_{soil} \qquad \text{Equation 35}$$

D_{subi} = depth of submerged soil above log i
D_{dryi} = depth of dry soil above log i
L_{emi} = embedded length of log i
d_{logi} = diameter of log i

Sliding Calculations

Project: Tucannon - Margin Deflector
Project No.: Project Number

Analyst: SJR
Calculations Checked By: SJR
Latest Revision: 5/12/2020

6. Lateral Resistance from Piles ($F_{piles\text{-}h}$)

N_{piles}	2		Number of piles (Design)
d_{piles}	0.83	ft	Diameter of piles (Design)
L_{piles}	10	ft	Embedded length of piles below scour (Design)
Placement Method	Excavated		Method of pile placement
Placement Multiplier	0.25		See RBDG (P. 52)
Pile Placement Location	Bed		Bed or Bank
γ_{water}	62.4	lb/ft^3	Unit weight of water
γ_{soil}	137	lb/ft^3	Unit weight of soil
γ_e	74.6	lb/ft^3	Eqn 37
ϕ_{soil}	0.72	radians	Calculated for material pile is located
K_p	4.81		Eqn 38
h_{load}**	3	ft	Height above scour depth load is applied
$F_{piles\text{-}h}$	**-5,733**	**lb**	**Eqn 15**

*** Top 2' of pile embedment disregarded for calculation to account for vortex shedding.**
**** Analysis also assumes that the resultant force is located at half of the flow depth on the upstream side of the LWM structure to produce a conservative moment on the pile.**

$$F_{piles-h} = -N_{piles} * \frac{L_{pile}^3 * \frac{1}{2} * \gamma_e * d_{pile} * K_p}{h_{load} + L_{pile}}$$ Equation 36

N_{piles} = number of piles
L_{pile} = length of pile embedded below potential scour depth

$$\gamma_e = \gamma_s - \gamma_w$$ *effective unit weight of soil* Equation 37

γ_s = dry unit weight of the soil

γ_w = unit weight of the soil
d_{pile} = diameter of the pile
h_{load} = height above the potential scour depth the load is applied

$$K_p = \frac{1+\sin\phi}{1-\sin\phi}$$ Equation 38

Factor of Safety

$FOS_{sliding}$ =	$(F_{hd} + F_f + F_{piles\text{-}h} + F_{passive}) / (F_d + F_{hu} + F_i)$		
F_d	8,476	lb	
F_{hu}		lb	
F_{hd}		lb	
F_i	6,081	lb	
F_f	-6,336	lb	
$F_{passive}$	-42,104	lb	
$F_{piles\text{-}h}$	-5,733	lb	
$FOS_{sliding}$	**3.72**		**STABLE FOR SLIDING**

Summary Comments:

Rotation Calculations

Project:	Tucannon - Margin Deflector	**Analyst:**	SJR
Project Number:	Project Number	**Calculations Checked By:**	SJR
		Latest Revision:	5/12/2020

Spreadsheet Description

Purpose: The spreadsheet below is used to calculate the Factor of Safety against LWM structure horizontal rotation.

Assumptions:
1) The LWM structue behaves as a single structure under the design load.
2) The effect of soil in back of the structure is negligible.
3) The structure will be submerged during the design event
4) This LWM structure experiences the largest loads. All LWM structures on site will be designed based on this LWM structure's loadings

Input (Cells Requiring Input from Structure Detail)
Input (Cells requiring Input from Hydraulic Model)
Input (Cells requiring input from a dropdown list)
Input (Cells automatically populated from Input to Interface Tab)
Output (Cells that are automatically updated are this color)
Output (Cells that are automatically updated with previously calculated values are this color)

FBD and Equations:

$$FOS_{rotation} = \frac{MR_{rotation}}{MD_{rotation}}$$ **Equation 45**

*** PROJECT NAME has a "XXXX" Public Safety Risk Factor and a "XXXX" Property Damage Risk Factor. The Design Rotation Factor of Safety ($FOS_{rotation}$) for this structure is #.# per Table 4 "Minimum Recommended Factors of Safety".**

Table 4. Minimum recommended factors of safety.

Public Safety Risk	Property Damage Risk	Stability Design Flow Criteria	$FOS_{sliding}$	$FOS_{bouyancy}$	$FOS_{rotation}$ $FOS_{overturning}$
High	High	100-year	1.75	2.0	1.75
High	Moderate	50-year	1.5	1.75	1.5
High	Low	25-year	1.5	1.75	1.5
Low	High	100-year	1.75	2.0	1.75
Low	Moderate	25-year	1.5	1.75	1.5
Low	Low	10-year	1.25	1.5	1.25

1. Resistance to Rotation ($MR_{rotation}$ and $MD_{rotation}$)

$$MD_{rotation} = (F_i + F_d + F_{hu}) * \left(\frac{L_{sp}+L_{ebp}}{2}\right)$$ **Equation 42**

L_{sp} = length of wood structure from tip to point of rotation measured perpendicular to flow

L_{ebp} = embedded length of wood structure measured perpendicular to flow

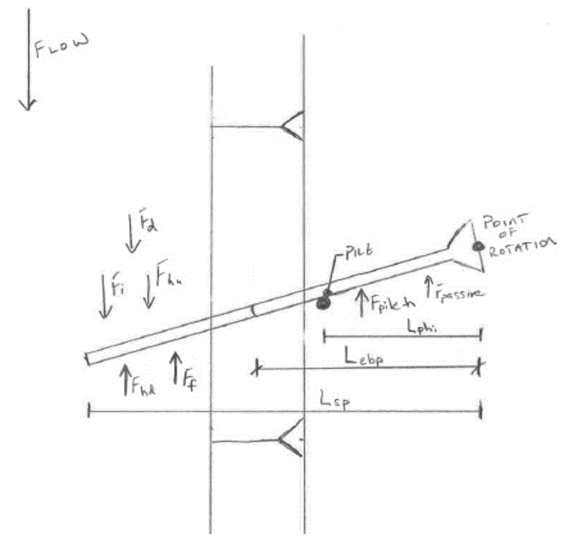
$$MR_{rotation} = \left| F_{hd} * \left(\frac{L_{sp} + L_{ebp}}{2}\right) + F_{passive} * \frac{L_{ebp}}{2} + F_f * \frac{L_{sp}}{2} + \sum_{i}^{n} F_{pile-h_i} * L_{ph_i} \right|$$ **Equation 43**

$$F_{pile-h_i} = \frac{F_{piles-h}}{N_{piles}}$$ **Equation 44**

L_{phi} = distance from pile 'i' to the point of rotation measured perpendicular to flow

Driving:

L_{sp}	40	ft	Length of wood structure from tip to point of rotation measured perpendicular to flow
L_{ebp}	25	ft	Embedded length of wood structure measured perp. to flow
F_i	6,081	lb	Impact Forces (Calc'd in Sliding)
F_d	8,476	lb	Drag Forces (Calc'd in Sliding)
F_{hu}		lb	Upstream Hydrostatic Forces (Calc'd in Sliding)
$MD_{rotation}$	**473,114**	**lb*ft**	**Eqn 42**



Resisting:

F_{hd}		lb	Downstream Hydrostatic Forces (Calc'd in Sliding)
$F_{passive}$	-42,104	lb	Passive Forces (Calc'd in Sliding)
F_f	-6,336	lb	Friction Forces (Calc'd in Sliding)
F_{pile-h}	-5,733	lb	Lateral Resistance from Piles (Calc'd in Sliding)
$F_{pile-hi}$	-2,867	lb	Lateral Resistance from Piles (Calc'd in Sliding)
N_{piles}	2		Number of Piles (Design)
L_{phi}	10	ft	Distance from pile to the point of rotation measured perp. to flow
$MR_{rotation}$	**710,342**	**lb*ft**	**Eqn 43**

Factor of Safety

$FOS_{rotation}$ =	$MR_{rotation}$ / $MD_{rotation}$		
$MD_{rotation}$	473,114	lb	
$MR_{rotation}$	710,342	lb	
$FOS_{rotation}$	**1.50**		**STABLE FOR ROTATION**

Summary Comments:

Buoyancy Calculations

Project: Tucannon - Bank Jam
Project No.: Project Number

Analyst: SJR
Calculations Checked By: SJR
Latest Revision: 5/12/2020

Spreadsheet Description

- The spreadsheet below is used to calculate the Factor of Safety against Buoyant uplift of the LWM

Assumptions:

1) The LWM structure behaves as a single structure under the design load and will not experience any shearing at joints
2) The LWM structure will be submerged during the design event.
3) Negative buoyancy is uplift, positive numbers equals downward.
4) Ballast material remains intact and is not scoured out.
5) The uplift due to racking material is evenly dividing among all layers.

Input (Cells Requiring Input from Structure Detail)
Input (Cells requiring Input from Hydraulic Model)
Input (Cells automatically populated from Input to Interface Tab)
Input (Cells requiring input from a dropdown list)
Output (Cells automatically updated are this color)
Output (Cells automatically updated with previously calculated values are this color)

FBD and Equations:

$$FOS_b = \frac{F_{LWMd}+F_{boulders}+F_{soil}+F_{piles-v}}{|F_{LWMs}+F_L|}$$ **Equation 18**

FOS_b = *buoyancy factor of safety*

*** PROJECT NAME has a "XXXX" Public Safety Risk Factor and a "XXXX" Property Damage Risk Factor. The Design buoyancy factor of safety (FOS_b) for this structure is #.# per Table 4 "*Minimum Recommended Factors of Safety*".**

Table 4. Minimum recommended factors of safety.

Public Safety Risk	Property Damage Risk	Stability Design Flow Criteria	$FOS_{sliding}$	$FOS_{buoyancy}$	$FOS_{rotation}$ $FOS_{overturning}$
High	High	100-year	1.75	2.0	1.75
High	Moderate	50-year	1.5	1.75	1.5
High	Low	25-year	1.5	1.75	1.5
Low	High	100-year	1.75	2.0	1.75
Low	Moderate	25-year	1.5	1.75	1.5
Low	Low	10-year	1.25	1.5	1.25

1. Large Wood Material Force - Dry (F_{LWMd})

$$F_{LWMd} = V_{LWMd} * \gamma_{wood}$$ **Equation 3**

V_{LWMd} = *volume of dry large wood material*

Comment: Assumed to be zero because structure assumed to be submerged during design event.

2. Boulder Ballast Force ($F_{boulder}$)

$N_{bouldersub}$	24		Number of submerged boulders (from design)
$d_{bouldersub}$	3	ft	Effective diameter of submerged boulder (ft, from spec)
$\gamma_{boulder}$	146	lb/ft^3	unit weight of boulders (Table 5)
γ_{water}	62.4	lb/ft^3	unit weight of water
$F_{bouldersub}$	28,365	lb	Eqn. 6
$N_{boulderdry}$			Number of dry boulders (from detail)
$d_{boulderdry}$	3	ft	Effective diameter of dry boulder (ft, from spec)
$F_{boulderdry}$		lb	Eqn. 7
$F_{boulder}$	**28,365**	**lb**	**Eqn. 5**

$$F_{boulder} = F_{bouldersub} + F_{boulderdry}$$ **Equation 5**

$$F_{bouldersub} = N_{bouldersub} * \frac{\pi}{6} * d_{bouldersub}^3 * (\gamma_{boulder} - \gamma_w)$$ **Equation 6**

$N_{bouldersub}$ = *number of submerged boulders*
$d_{bouldersub}$ = *effective diameter of submerged boulders*
$\gamma_{boulder}$ = *unit weight of boulders*

$$F_{boulderdry} = N_{boulderdry} * \frac{\pi}{6} * d_{boulderdry}^3 * \gamma_{boulder}$$ **Equation 7**

$N_{boulderdry}$ = *number of unsubmerged boulders*
$d_{boulderdry}$ = *effective diameter of unsubmerged boulders*

Comment: The intent is design without the use of boulders so it is assumed no boulders are used.

Buoyancy Calculations

Project: Tucannon - Bank Jam
Project No.: Project Number

Analyst: SJR
Calculations Checked By: SJR
Latest Revision: 5/12/2020

3. Soil Backfill Force (F_{soil})

$N_{logssub1}$	6		Number of Type 1 buried logs (from detail)
L_{eb1}	40	ft	Average embedded length of Type 1 logs (from detail)
d_{bole1}	1.5	ft	Average diameter of Type 1 logs (from detail)
$h_{soilsub1}$		ft	Average height of submerged soil above Type 1 log (from detail)
$V_{soilsub1}$		ft^3	Volume of submerged soil above Type 1 log (from detail)
$h_{soildry1}$		ft	Average height of dry soil above Type 1 log (from detail)
$V_{soildry1}$		ft^3	Volume of dry soil above Type 1 log (from detail)
$N_{logssub2}$	6		Number of Type 2 buried logs (from detail)
L_{eb2}	20	ft	Average embedded length of Type 2 logs (from detail)
d_{bole2}	1.5	ft	Average diameter of Type 2 logs (from detail)
$h_{soilsub2}$	3	ft	Average height of submerged soil above Type 2 log (from detail)
$V_{soilsub2}$	540	ft^3	Volume of submerged soil above Type 2 log (from detail)
$h_{soildry2}$		ft	Average height of dry soil above Type 2 log (from detail)
$V_{soildry2}$		ft^3	Volume of dry soil above Type 2 log (from detail)
$N_{logssub3}$	2		Number of Type 3 buried logs (from detail)
L_{eb3}	20	ft	Average embedded length of Type 3 logs (from detail)
d_{bole3}	1.5	ft	Average diameter of Type 3 logs (from detail)
$h_{soilsub3}$	2	ft	Average height of submerged soil above Type 3 log (from detail)
$V_{soilsub3}$	120	ft^3	Volume of submerged soil above Type 3 log (from detail)
$h_{soildry3}$		ft	Average height of dry soil above Type 3 log (from detail)
$V_{soildry3}$		ft^3	Volume of dry soil above Type 3 log (from detail)
γ_{soil}	131	lb/ft^3	Specific Gravity of bank/backfill material (Table 5)
γ_{water}	62.4	lb/ft^3	Unit weight of water
SG_{rock}	2.64		Specific Gravity of Rock (Using unit weight of bedrock from Table 5)
e	0.26		Eqn. 14
γ_{sat}	144	lb/ft^3	Eqn. 13
γ'_{soil}	81.4	lb/ft^3	Eqn. 12
F_{soil}	**53,710**	**lb**	**Eqn. 8**

$$F_{soil} = \sum_i^n V_{soilsub_i} * \gamma'_{soil} + V_{soildry_i} * \gamma_{soil}$$ **Equation 8**

$$V_{soilsub_i} = L_{eb_i} d_{bole_i} h_{soilsub_i}$$ **Equation 9**

$V_{soilsubi}$ = volume of submerged soil above log i
L_{ebi} = embedded length of log i
d_{bolei} = bole diameter of log i
$h_{soilsubi}$ = height of submerged soil above log i

$$V_{soildry_i} = L_{eb_i} d_{bole_i} h_{soildry_i}$$ ***Equation 10***

$V_{soildryi}$ = volume of dry soil above log i
$h_{soildryi}$ = height of dry soil above log i

$$\gamma_{soil} = (99.2 + 18.6 * \log(d_{50}))$$ **Equation 11**

d_{50} = median grain size in millimeters

$$\gamma'_{soil} = \gamma_{sat} - \gamma_w$$ **Equation 12**

$$\gamma_{sat} = \frac{(SG_{rock} + e) * \gamma_w}{1 + e}$$ **Equation 13**

$$e = \frac{SG_{rock} * \gamma_w}{\gamma_{soil}} - 1$$ **Equation 14**

Buoyancy Calculations

Project: Tucannon - Bank Jam
Project No.: Project Number

Analyst: SJR
Calculations Checked By: SJR
Latest Revision: 5/12/2020

4. Pile Skin Friction

N_{piles}	8		Number of piles (Design)
d_{piles}	0.75	ft	Diameter of piles (Design)
L_{piles}	8	ft	Embedded length of piles (Design)
k_s	1		Coefficient of lateral earth pressure (0.5 to 1.5 depending on soil and density)
Placement Method	Excavated		Method of pile placement
Placement Multiplier	0.25		See RBDG (P. 52)
Pile Placement Location	Bed		Bed or Bank
ϕ_{soil}	0.72	rad	Internal angle of friction of soils (Table 5)
γ_{soil}	137	lb/ft^3	Specific Weight of Soil
e	0.20		Eqn. 14
γ_{sat}	148	lb/ft^3	Eqn. 13
γ_{water}	62.4	lb/ft^3	Unit weight of water
σ'	681	lb/ft^2	Eqn 16
γ_{wood}	33	lb/ft^3	Unit weight of wood
$F_{piles-v}$	**13,059**	**lb**	**Eqn 15**

Assumptions:
*** k_s = 1**
**** This calculation is based on the assumption that piles are driven or vibrated into place. If piles are drilled or excavated, the associated coefficicient of lateral earth pressures shall be approx. 50% and 25% of the driven value, respectively.**
***** For use in buoyancy calculations, piles must be mechanically fastened.**
****** Top 2' of pile embedment disregarded for calculation to account for vortex shedding.**

$$F_{piles-v} = N_{piles} * \pi * d_{piles} * L_{piles}(k_s * \tan\frac{2}{3}\emptyset * \sigma' + \frac{d_{piles}}{4} * (\gamma_{wood} - \gamma_w))$$

Equation 15

N_{piles} = number of piles
d_{piles} = diameter of piles
L_{piles} = embedded length of piles
k_s = coefficient of lateral earth pressure (0.5 to 1.5 depending on soil and density)
ϕ = internal angle of friction of soils

$$\sigma' = L_{piles} * (\gamma_{sat} - \gamma_w)$$

Equation 16

$$\gamma_{sat} = \frac{(SG_{rock} + e) * \gamma_w}{1 + e}$$

Equation 13

$$e = \frac{SG_{rock} * \gamma_w}{\gamma_{soil}} - 1$$

Equation 14

Buoyancy Calculations

Project: Tucannon - Bank Jam
Project No.: Project Number

Analyst: SJR
Calculations Checked By: SJR
Latest Revision: 5/12/2020

5. Large Wood Material Force - Submerged (F_{LWMs})

$$F_{LWMs} = V_{LWMs} * (\gamma_{wood} - \gamma_w)$$ **Equation 2**

V_{LWMs} = volume of submerged large wood material
γ_{wood} = unit weight of wood
γ_w = unit weight of water

$N_{logssub1}$	6		Number of log type 1 (from detail)
L_{log1}	40	ft	Length of log type 1 (from detail)
d_{bole1}	1.5	ft	Diameter of log type 1 (from detail)
d_{rw1}	3.75	ft	Diameter of rootwad of log type 1 (from detail)
V_{LWMs1}	490	ft^3	Volume of LWM1
$N_{logssub2}$	6		Number of log type 2 (from detail)
L_{eb2}	40	ft	Length of log type 2 (from detail)
d_{bole2}	1.5	ft	Diameter of log type 2 (from detail)
d_{rw2}	3.75	ft	Diameter of rootwad of log type 2 (from detail)
V_{LWMs2}	490	ft^3	Volume of LWM2
$N_{logssub3}$	2		Number of log type 3 (from detail)
L_{eb3}	40	ft	Length of log type 3 (from detail)
d_{bole3}	1.5	ft	Diameter of log type 3 (from detail)
d_{rw3}	3.75	ft	Diameter of rootwad of log type 3 (from detail)
V_{LWMs3}	163	ft^3	Volume of LWM3
V_{LWMs}	1,144	ft^3	Volume of LWM
γ_{wood}	33.0	lb/ft^3	Unit weight of logs
γ_w	62.4	lb/ft^3	Unit weight of water
F_{LWMs}	**-33,640**	**lb**	**Eqn. 3**

Volume of Rootwad

National Large Wood Manual. 2016

Equation 6-4 (p. 6-38)

$V_{rw} = \pi * t_k * w_k^2 / 3$

$\pi*(2d_{bole}) * (1/2d_{rw})^2 / 3$

t_k = Thickness of rootwad measured in direction parallel to trunk

= 4 times the radius of the log ($4r_k$ or

w_k =

Radius of rootwad

= 2.5 times the radius of the log ($2.5r_k$ or $1.25d_{bole}$) or 1/2 d_{rw} specified

6. Lift Forces (F_L)

$$F_L = -\frac{C_L * A_{LWM} * \gamma_w * U_o^2}{2 * g}$$ **Equation 4**

C_L = lift coefficient
A_{LWM} = area of large woody material perpendicular to flow
u_o = upstream channel velocity at design event
g = acceleration due to gravity

C_L	0.45		Lift Coefficient
A_{LWM}	64	ft^2	Calc'd in Drag Forces
γ_w	62.4	lb/ft^3	Unit weight of water
U_o	9.0	ft/s	upstream velocity (from model)
g	32.2	ft/s^2	Unit weight of water
F_L	**-2,260**	**lb**	**Eqn. 4**

Comment: Lift forces neglected per Section 6.4.2 of BOR Risk Based Design Guidelines

Factor of Safety

FOS_b =	$(F_{LMDd} + F_{boulders} + F_{soil} + F_{piles-v}) / (F_{LWMs} + F_L)$		
F_{LWMd}		lb	Assumed Zero
$F_{boulder}$	28,365	lb	
F_{soil}	53,710	lb	
$F_{piles-v}$	13,059	lb	
F_{LWMs}	-33,640	lb	
F_L	-2,260	lb	
FOS_b	**2.65**		**STABLE FOR BUOYANCY**

Summary Comments:

Sliding Calculations

Project: Tucannon - Bank Jam
Project No.: Project Number

Analyst: SJR
Calculations Checked By: SJR
Latest Revision: 5/12/2020

Spreadsheet Description

Purpose: The spreadsheet below is used to calculate the Factor of Safety against LWM sliding.

Assumptions:
1) The LWM structure behaves as a single structure under the design load and will not experience any shearing at joints.
2) The effect of soil in back of the structure is negligible.
3) The structure will be submerged during the design event.
4) Channel velocity (V_c) taken from hydraulic model.
5) This LWM structure experiences the largest loads. All LWM structures on site will be designed based on this LWM structure's loadings.

Input (Cells Requiring Input from Structure Detail)
Input (Cells requiring Input from Hydraulic Model)
Input (Cells requiring input from a dropdown list)
Input (Cells automatically populated from Input to Interface Tab)
Output (Cells automatically updated are this color)
Output (Cells automatically updated with previously calculated values are this color)

FBD and Equations:

$$FOS_{sliding} = \frac{|F_{hd}+F_f+F_{piles-h}+F_{passive}|}{F_d+F_{hu}+F_i}$$ Equation 41

* **PROJECT NAME has a "XXXX" Public Safety Risk Factor and a "XXXX" Property Damage Risk Factor. The Design Sliding Factor of Safety ($FOS_{sliding}$) for this structure is #.# per Table 4 "Minimum Recommended Factors of Safety".**

Table 4. Minimum recommended factors of safety.

Public Safety Risk	Property Damage Risk	Stability Design Flow Criteria	$FOS_{sliding}$	$FOS_{bouyancy}$	$FOS_{rotation}$ $FOS_{overturning}$
High	High	100-year	1.75	2.0	1.75
High	Moderate	50-year	1.5	1.75	1.5
High	Low	25-year	1.5	1.75	1.5
Low	High	100-year	1.75	2.0	1.75
Low	Moderate	25-year	1.5	1.75	1.5
Low	Low	10-year	1.25	1.5	1.25

1. Drag Force (F_d)

Y_u	8.00	ft	Upstream water depth
hdebris	8	ft	Debris height (incl. accumulation)
wdebris	16	ft	Debris width (incl. accumulation)
Debris Shape	Triangle		
A_{LWM}	64	ft^2	Wetted area of LWM
γ_{water}	62.40	lb/ft^3	Unit weight of water
v_c	9.00	ft/s	Velocity from Model
g	32.20	ft/s^2	Acceleration due to gravity
A_b	64.00	ft^2	Debris area
$w_{channel}$	60	ft	Channel width
c_d	1.50		NLWM Worst Case
F_d	7535	lb	Eqn 19

$$F_d = \frac{C_D * A_{LWM} * \gamma_w * U_c^2}{2 * g}$$ Equation 19

$F_d = drag\ force$
$C_d = drag\ coefficient$
A_{LWM} = area of wetted debris based on the upstream water surface elevation projected normal to flow direction and the potential drift accumulation
$\gamma_w = unit\ weight\ of\ water$
$U_c = velocity\ in\ contracted\ section$
$g = acceleration\ due\ to\ gravity$

Cd can be assumed 0.9 when fully submerged, 1.5 when WSEL within

$$C_{d-applied} = \frac{C_d}{(1-B)^2}$$ C_d is typically estimated as 1.0 Equation 27

Sliding Calculations

Project: Tucannon - Bank Jam
Project No.: Project Number

Analyst: SJR
Calculations Checked By: SJR
Latest Revision: 5/12/2020

3. Impact Force (F_i)

L_{debris}	30	ft	Length of debris member (Design)
$d_{boledebris}$	1.5	ft	Bole diameter of debris member (Design)
$d_{rwdebris}$	4	ft	Rootwad diameter of debris member (Design)
V_{debris}	66	ft^3	Volume of debris
γ_{wood}	33	lb/ft^3	Unit weight of wood
w_{debris}	2,164	lb	weight of debris
g	32.2	ft/s^2	Acceleration due to gravity
$V_{channel}$	9.0	ft/s	Velocity from Model
Δt	0.03	sec	Impact Interval (0.03 sec recommended)
C_i	0.8		Coefficient of importance (from Table 6)
C_o	0.8		Coefficient of orientation
C_d	1		Figure 11 (need water depth from model)
Degree of Screening or Sheltering Upstream	No upstream screening, flow path wider than 30'		ASCE 7-05
C_b	1		ASCE 7-05
R_{max}	0.8		Response ratio for impulsive loads
F_i	**16,216**	**lb**	**Eqn 30**

Assumption:

***Largest impact force would be generated by structure being struck by floating large key member. For impact calculation, assuming 18" diameter, 30' long member with rootwad impacts structure.**
****See Section 6.3.3 of LWM RBDG (P. 44) for debris loading sizing.**

$$F_i = \frac{\pi w_{debris} * V_{channel} * C_i * C_o * C_d * C_b * R_{max}}{2 * g * \Delta t}$$ **Equation 30**

F_i = impact force

w_{debris} = weight of debris

g = acceleration constant due to gravity

$V_{channel}$ = water velocity in channel

Δt = time from initial velocity to zero velocity

C_i = coefficient of importance

C_o = coefficient of orientation = 0.8

C_d = coefficient of depth

C_b = coefficient of blockage

R_{max} = response ratio for impulsive loads = 0.8

4. Friction Force (F_f)

ϕ_{bed}	0.72	radians	Calculated for streambed material (small cobble)
μ_{bed}	0.87		Eqn 32
F_{LWMd}		lb	Buoyancy Calcs
$F_{boulder}$	28365	lb	Buoyancy Calcs
F_{soil}	53710	lb	Buoyancy Calcs
$F_{piles-v}$	13059	lb	Buoyancy Calcs
F_{LWMs}	-33640	lb	Buoyancy Calcs
F_L	-2260	lb	Buoyancy Calcs
F_b	59,233	lb	Eqn 17
F_f	**-40,139**	**lb**	**Eqn 31**

Note:
***If buoyancy forces are less than vertical pile forces (Fb-Fpiles-v<0), then friction force = 0.**

$$F_f = -\mu_{bed} * (F_b - F_{piles-v})$$ Equation 31

F_f = force due to frictional resistance

F_b-$F_{piles-v}$ >0

$$\mu_{bed} = \tan \emptyset$$ Equation 32

$$F_b = F_{LWMs} + F_{LWMd} + F_L + F_{boulder} + F_{soil} + F_{piles-v}$$ ***Equation 17***

Sliding Calculations

Project:	Tucannon - Bank Jam	**Analyst:**	SJR
Project No.:	Project Number	**Calculations Checked By:**	SJR
		Latest Revision:	5/12/2020

5. Passive Forces ($F_{passive}$)

ϕ_{bank}	0.70	radians	Calculated for bank material (very course gravel)	
K_p	4.60		Eqn 34	4.59890993
γ_{water}	62.4	lb/ft^3	Unit weight of water	
γ_{soil}	131	lb/ft^3	Unit weight of soil	
γ_{sat}	144	lb/ft^3	Previously calculated for buoyancy calcs	
$N_{logssub1}$	6		Number of log type 1 (from detail)	
$Orientation_1$**	Parallel		Perpendicular or Parallel to flow	
L_{eb1}	40	ft	Length of log type 1 (from detail)	
d_{bole1}	1.5	ft	Diameter of log type 1 (from detail)	
D_{sub1}		ft	Depth of submerged soil above log 1	
D_{dry1}		ft	Depth of dry soil above log 1	
σ_{v1}		lb/ft^2		
$\sigma_{v1} * L_{eb1} * \gamma_{soil}$		lb		
$N_{logssub2}$	6		Number of log type 2 (from detail)	
$Orientation_2$**	Perpendicular		Perpendicular or Parallel to flow	
L_{eb2}	20	ft	Length of log type 2 (from detail)	
d_{bole2}	1.5	ft	Diameter of log type 2 (from detail)	
D_{sub2}	3	ft	Depth of submerged soil above log 2	
D_{dry2}		ft	Depth of dry soil above log 2	
σ_{v2}	244	lb/ft^2		
$\sigma_{v2} * L_{eb2} * \gamma_{soil}$	43,945	lb		
$N_{logssub3}$	2		Number of log type 3(from detail)	
$Orientation_3$**	Perpendicular		Perpendicular or Parallel to flow	
L_{eb3}	20	ft	Length of log type 3 (from detail)	
d_{bole3}	1.5	ft	Diameter of log type 3 (from detail)	
D_{sub3}	2	ft	Depth of submerged soil above log 3	
D_{dry3}		ft	Depth of dry soil above log 3	
σ_{v3}	163	lb/ft^2		
$\sigma_{v3} * L_{eb3} * \gamma_{soil}$	9,765	lb		
$F_{passive}$	**-123,504**	**lb**	**Eqn 31**	

**** Eqns 33 through 35 represent the case where passive forces act along**

$$F_{passive} = -0.5 * K_p * \sum_i^n \sigma_{v_i} * L_{em_i} * d_{log_i}$$ E

$$K_p = \frac{1+\sin\phi}{1-\sin\phi}$$ E

$$\sigma_{v_i} = D_{sub_i} * (\gamma_{sat} - \gamma_{water}) + D_{dry_i} * \gamma_{soil}$$ E

D_{subi} = depth of submerged soil above log i

D_{dryi} = depth of dry soil above log i

L_{emi} = embedded length of log i

d_{logi} = diameter of log i

Sliding Calculations

Project: Tucannon - Bank Jam
Project No.: Project Number

Analyst: SJR
Calculations Checked By: SJR
Latest Revision: 5/12/2020

6. Lateral Resistance from Piles ($F_{piles\text{-}h}$)

N_{piles}	8		Number of piles (Design)
d_{piles}	0.75	ft	Diameter of piles (Design)
L_{piles}	8	ft	Embedded length of piles below scour (Design)
Placement Method	Excavated		Method of pile placement
Placement Multiplier	0.25		See RBDG (P. 52)
Pile Placement Location	Bed		Bed or Bank
γ_{water}	62.4	lb/ft^3	Unit weight of water
γ_{soil}	137	lb/ft^3	Unit weight of soil
γ_e	74.6	lb/ft^3	Eqn 37
ϕ_{soil}	0.72	radians	Calculated for material pile is located
K_p	4.81		Eqn 38
h_{load}**	4	ft	Height above scour depth load is applied
$F_{piles\text{-}h}$	**-11,494**	**lb**	**Eqn 15**

*** Top 2' of pile embedment disregarded for calculation to account for vortex shedding.**

**** Analysis also assumes that the resultant force is located at half of the flow depth on the upstream side of the LWM structure to produce a conservative moment on the pile.**

$$F_{piles-h} = -N_{piles} * \frac{L_{pile}^3 * \frac{1}{2} * \gamma_e * d_{pile} * K_p}{h_{load} + L_{pile}}$$ Equation 36

N_{piles} = number of piles
L_{pile} = length of pile embedded below potential scour depth

$$\gamma_e = \gamma_s - \gamma_w$$ *effective unit weight of soil* Equation 37

γ_s = dry unit weight of the soil

γ_w = unit weight of the soil
d_{pile} = diameter of the pile
h_{load} = height above the potential scour depth the load is applied

$$K_p = \frac{1+\sin\phi}{1-\sin\phi}$$ Equation 38

Factor of Safety

$FOS_{sliding}$ =	$(F_{hd} + F_f + F_{piles\text{-}h} + F_{passive}) / (F_d + F_{hu} + F_i)$		
F_d	7,535	lb	
F_{hu}		lb	
F_{hd}		lb	
F_i	16,216	lb	
F_f	-40,139	lb	
$F_{passive}$	-123,504	lb	
$F_{piles\text{-}h}$	-11,494	lb	
$FOS_{sliding}$	**7.37**		**STABLE FOR SLIDING**

Summary Comments:

Rotation Calculations

Project: Tucannon - Bank Jam
Project Number: Project Number

Analyst: SJR
Calculations Checked By: SJR
Latest Revision: 5/12/2020

Spreadsheet Description

Purpose: The spreadsheet below is used to calculate the Factor of Safety against LWM structure horizontal rotation.

Assumptions:
1) The LWM structue behaves as a single structure under the design load.
2) The effect of soil in back of the structure is negligible.
3) The structure will be submerged during the design event
4) This LWM structure experiences the largest loads. All LWM structures on site will be designed based on this LWM structure's loadings

Input (Cells Requiring Input from Structure Detail)
Input (Cells requiring Input from Hydraulic Model)
Input (Cells requiring input from a dropdown list)
Input (Cells automatically populated from Input to Interface Tab)
Output (Cells that are automatically updated are this color)
Output (Cells that are automatically updated with previously calculated values are this color)

FBD and Equations:

$$FOS_{rotation} = \frac{MR_{rotation}}{MD_{rotation}}$$ **Equation 45**

*** PROJECT NAME has a "XXXX" Public Safety Risk Factor and a "XXXX" Property Damage Risk Factor. The Design Rotation Factor of Safety ($FOS_{rotation}$) for this structure is #.# per Table 4 "Minimum Recommended Factors of Safety".**

Table 4. Minimum recommended factors of safety.

Public Safety Risk	Property Damage Risk	Stability Design Flow Criteria	$FOS_{sliding}$	$FOS_{buoyancy}$	$FOS_{rotation}$ $FOS_{overturning}$
High	High	100-year	1.75	2.0	1.75
High	Moderate	50-year	1.5	1.75	1.5
High	Low	25-year	1.5	1.75	1.5
Low	High	100-year	1.75	2.0	1.75
Low	Moderate	25-year	1.5	1.75	1.5
Low	Low	10-year	1.25	1.5	1.25

1. Resistance to Rotation ($MR_{rotation}$ and $MD_{rotation}$)

$$MD_{rotation} = (F_i + F_d + F_{hu}) * (\frac{L_{sp}+L_{ebp}}{2})$$ **Equation 42**

L_{sp} = length of wood structure from tip to point of rotation measured perpendicular to flow
L_{ebp} = embedded length of wood structure measured perpendicular to flow

$$MR_{rotation} = \left| F_{hd} * \left(\frac{L_{sp}+L_{ebp}}{2}\right) + F_{passive} * \frac{L_{ebp}}{2} + F_f * \frac{L_{sp}}{2} + \sum_{i}^{n} F_{pile-h_i} * L_{ph_i} \right|$$

Equation 43

$$F_{pile-h_i} = \frac{F_{piles-h}}{N_{piles}}$$ **Equation 44**

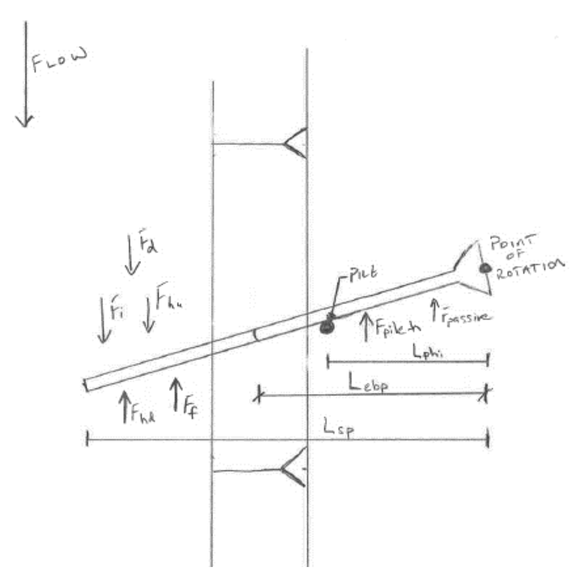
L_{phi} = distance from pile 'i' to the point of rotation measured perpendicular to flow

Driving:

L_{sp}	40	ft	Length of wood structure from tip to point of rotation measured perpendicular to flow
L_{ebp}	20	ft	Embedded length of wood structure measured perp. to flow
F_i	16,216	lb	Impact Forces (Calc'd in Sliding)
F_d	7,535	lb	Drag Forces (Calc'd in Sliding)
F_{hu}		lb	Upstream Hydrostatic Forces (Calc'd in Sliding)
$MD_{rotation}$	**712,517**	**lb*ft**	**Eqn 42**

Resisting:

F_{hd}		lb	Downstream Hydrostatic Forces (Calc'd in Sliding)
$F_{passive}$	-123,504	lb	Passive Forces (Calc'd in Sliding)
F_f	-40,139	lb	Friction Forces (Calc'd in Sliding)
F_{pile-h}	-11,494	lb	Lateral Resistance from Piles (Calc'd in Sliding)
$F_{pile-hi}$	-1,437	lb	Lateral Resistance from Piles (Calc'd in Sliding)
N_{piles}	8		Number of Piles (Design)
L_{phi}	25	ft	Distance from pile to the point of rotation measured perp. to flow
$MR_{rotation}$	**2,325,166**	**lb*ft**	**Eqn 43**



Factor of Safety

FOS rotation =	*MR rotation / MD rotation*		
$MD_{rotation}$	712,517	lb	
$MR_{rotation}$	2,325,166	lb	
$FOS_{rotation}$	**3.26**		**STABLE FOR ROTATION**

Summary Comments:

Buoyancy Calculations

Project: Tucannon - Floodplain
Project No.: Project Number

Analyst: SJR
Calculations Checked By: SJR
Latest Revision: 5/12/2020

Spreadsheet Description

- The spreadsheet below is used to calculate the Factor of Safety against Buoyant uplift of the LWM

Assumptions:

1) The LWM structure behaves as a single structure under the design load and will not experience any shearing at joints
2) The LWM structure will be submerged during the design event.
3) Negative buoyancy is uplift, positive numbers equals downward.
4) Ballast material remains intact and is not scoured out.
5) The uplift due to racking material is evenly dividing among all layers.

Input (Cells Requiring Input from Structure Detail)
Input (Cells requiring Input from Hydraulic Model)
Input (Cells automatically populated from Input to Interface Tab)
Input (Cells requiring input from a dropdown list)
Output (Cells automatically updated are this color)
Output (Cells automatically updated with previously calculated values are this color)

FBD and Equations:

$$FOS_b = \frac{F_{LWMd} + F_{boulders} + F_{soil} + F_{piles-v}}{|F_{LWMs} + F_L|}$$ **Equation 18**

FOS_b = *buoyancy factor of safety*

*** PROJECT NAME has a "XXXX" Public Safety Risk Factor and a "XXXX" Property Damage Risk Factor. The Design buoyancy factor of safety (FOS_b) for this structure is #.# per Table 4 "*Minimum Recommended Factors of Safety*".**

Table 4. Minimum recommended factors of safety.

Public Safety Risk	Property Damage Risk	Stability Design Flow Criteria	$FOS_{sliding}$	$FOS_{buoyancy}$	$FOS_{rotation}$ $FOS_{overturning}$
High	High	100-year	1.75	2.0	1.75
High	Moderate	50-year	1.5	1.75	1.5
High	Low	25-year	1.5	1.75	1.5
Low	High	100-year	1.75	2.0	1.75
Low	Moderate	25-year	1.5	1.75	1.5
Low	Low	10-year	1.25	1.5	1.25

1. Large Wood Material Force - Dry (F_{LWMd})

$$F_{LWMd} = V_{LWMd} * \gamma_{wood}$$ **Equation 3**

V_{LWMd} = *volume of dry large wood material*

Comment: Assumed to be zero because structure assumed to be submerged during design event.

2. Boulder Ballast Force ($F_{boulder}$)

$N_{bouldersub}$			Number of submerged boulders (from design)
$d_{bouldersub}$	2.5	ft	Effective diameter of submerged boulder (ft, from spec)
$\gamma_{boulder}$	146	lb/ft^3	unit weight of boulders (Table 5)
γ_{water}	62.4	lb/ft^3	unit weight of water
$F_{bouldersub}$		lb	Eqn. 6
$N_{boulderdry}$			Number of dry boulders (from detail)
$d_{boulderdry}$	2.5	ft	Effective diameter of dry boulder (ft, from spec)
$F_{boulderdry}$		lb	Eqn. 7
$F_{boulder}$		**lb**	**Eqn. 5**

Comment: The intent is design without the use of boulders so it is assumed no boulders are used.

$$F_{boulder} = F_{bouldersub} + F_{boulderdry}$$ **Equation 5**

$$F_{bouldersub} = N_{bouldersub} * \frac{\pi}{6} * d^3_{bouldersub} * (\gamma_{boulder} - \gamma_w)$$ **Equation 6**

$N_{bouldersub}$ = *number of submerged boulders*
$d_{bouldersub}$ = *effective diameter of submerged boulders*
$\gamma_{boulder}$ = *unit weight of boulders*

$$F_{boulderdry} = N_{boulderdry} * \frac{\pi}{6} * d^3_{boulderdry} * \gamma_{boulder}$$ **Equation 7**

$N_{boulderdry}$ = *number of unsubmerged boulders*
$d_{boulderdry}$ = *effective diameter of unsubmerged boulders*

Buoyancy Calculations

Project: Tucannon - Floodplain
Project No.: Project Number

Analyst: SJR
Calculations Checked By: SJR
Latest Revision: 5/12/2020

3. Soil Backfill Force (F_{soil})

$N_{logssub1}$	1		Number of Type 1 buried logs (from detail)
L_{eb1}	30	ft	Average embedded length of Type 1 logs (from detail)
d_{bole1}	1	ft	Average diameter of Type 1 logs (from detail)
$h_{soilsub1}$		ft	Average height of submerged soil above Type 1 log (from detail)
$V_{soilsub1}$		ft^3	Volume of submerged soil above Type 1 log (from detail)
$h_{soildry1}$		ft	Average height of dry soil above Type 1 log (from detail)
$V_{soildry1}$		ft^3	Volume of dry soil above Type 1 log (from detail)
$N_{logssub2}$			Number of Type 2 buried logs (from detail)
L_{eb2}	26	ft	Average embedded length of Type 2 logs (from detail)
d_{bole2}	1.5	ft	Average diameter of Type 2 logs (from detail)
$h_{soilsub2}$	3	ft	Average height of submerged soil above Type 2 log (from detail)
$V_{soilsub2}$		ft^3	Volume of submerged soil above Type 2 log (from detail)
$h_{soildry2}$		ft	Average height of dry soil above Type 2 log (from detail)
$V_{soildry2}$		ft^3	Volume of dry soil above Type 2 log (from detail)
$N_{logssub3}$			Number of Type 3 buried logs (from detail)
L_{eb3}	23	ft	Average embedded length of Type 3 logs (from detail)
d_{bole3}	1.5	ft	Average diameter of Type 3 logs (from detail)
$h_{soilsub3}$	3	ft	Average height of submerged soil above Type 3 log (from detail)
$V_{soilsub3}$		ft^3	Volume of submerged soil above Type 3 log (from detail)
$h_{soildry3}$		ft	Average height of dry soil above Type 3 log (from detail)
$V_{soildry3}$		ft^3	Volume of dry soil above Type 3 log (from detail)
γ_{soil}	131	lb/ft^3	Specific Gravity of bank/backfill material (Table 5)
γ_{water}	62.4	lb/ft^3	Unit weight of water
SG_{rock}	2.64		Specific Gravity of Rock (Using unit weight of bedrock from Table 5)
e	0.26		Eqn. 14
γ_{sat}	144	lb/ft^3	Eqn. 13
γ'_{soil}	81.4	lb/ft^3	Eqn. 12
F_{soil}		**lb**	**Eqn. 8**

$$F_{soil} = \sum_i^n V_{soilsub_i} * \gamma'_{soil} + V_{soildry_i} * \gamma_{soil}$$ **Equation 8**

$$V_{soilsub_i} = L_{eb_i} d_{bole_i} h_{soilsub_i}$$ **Equation 9**

$V_{soilsubi}$ = volume of submerged soil above log i
L_{ebi} = embedded length of log i
d_{bolei} = bole diameter of log i
$h_{soilsubi}$ = height of submerged soil above log i

$$V_{soildry_i} = L_{eb_i} d_{bole_i} h_{soildry_i}$$ ***Equation 10***

$V_{soildryi}$ = volume of dry soil above log i
$h_{soildryi}$ = height of dry soil above log i

$$\gamma_{soil} = (99.2 + 18.6 * \log(d_{50}))$$ **Equation 11**

d_{50} = median grain size in millimeters

$$\gamma'_{soil} = \gamma_{sat} - \gamma_w$$ **Equation 12**

$$\gamma_{sat} = \frac{(SG_{rock} + e) * \gamma_w}{1 + e}$$ **Equation 13**

$$e = \frac{SG_{rock} * \gamma_w}{\gamma_{soil}} - 1$$ **Equation 14**

Buoyancy Calculations

Project: Tucannon - Floodplain
Project No.: Project Number

Analyst: SJR
Calculations Checked By: SJR
Latest Revision: 5/12/2020

4. Pile Skin Friction

N_{piles}	1		Number of piles (Design)
d_{piles}	0.83	ft	Diameter of piles (Design)
L_{piles}	8	ft	Embedded length of piles (Design)
k_s	1		Coefficient of lateral earth pressure (0.5 to 1.5 depending on soil and density)
Placement Method	Driven or Vibrated		Method of pile placement
Placement Multiplier	1		See RBDG (P. 52)
Pile Placement Location	Bed		Bed or Bank
ϕ_{soil}	0.72	rad	Internal angle of friction of soils (Table 5)
γ_{soil}	137	lb/ft^3	Specific Weight of Soil
e	0.20		Eqn. 14
γ_{sat}	148	lb/ft^3	Eqn. 13
γ_{water}	62.4	lb/ft^3	Unit weight of water
σ'	681	lb/ft^2	Eqn 16
γ_{wood}	33	lb/ft^3	Unit weight of wood
$F_{piles-v}$	**7,214**	**lb**	**Eqn 15**

Assumptions:
*** k_s = 1**
**** This calculation is based on the assumption that piles are driven or vibrated into place. If piles are drilled or excavated, the associated coefficicient of lateral earth pressures shall be approx. 50% and 25% of the driven value, respectively.**
***** For use in buoyancy calculations, piles must be mechanically fastened.**
****** Top 2' of pile embedment disregarded for calculation to account for vortex shedding.**

$$F_{piles-v} = N_{piles} * \pi * d_{piles} * L_{piles}(k_s * \tan\frac{2}{3}\emptyset * \sigma' + \frac{d_{piles}}{4} * (\gamma_{wood} - \gamma_w))$$

Equation 15

N_{piles} = number of piles
d_{piles} = diameter of piles
L_{piles} = embedded length of piles
k_s = coefficient of lateral earth pressure (0.5 to 1.5 depending on soil and density)
ϕ = internal angle of friction of soils

$$\sigma' = L_{piles} * (\gamma_{sat} - \gamma_w)$$

Equation 16

$$\gamma_{sat} = \frac{(SG_{rock}+e)*\gamma_w}{1+e}$$

Equation 13

$$e = \frac{SG_{rock}*\gamma_w}{\gamma_{soil}} - 1$$

Equation 14

Buoyancy Calculations

Project: Tucannon - Floodplain
Project No.: Project Number

Analyst: SJR
Calculations Checked By: SJR
Latest Revision: 5/12/2020

5. Large Wood Material Force - Submerged (F_{LWMs})

$$F_{LWMs} = V_{LWMs} * (\gamma_{wood} - \gamma_w)$$ **Equation 2**

V_{LWMs} = *volume of submerged large wood material*
γ_{wood} = *unit weight of wood*
γ_w = *unit weight of water*

$N_{logssub1}$	1		Number of log type 1 (from detail)
L_{log1}	30	ft	Length of log type 1 (from detail)
d_{bole1}	1	ft	Diameter of log type 1 (from detail)
d_{rw1}	2.50	ft	Diameter of rootwad of log type 1 (from detail)
V_{LWMs1}	27	ft^3	Volume of LWM1
$N_{logssub2}$			Number of log type 2 (from detail)
L_{eb2}	40	ft	Length of log type 2 (from detail)
d_{bole2}	1.5	ft	Diameter of log type 2 (from detail)
d_{rw2}	3.75	ft	Diameter of rootwad of log type 2 (from detail)
V_{LWMs2}		ft^3	Volume of LWM2
$N_{logssub3}$			Number of log type 3 (from detail)
L_{eb3}	30	ft	Length of log type 3 (from detail)
d_{bole3}	1.5	ft	Diameter of log type 3 (from detail)
d_{rw3}		ft	Diameter of rootwad of log type 3 (from detail)
V_{LWMs3}		ft^3	Volume of LWM3
V_{LWMs}	27	ft^3	Volume of LWM
γ_{wood}	33.0	lb/ft^3	Unit weight of logs
γ_w	62.4	lb/ft^3	Unit weight of water
F_{LWMs}	**-789**	**lb**	**Eqn. 3**

Volume of Rootwad

National Large Wood Manual. 2016

Equation 6-4 (p. 6-38)

$V_{rw} = \pi * t_k * w_k^2 / 3$

$\pi * (2d_{bole}) * (1/2d_{rw})^2 / 3$

t_k = Thickness of rootwad measured in direction parallel to trunk

= 4 times the radius of the log ($4r_k$ or

w_k =

Radius of rootwad

= 2.5 times the radius of the log ($2.5r_k$ or $1.25d_{bole}$) or 1/2 d_{rw} specified

6. Lift Forces (F_L)

$$F_L = -\frac{C_L * A_{LWM} * \gamma_w * U_o^2}{2 * g}$$ **Equation 4**

C_L = *lift coefficient*
A_{LWM} = *area of large woody material perpendicular to flow*
u_o = *upstream channel velocity at design event*
g = *acceleration due to gravity*

C_L	1		Lift Coefficient
A_{LWM}	45	ft^2	Calc'd in Drag Forces
γ_w	62.4	lb/ft^3	Unit weight of water
U_o	6.0	ft/s	upstream velocity (from model)
g	32.2	ft/s^2	Unit weight of water
F_L	**-1,570**	**lb**	**Eqn. 4**

Comment: Lift forces neglected per Section 6.4.2 of BOR Risk Based Design Guidelines

Factor of Safety

FOS_b =	$(F_{LMDd} + F_{boulders} + F_{soil} + F_{piles-v}) / (F_{LWMs} + F_L)$		
F_{LWMd}		lb	Assumed Zero
$F_{boulder}$		lb	
F_{soil}		lb	
$F_{piles-v}$	7,214	lb	
F_{LWMs}	-789	lb	
F_L	-1,570	lb	
FOS_b	**3.06**		**STABLE FOR BUOYANCY**

Summary Comments:

Sliding Calculations

Project:	Tucannon - Floodplain	**Analyst:**	SJR
Project No.:	Project Number	**Calculations Checked By:**	SJR
		Latest Revision:	5/12/2020

Spreadsheet Description

Purpose: The spreadsheet below is used to calculate the Factor of Safety against LWM sliding.

Assumptions:
1) The LWM structure behaves as a single structure under the design load and will not experience any shearing at joints.
2) The effect of soil in back of the structure is negligible.
3) The structure will be submerged during the design event.
4) Channel velocity (V_c) taken from hydraulic model.
5) This LWM structure experiences the largest loads. All LWM structures on site will be designed based on this LWM structure's loadings.

Input (Cells Requiring Input from Structure Detail)
Input (Cells requiring Input from Hydraulic Model)
Input (Cells requiring input from a dropdown list)
Input (Cells automatically populated from Input to Interface Tab)
Output (Cells automatically updated are this color)
Output (Cells automatically updated with previously calculated values are this color)

FBD and Equations:

$$FOS_{sliding} = \frac{|F_{hd}+F_f+F_{piles-h}+F_{passive}|}{F_d+F_{hu}+F_i}$$ Equation 41

* **PROJECT NAME has a "XXXX" Public Safety Risk Factor and a "XXXX" Property Damage Risk Factor. The Design Sliding Factor of Safety ($FOS_{sliding}$) for this structure is #.# per Table 4 "Minimum Recommended Factors of Safety".**

Table 4. Minimum recommended factors of safety.

Public Safety Risk	Property Damage Risk	Stability Design Flow Criteria	$FOS_{sliding}$	$FOS_{bouyancy}$	$FOS_{rotation}$ $FOS_{overturning}$
High	High	100-year	1.75	2.0	1.75
High	Moderate	50-year	1.5	1.75	1.5
High	Low	25-year	1.5	1.75	1.5
Low	High	100-year	1.75	2.0	1.75
Low	Moderate	25-year	1.5	1.75	1.5
Low	Low	10-year	1.25	1.5	1.25

1. Drag Force (F_d)

Y_u	3.00	ft	Upstream water depth
hdebris	1.5	ft	Debris height (incl. accumulation)
wdebris	30	ft	Debris width (incl. accumulation)
Debris Shape	Rectangle		
A_{LWM}	45	ft^2	Wetted area of LWM
γ_{water}	62.40	lb/ft^3	Unit weight of water
v_c	6.00	ft/s	Velocity from Model
g	32.20	ft/s^2	Acceleration due to gravity
A_b	45.00	ft^2	Debris area
$w_{channel}$	60	ft	Channel width
c_d	0.90		NLWM Worst Case
F_d	1413	lb	Eqn 19

$$F_d = \frac{C_D * A_{LWM} * \gamma_w * U_c^2}{2 * g}$$ Equation 19

$F_d = drag\ force$
$C_d = drag\ coefficient$
A_{LWM} = area of wetted debris based on the upstream water surface elevation projected normal to flow direction and the potential drift accumulation
$\gamma_w = unit\ weight\ of\ water$
$U_c = velocity\ in\ contracted\ section$
$g = acceleration\ due\ to\ gravity$

Cd can be assumed 0.9 when fully submerged, 1.5 when WSEL within

$$C_{d-applied} = \frac{C_d}{(1-B)^2}$$ C_d is typically estimated as 1.0 Equation 27

Sliding Calculations

Project: Tucannon - Floodplain
Project No.: Project Number

Analyst: SJR
Calculations Checked By: SJR
Latest Revision: 5/12/2020

3. Impact Force (F_i)

L_{debris}	30	ft	Length of debris member (Design)
$d_{boledebris}$	1.5	ft	Bole diameter of debris member (Design)
$d_{rwdebris}$	4	ft	Rootwad diameter of debris member (Design)
V_{debris}	66	ft^3	Volume of debris
γ_{wood}	33	lb/ft^3	Unit weight of wood
w_{debris}	2,164	lb	weight of debris
g	32.2	ft/s^2	Acceleration due to gravity
$V_{channel}$	6.0	ft/s	Velocity from Model
Δt	0.03	sec	Impact Interval (0.03 sec recommended)
C_i	0.5		Coefficient of importance (from Table 6)
C_o	0.8		Coefficient of orientation
C_d	0.5		Figure 11 (need water depth from model)
Degree of Screening or Sheltering Upstream	Dense upstream screening, flow path less than 5' wide		ASCE 7-05
C_b			ASCE 7-05
R_{max}	0.8		Response ratio for impulsive loads
F_i		**lb**	**Eqn 30**

$$F_i = \frac{\pi w_{debris} * V_{channel} * C_i * C_o * C_d * C_b * R_{max}}{2 * g * \Delta t}$$ **Equation 30**

F_i = impact force

w_{debris} = weight of debris

g = acceleration constant due to gravity

$V_{channel}$ = water velocity in channel

Δt = time from initial velocity to zero velocity

C_i = coefficient of importance

C_o = coefficient of orientation = 0.8

C_d = coefficient of depth

C_b = coefficient of blockage

R_{max} = response ratio for impulsive loads = 0.8

Assumption:

***Largest impact force would be generated by structure being struck by floating large key member. For impact calculation, assuming 18" diameter, 30' long member with rootwad impacts structure.**
****See Section 6.3.3 of LWM RBDG (P. 44) for debris loading sizing.**

4. Friction Force (F_f)

ϕ_{bed}	0.72	radians	Calculated for streambed material (small cobble)
μ_{bed}	0.87		Eqn 32
F_{LWMd}		lb	Buoyancy Calcs
$F_{boulder}$		lb	Buoyancy Calcs
F_{soil}		lb	Buoyancy Calcs
$F_{piles-v}$	7214	lb	Buoyancy Calcs
F_{LWMs}	-789	lb	Buoyancy Calcs
F_L	-1570	lb	Buoyancy Calcs
F_b	4,855	lb	Eqn 17
F_f		**lb**	**Eqn 31**

$$F_f = -\mu_{bed} * (F_b - F_{piles-v})$$ **Equation 31**

F_f = force due to frictional resistance

F_b-$F_{piles-v}$ >0

$$\mu_{bed} = \tan \emptyset$$ **Equation 32**

$$F_b = F_{LWMs} + F_{LWMd} + F_L + F_{boulder} + F_{soil} + F_{piles-v}$$ ***Equation 17***

Note:
***If buoyancy forces are less than vertical pile forces (Fb-Fpiles-v<0), then friction force = 0.**

Sliding Calculations

Project: Tucannon - Floodplain
Project No.: Project Number

Analyst: SJR
Calculations Checked By: SJR
Latest Revision: 5/12/2020

5. Passive Forces ($F_{passive}$)

ϕ_{bank}	0.70	radians	Calculated for bank material (very course gravel)	
K_p	4.60		Eqn 34	4.59890993
γ_{water}	62.4	lb/ft^3	Unit weight of water	
γ_{soil}	131	lb/ft^3	Unit weight of soil	
γ_{sat}	144	lb/ft^3	Previously calculated for buoyancy calcs	
$N_{logssub1}$	1		Number of log type 1 (from detail)	
Orientation$_1$**	Perpendicular		Perpendicular or Parallel to flow	
L_{eb1}	30	ft	Length of log type 1 (from detail)	
d_{bole1}	1	ft	Diameter of log type 1 (from detail)	
D_{sub1}		ft	Depth of submerged soil above log 1	
D_{dry1}		ft	Depth of dry soil above log 1	
σ_{v1}		lb/ft^2		
$\sigma_{v1} * L_{eb1} * \gamma_{soil}$		lb		
$N_{logssub2}$			Number of log type 2 (from detail)	
Orientation$_2$**	Perpendicular		Perpendicular or Parallel to flow	
L_{eb2}	26	ft	Length of log type 2 (from detail)	
d_{bole2}	1.5	ft	Diameter of log type 2 (from detail)	
D_{sub2}	3	ft	Depth of submerged soil above log 2	
D_{dry2}		ft	Depth of dry soil above log 2	
σ_{v2}	244	lb/ft^2		
$\sigma_{v2} * L_{eb2} * \gamma_{soil}$		lb		
$N_{logssub3}$			Number of log type 3(from detail)	
Orientation$_3$**	Perpendicular		Perpendicular or Parallel to flow	
L_{eb3}	23	ft	Length of log type 3 (from detail)	
d_{bole3}	1.5	ft	Diameter of log type 3 (from detail)	
D_{sub3}	3	ft	Depth of submerged soil above log 3	
D_{dry3}		ft	Depth of dry soil above log 3	
σ_{v3}	244	lb/ft^2		
$\sigma_{v3} * L_{eb3} * \gamma_{soil}$		lb		
$F_{passive}$		**lb**	**Eqn 31**	

**** Eqns 33 through 35 represent the case where passive forces act along**

$$F_{passive} = -0.5 * K_p * \sum_i^n \sigma_{v_i} * L_{em_i} * d_{log_i}$$ E

$$K_p = \frac{1+\sin\emptyset}{1-\sin\emptyset}$$ E

$$\sigma_{v_i} = D_{sub_i} * (\gamma_{sat} - \gamma_{water}) + D_{dry_i} * \gamma_{soil}$$ E

D_{subi} = depth of submerged soil above log i

D_{dryi} = depth of dry soil above log i

L_{emi} = embedded length of log i

d_{logi} = diameter of log i

Sliding Calculations

Project: Tucannon - Floodplain
Project No.: Project Number

Analyst: SJR
Calculations Checked By: SJR
Latest Revision: 5/12/2020

6. Lateral Resistance from Piles ($F_{piles-h}$)

$$F_{piles-h} = -N_{piles} * \frac{L_{pile}^3 * \frac{1}{2} * \gamma_e * d_{pile} * K_p}{h_{load} + L_{pile}}$$ Equation 36

N_{piles} = number of piles
L_{pile} = length of pile embedded below potential scour depth

$$\gamma_e = \gamma_s - \gamma_w$$ effective unit weight of soil Equation 37

γ_s = dry unit weight of the soil

N_{piles}	1		Number of piles (Design)
d_{piles}	0.83	ft	Diameter of piles (Design)
L_{piles}	8	ft	Embedded length of piles below scour (Design)
Placement Method	Driven or Vibrated		Method of pile placement
Placement Multiplier	1		See RBDG (P. 52)
Pile Placement Location	Bed		Bed or Bank
γ_{water}	62.4	lb/ft^3	Unit weight of water
γ_{soil}	137	lb/ft^3	Unit weight of soil
γ_e	74.6	lb/ft^3	Eqn 37
ϕ_{soil}	0.72	radians	Calculated for material pile is located
K_p	4.81		Eqn 38
h_{load}**	0.75	ft	Height above scour depth load is applied
$F_{piles-h}$	**-8,722**	**lb**	**Eqn 15**

γ_w = unit weight of the soil
d_{pile} = diameter of the pile
h_{load} = height above the potential scour depth the load is applied

$$K_p = \frac{1+\sin\phi}{1-\sin\phi}$$ Equation 38

*** Top 2' of pile embedment disregarded for calculation to account for vortex shedding.**
**** Analysis also assumes that the resultant force is located at half of the flow depth on the upstream side of the LWM structure to produce a conservative moment on the pile.**

Factor of Safety

$FOS_{sliding}$ =	$(F_{hd} + F_f + F_{piles-h} + F_{passive}) / (F_d + F_{hu} + F_i)$		
F_d	1,413	lb	
F_{hu}		lb	
F_{hd}		lb	
F_i		lb	
F_f		lb	
$F_{passive}$		lb	
$F_{piles-h}$	-8,722	lb	
$FOS_{sliding}$	**6.17**		**STABLE FOR SLIDING**

Summary Comments:

Rotation Calculations

Project: Tucannon - Floodplain
Project Number: Project Number

Analyst: SJR
Calculations Checked By: SJR
Latest Revision: 5/12/2020

Spreadsheet Description

Purpose: The spreadsheet below is used to calculate the Factor of Safety against LWM structure horizontal rotation.

Assumptions:
1) The LWM structue behaves as a single structure under the design load.
2) The effect of soil in back of the structure is negligible.
3) The structure will be submerged during the design event
4) This LWM structure experiences the largest loads. All LWM structures on site will be designed based on this LWM structure's loadings

Input (Cells Requiring Input from Structure Detail)
Input (Cells requiring Input from Hydraulic Model)
Input (Cells requiring input from a dropdown list)
Input (Cells automatically populated from Input to Interface Tab)
Output (Cells that are automatically updated are this color)
Output (Cells that are automatically updated with previously calculated values are this color)

FBD and Equations:

$$FOS_{rotation} = \frac{MR_{rotation}}{MD_{rotation}}$$ **Equation 45**

*** PROJECT NAME has a "XXXX" Public Safety Risk Factor and a "XXXX" Property Damage Risk Factor. The Design Rotation Factor of Safety ($FOS_{rotation}$) for this structure is #.# per Table 4 "Minimum Recommended Factors of Safety".**

Table 4. Minimum recommended factors of safety.

Public Safety Risk	Property Damage Risk	Stability Design Flow Criteria	$FOS_{sliding}$	$FOS_{bouyancy}$	$FOS_{rotation}$ $FOS_{overturning}$
High	High	100-year	1.75	2.0	1.75
High	Moderate	50-year	1.5	1.75	1.5
High	Low	25-year	1.5	1.75	1.5
Low	High	100-year	1.75	2.0	1.75
Low	Moderate	25-year	1.5	1.75	1.5
Low	Low	10-year	1.25	1.5	1.25

1. Resistance to Rotation ($MR_{rotation}$ and $MD_{rotation}$)

$$MD_{rotation} = (F_i + F_d + F_{hu}) * (\frac{L_{sp}+L_{ebp}}{2})$$ **Equation 42**

L_{sp} = length of wood structure from tip to point of rotation measured perpendicular to flow

L_{ebp} = embedded length of wood structure measured perpendicular to flow

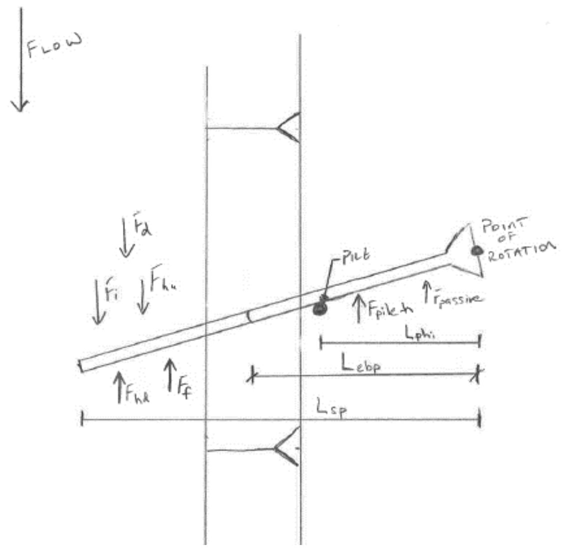
$$MR_{rotation} = \left| F_{hd} * \left(\frac{L_{sp} + L_{ebp}}{2}\right) + F_{passive} * \frac{L_{ebp}}{2} + F_f * \frac{L_{sp}}{2} + \sum_{i}^{n} F_{pile-h_i} * L_{ph_i} \right|$$ **Equation 43**

$$F_{pile-h_i} = \frac{F_{piles-h}}{N_{piles}}$$ **Equation 44**

L_{phi} = distance from pile 'i' to the point of rotation measured perpendicular to flow

Driving:

L_{sp}	30	ft	Length of wood structure from tip to point of rotation measured perpendicular to flow
L_{ebp}	30	ft	Embedded length of wood structure measured perp. to flow
F_i		lb	Impact Forces (Calc'd in Sliding)
F_d	1,413	lb	Drag Forces (Calc'd in Sliding)
F_{hu}		lb	Upstream Hydrostatic Forces (Calc'd in Sliding)
$MD_{rotation}$	**42,382**	**lb*ft**	**Eqn 42**



Resisting:

F_{hd}		lb	Downstream Hydrostatic Forces (Calc'd in Sliding)
$F_{passive}$		lb	Passive Forces (Calc'd in Sliding)
F_f		lb	Friction Forces (Calc'd in Sliding)
F_{pile-h}	-8,722	lb	Lateral Resistance from Piles (Calc'd in Sliding)
$F_{pile-hi}$	-8,722	lb	Lateral Resistance from Piles (Calc'd in Sliding)
N_{piles}	1		Number of Piles (Design)
L_{phi}	10	ft	Distance from pile to the point of rotation measured perp. to flow
$MR_{rotation}$	**87,225**	**lb*ft**	**Eqn 43**

Factor of Safety

$FOS_{rotation}$ =	$MR_{rotation}$ / $MD_{rotation}$		
$MD_{rotation}$	42,382	lb	
$MR_{rotation}$	87,225	lb	
$FOS_{rotation}$	**2.06**		**STABLE FOR ROTATION**

Summary Comments:
Recommend locating where impact is less likely as this significantly drives the stability calcs. Can get more aggressive (extend further into the channel), if impact forces are not of

Buoyancy Calculations

Project:	Tucannon - Channel Spanning	**Analyst:**	ASD
Project No.:	Project Number	**Calculations Checked By:**	ASD
		Latest Revision:	7/2/2021

Spreadsheet Description

- The spreadsheet below is used to calculate the Factor of Safety against Buoyant uplift of the LWM

Assumptions:

1) The LWM structure behaves as a single structure under the design load and will not experience any shearing at joints
2) The LWM structure will be submerged during the design event.
3) Negative buoyancy is uplift, positive numbers equals downward.
4) Ballast material remains intact and is not scoured out.
5) The uplift due to racking material is evenly dividing among all layers.

Input (Cells Requiring Input from Structure Detail)
Input (Cells requiring Input from Hydraulic Model)
Input (Cells automatically populated from Input to Interface Tab)
Input (Cells requiring input from a dropdown list)
Output (Cells automatically updated are this color)
Output (Cells automatically updated with previously calculated values are this color)

FBD and Equations:

$$FOS_b = \frac{F_{LWMd} + F_{boulders} + F_{soil} + F_{piles-e}}{|F_{LWMs} + F_L|}$$ **Equation 18**

FOS_b = buoyancy factor of safety

*** PROJECT NAME has a "XXXX" Public Safety Risk Factor and a "XXXX" Property Damage Risk Factor. The Design buoyancy factor of safety (FOS_b) for this structure is #.# per Table 4 "*Minimum Recommended Factors of Safety*".**

Table 4. Minimum recommended factors of safety.

Public Safety Risk	Property Damage Risk	Stability Design Flow Criteria	$FOS_{sliding}$	$FOS_{buoyancy}$	$FOS_{rotation}$ $FOS_{overturning}$
High	High	100-year	1.75	2.0	1.75
High	Moderate	50-year	1.5	1.75	1.5
High	Low	25-year	1.5	1.75	1.5
Low	High	100-year	1.75	2.0	1.75
Low	Moderate	25-year	1.5	1.75	1.5
Low	Low	10-year	1.25	1.5	1.25

1. Large Wood Material Force - Dry (F_{LWMd})

$$F_{LWMd} = V_{LWMd} * \gamma_{wood}$$ **Equation 3**

V_{LWMd} = volume of dry large wood material

Comment: Assumed to be zero because structure assumed to be submerged during design event.

2. Boulder Ballast Force ($F_{boulder}$)

$N_{bouldersub}$			Number of submerged boulders (from design)
$d_{bouldersub}$	2.5	ft	Effective diameter of submerged boulder (ft, from spec)
$\gamma_{boulder}$	146	lb/ft^3	unit weight of boulders (Table 5)
γ_{water}	62.4	lb/ft^3	unit weight of water
$F_{bouldersub}$		lb	Eqn. 6
$N_{boulderdry}$			Number of dry boulders (from detail)
$d_{boulderdry}$	2.5	ft	Effective diameter of dry boulder (ft, from spec)
$F_{boulderdry}$		lb	Eqn. 7
$F_{boulder}$		**lb**	**Eqn. 5**

$$F_{boulder} = F_{bouldersub} + F_{boulderdry}$$ **Equation 5**

$$F_{bouldersub} = N_{bouldersub} * \frac{\pi}{6} * d^3_{bouldersub} * (\gamma_{boulder} - \gamma_w)$$ **Equation 6**

$N_{bouldersub}$ = number of submerged boulders
$d_{bouldersub}$ = effective diameter of submerged boulders
$\gamma_{boulder}$ = unit weight of boulders

$$F_{boulderdry} = N_{boulderdry} * \frac{\pi}{6} * d^3_{boulderdry} * \gamma_{boulder}$$ **Equation 7**

$N_{boulderdry}$ = number of unsubmerged boulders
$d_{boulderdry}$ = effective diameter of unsubmerged boulders

Comment: The intent is design without the use of boulders so it is assumed no boulders are used.

Buoyancy Calculations

Project: Tucannon - Channel Spanning
Project No.: Project Number

Analyst: ASD
Calculations Checked By: ASD
Latest Revision: 7/2/2021

3. Soil Backfill Force (F_{soil})

$N_{logssub1}$	4		Number of Type 1 buried logs (from detail)
L_{eb1}	36	ft	Average embedded length of Type 1 logs (from detail)
d_{bole1}	1.25	ft	Average diameter of Type 1 logs (from detail)
$h_{soilsub1}$	2.75	ft	Average height of submerged soil above Type 1 log (from detail)
$V_{soilsub1}$	495	ft^3	Volume of submerged soil above Type 1 log (from detail)
$h_{soildry1}$		ft	Average height of dry soil above Type 1 log (from detail)
$V_{soildry1}$		ft^3	Volume of dry soil above Type 1 log (from detail)
$N_{logssub2}$	1		Number of Type 2 buried logs (from detail)
L_{eb2}	40	ft	Average embedded length of Type 2 logs (from detail)
d_{bole2}	1.25	ft	Average diameter of Type 2 logs (from detail)
$h_{soilsub2}$	3.5	ft	Average height of submerged soil above Type 2 log (from detail)
$V_{soilsub2}$	175	ft^3	Volume of submerged soil above Type 2 log (from detail)
$h_{soildry2}$		ft	Average height of dry soil above Type 2 log (from detail)
$V_{soildry2}$		ft^3	Volume of dry soil above Type 2 log (from detail)
$N_{logssub3}$	1		Number of Type 3 buried logs (from detail)
L_{eb3}	15	ft	Average embedded length of Type 3 logs (from detail)
d_{bole3}	1.5	ft	Average diameter of Type 3 logs (from detail)
$h_{soilsub3}$	2.2	ft	Average height of submerged soil above Type 3 log (from detail)
$V_{soilsub3}$	50	ft^3	Volume of submerged soil above Type 3 log (from detail)
$h_{soildry3}$		ft	Average height of dry soil above Type 3 log (from detail)
$V_{soildry3}$		ft^3	Volume of dry soil above Type 3 log (from detail)
γ_{soil}	131	lb/ft^3	Specific Gravity of bank/backfill material (Table 5)
γ_{water}	62.4	lb/ft^3	Unit weight of water
SG_{rock}	2.64		Specific Gravity of Rock (Using unit weight of bedrock from Table 5)
e	0.26		Eqn. 14
γ_{sat}	144	lb/ft^3	Eqn. 13
γ'_{soil}	81.4	lb/ft^3	Eqn. 12
F_{soil}	**58,552**	**lb**	**Eqn. 8**

$$F_{soil} = \sum_i^n V_{soilsub_i} * \gamma'_{soil} + V_{soildry_i} * \gamma_{soil}$$ **Equation 8**

$$V_{soilsub_i} = L_{eb_i} d_{bole_i} h_{soilsub_i}$$ **Equation 9**

$V_{soilsubi}$ = volume of submerged soil above log i
L_{ebi} = embedded length of log i
d_{bolei} = bole diameter of log i
$h_{soilsubi}$ = height of submerged soil above log i

$$V_{soildry_i} = L_{eb_i} d_{bole_i} h_{soildry_i}$$ ***Equation 10***

$V_{soildryi}$ = volume of dry soil above log i
$h_{soildryi}$ = height of dry soil above log i

$$\gamma_{soil} = (99.2 + 18.6 * \log(d_{50}))$$ **Equation 11**

d_{50} = median grain size in millimeters

$$\gamma'_{soil} = \gamma_{sat} - \gamma_w$$ **Equation 12**

$$\gamma_{sat} = \frac{(SG_{rock} + e) * \gamma_w}{1 + e}$$ **Equation 13**

$$e = \frac{SG_{rock} * \gamma_w}{\gamma_{soil}} - 1$$ **Equation 14**

Buoyancy Calculations

Project: Tucannon - Channel Spanning
Project No.: Project Number

Analyst: ASD
Calculations Checked By: ASD
Latest Revision: 7/2/2021

4. Pile Skin Friction

N_{piles}			Number of piles (Design)
d_{piles}	0.83	ft	Diameter of piles (Design)
L_{piles}	8	ft	Embedded length of piles (Design)
k_s	1		Coefficient of lateral earth pressure (0.5 to 1.5 depending on soil and density)
Placement Method	Excavated		Method of pile placement
Placement Multiplier	0.25		See RBDG (P. 52)
Pile Placement Location	Bank		Bed or Bank
ϕ_{soil}	0.70	rad	Internal angle of friction of soils (Table 5)
γ_{soil}	131	lb/ft^3	Specific Weight of Soil
e	0.26		Eqn. 14
γ_{sat}	144	lb/ft^3	Eqn. 13
γ_{water}	62.4	lb/ft^3	Unit weight of water
σ'	651	lb/ft^2	Eqn 16
γ_{wood}	33	lb/ft^3	Unit weight of wood
$F_{piles-v}$		**lb**	**Eqn 15**

Assumptions:
*** k_s = 1**
**** This calculation is based on the assumption that piles are driven or vibrated into place. If piles are drilled or excavated, the associated coefficicient of lateral earth pressures shall be approx. 50% and 25% of the driven value, respectively.**
***** For use in buoyancy calculations, piles must be mechanically fastened.**
****** Top 2' of pile embedment disregarded for calculation to account for vortex shedding.**

$$F_{piles-v} = N_{piles} * \pi * d_{piles} * L_{piles}(k_s * \tan\frac{2}{3}\emptyset * \sigma' + \frac{d_{piles}}{4} * (\gamma_{wood} - \gamma_w))$$

Equation 15

N_{piles} = *number of piles*
d_{piles} = *diameter of piles*
L_{piles} = *embedded length of piles*
k_s = *coefficient of lateral earth pressure (0.5 to 1.5 depending on soil and density)*
ϕ = *internal angle of friction of soils*

$$\sigma' = L_{piles} * (\gamma_{sat} - \gamma_w)$$

Equation 16

$$\gamma_{sat} = \frac{(SG_{rock} + e) * \gamma_w}{1 + e}$$

Equation 13

$$e = \frac{SG_{rock} * \gamma_w}{\gamma_{soil}} - 1$$

Equation 14

Buoyancy Calculations

Project: Tucannon - Channel Spanning
Project No.: Project Number

Analyst: ASD
Calculations Checked By: ASD
Latest Revision: 7/2/2021

5. Large Wood Material Force - Submerged (F_{LWMs})

$$F_{LWMs} = V_{LWMs} * (\gamma_{wood} - \gamma_w)$$ **Equation 2**

V_{LWMs} = *volume of submerged large wood material*
γ_{wood} = *unit weight of wood*
γ_w = *unit weight of water*

$N_{logssub1}$	4		Number of log type 1 (from detail)
L_{log1}	50	ft	Length of log type 1 (from detail)
d_{bole1}	1.25	ft	Diameter of log type 1 (from detail)
d_{rw1}	3.13	ft	Diameter of rootwad of log type 1 (from detail)
V_{LWMs1}	271	ft^3	Volume of LWM1
$N_{logssub2}$	1		Number of log type 2 (from detail)
L_{eb2}	50	ft	Length of log type 2 (from detail)
d_{bole2}	1.25	ft	Diameter of log type 2 (from detail)
d_{rw2}	3.13	ft	Diameter of rootwad of log type 2 (from detail)
V_{LWMs2}	68	ft^3	Volume of LWM2
$N_{logssub3}$	2		Number of log type 3 (from detail)
L_{eb3}	50	ft	Length of log type 3 (from detail)
d_{bole3}	1.25	ft	Diameter of log type 3 (from detail)
d_{rw3}	3.13	ft	Diameter of rootwad of log type 3 (from detail)
V_{LWMs3}	136	ft^3	Volume of LWM3
V_{LWMs}	474	ft^3	Volume of LWM
γ_{wood}	33.0	lb/ft^3	Unit weight of logs
γ_w	62.4	lb/ft^3	Unit weight of water
F_{LWMs}	**-13,943**	**lb**	**Eqn. 3**

Volume of Rootwad

National Large Wood Manual. 2016

Equation 6-4 (p. 6-38)

$V_{rw} = \pi * t_k * w_k^2 / 3$

$\pi*(2d_{bole}) * (1/2d_{rw})^2 / 3$

t_k = Thickness of rootwad measured in direction parallel to trunk

= 4 times the radius of the log ($4r_k$ or

w_k =

Radius of rootwad

= 2.5 times the radius of the log ($2.5r_k$ or $1.25d_{bole}$) or 1/2 d_{rw} specified

6. Lift Forces (F_L)

$$F_L = -\frac{C_L * A_{LWM} * \gamma_w * U_o^2}{2*g}$$ **Equation 4**

C_L = *lift coefficient*
A_{LWM} = *area of large woody material perpendicular to flow*
u_u = *upstream channel velocity at design event*
g = *acceleration due to gravity*

C_L	0.45		Lift Coefficient
A_{LWM}	140	ft^2	Calc'd in Drag Forces
γ_w	62.4	lb/ft^3	Unit weight of water
U_o	8.0	ft/s	upstream velocity (from model)
g	32.2	ft/s^2	Unit weight of water
F_L	**-3,907**	**lb**	**Eqn. 4**

Comment: Lift forces neglected per Section 6.4.2 of BOR Risk Based Design Guidelines

Factor of Safety

FOS_b =	$(F_{LMDd} + F_{boulders} + F_{soil} + F_{piles-v}) / (F_{LWMs} + F_L)$		
F_{LWMd}		lb	Assumed Zero
$F_{boulder}$		lb	
F_{soil}	58,552	lb	
$F_{piles-v}$		lb	
F_{LWMs}	-13,943	lb	
F_L	-3,907	lb	
FOS_b	**3.28**		**STABLE FOR BUOYANCY**

Summary Comments:

Sliding Calculations

Project:	Tucannon - Channel Spanning	**Analyst:**	ASD
Project No.:	Project Number	**Calculations Checked By:**	ASD
		Latest Revision:	7/2/2021

Spreadsheet Description

Purpose: The spreadsheet below is used to calculate the Factor of Safety against LWM sliding.

Assumptions:
1) The LWM structure behaves as a single structure under the design load and will not experience any shearing at joints.
2) The effect of soil in back of the structure is negligible.
3) The structure will be submerged during the design event.
4) Channel velocity (V_c) taken from hydraulic model.
5) This LWM structure experiences the largest loads. All LWM structures on site will be designed based on this LWM structure's loadings.

Input (Cells Requiring Input from Structure Detail)
Input (Cells requiring Input from Hydraulic Model)
Input (Cells requiring input from a dropdown list)
Input (Cells automatically populated from Input to Interface Tab)
Output (Cells automatically updated are this color)
Output (Cells automatically updated with previously calculated values are this color)

FBD and Equations:

$$FOS_{sliding} = \frac{|F_{hd}+F_f+F_{piles-h}+F_{passive}|}{F_d+F_{hu}+F_l}$$ **Equation 41**

*** PROJECT NAME has a "XXXX" Public Safety Risk Factor and a "XXXX" Property Damage Risk Factor. The Design Sliding Factor of Safety ($FOS_{sliding}$) for this structure is #.# per Table 4 "Minimum Recommended Factors of Safety".**

Table 4. Minimum recommended factors of safety.

Public Safety Risk	Property Damage Risk	Stability Design Flow Criteria	$FOS_{sliding}$	$FOS_{bouyancy}$	$FOS_{rotation}$ $FOS_{overturning}$
High	High	100-year	1.75	2.0	1.75
High	Moderate	50-year	1.5	1.75	1.5
High	Low	25-year	1.5	1.75	1.5
Low	High	100-year	1.75	2.0	1.75
Low	Moderate	25-year	1.5	1.75	1.5
Low	Low	10-year	1.25	1.5	1.25

1. Drag Force (F_d)

Y_u	3.80	ft	Upstream water depth
hdebris	3.8	ft	Debris height (incl. accumulation)
wdebris	35	ft	Debris width (incl. accumulation)
Debris Shape	Rectangle		
A_{LWM}	140	ft^2	Wetted area of LWM
γ_{water}	62.40	lb/ft^3	Unit weight of water
v_c	8.00	ft/s	Velocity from Model
g	32.20	ft/s^2	Acceleration due to gravity
A_b	140.00	ft^2	Debris area
$w_{channel}$	120	ft	Channel width
c_d	1.50		NLWM Worst Case
F_d	13023	lb	Eqn 19

$$F_d = \frac{C_D * A_{LWM} * \gamma_w * U_c^2}{2 * g}$$ **Equation 19**

F_d = *drag force*
C_d = *drag coefficient*
A_{LWM} = *area of wetted debris based on the upstream water surface elevation projected normal to flow direction and the potential drift accumulation*
γ_w = *unit weight of water*
U_c = *velocity in contracted section*
g = *acceleration due to gravity*

Cd can be assumed 0.9 when fully submerged, 1.5 when WSEL withi

$$C_{d-applied} = \frac{C_d}{(1-B)^2}$$ C_d is typically estimated as 1.0 **Equation 27**

Sliding Calculations

Project: Tucannon - Channel Spanning
Project No.: Project Number

Analyst: ASD
Calculations Checked By: ASD
Latest Revision: 7/2/2021

3. Impact Force (F_i)

L_{debris}	30	ft	Length of debris member (Design)
$d_{boledebris}$	1.5	ft	Bole diameter of debris member (Design)
$d_{rwdebris}$	4	ft	Rootwad diameter of debris member (Design)
V_{debris}	66	ft^3	Volume of debris
γ_{wood}	33	lb/ft^3	Unit weight of wood
w_{debris}	2,164	lb	weight of debris
g	32.2	ft/s^2	Acceleration due to gravity
$V_{channel}$	8.0	ft/s	Velocity from Model
Δt	0.03	sec	Impact Interval (0.03 sec recommended)
C_i	0.8		Coefficient of importance (from Table 6)
C_o	0.8		Coefficient of orientation
C_d	1		Figure 11 (need water depth from model)
Degree of Screening or Sheltering Upstream	No upstream screening, flow path wider than 30'		ASCE 7-05
C_b	1		ASCE 7-05
R_{max}	0.8		Response ratio for impulsive loads
F_i	**14,414**	**lb**	**Eqn 30**

$$F_i = \frac{\pi w_{debris} * V_{channel} * C_i * C_o * C_d * C_b * R_{max}}{2 * g * \Delta t}$$ **Equation 30**

F_i = impact force

w_{debris} = weight of debris

g = acceleration constant due to gravity

$V_{channel}$ = water velocity in channel

Δt = time from initial velocity to zero velocity

C_i = coefficient of importance

C_o = coefficient of orientation = 0.8

C_d = coefficient of depth

C_b = coefficient of blockage

R_{max} = response ratio for impulsive loads = 0.8

Assumption:

***Largest impact force would be generated by structure being struck by floating large key member. For impact calculation, assuming 18" diameter, 30' long member with rootwad impacts structure.**
****See Section 6.3.3 of LWM RBDG (P. 44) for debris loading sizing.**

4. Friction Force (F_f)

ϕ_{bed}	0.72	radians	Calculated for streambed material (small cobble)
μ_{bed}	0.87		Eqn 32
F_{LWMd}		lb	Buoyancy Calcs
$F_{boulder}$		lb	Buoyancy Calcs
F_{soil}	58552	lb	Buoyancy Calcs
$F_{piles-v}$		lb	Buoyancy Calcs
F_{LWMs}	-13943	lb	Buoyancy Calcs
F_L	-3907	lb	Buoyancy Calcs
F_b	40,702	lb	Eqn 17
F_f	**-35,382**	**lb**	**Eqn 31**

$$F_f = -\mu_{bed} * (F_b - F_{piles-v})$$ Equation 31

F_f = force due to frictional resistance

F_b-$F_{piles-v}$ >0

$$\mu_{bed} = \tan \emptyset$$ Equation 32

$$F_b = F_{LWMs} + F_{LWMd} + F_L + F_{boulder} + F_{soil} + F_{piles-v}$$ ***Equation 17***

Note:
***If buoyancy forces are less than vertical pile forces (Fb-Fpiles-v<0), then friction force = 0.**

Sliding Calculations

Project: Tucannon - Channel Spanning
Project No.: Project Number

Analyst: ASD
Calculations Checked By: ASD
Latest Revision: 7/2/2021

5. Passive Forces ($F_{passive}$)

Φ_{bank}	0.70	radians	Calculated for bank material (very course gravel)
K_p	4.60		Eqn 34
γ_{water}	62.4	lb/ft^3	Unit weight of water
γ_{soil}	131	lb/ft^3	Unit weight of soil
γ_{sat}	144	lb/ft^3	Previously calculated for buoyancy calcs
$N_{logssub1}$	4		Number of log type 1 (from detail)
Orientation$_1$**	Perpendicular		Perpendicular or Parallel to flow
L_{eb1}	36	ft	Length of log type 1 (from detail)
d_{bole1}	1.25	ft	Diameter of log type 1 (from detail)
D_{sub1}	2.75	ft	Depth of submerged soil above log 1
D_{dry1}		ft	Depth of dry soil above log 1
σ_{v1}	224	lb/ft^2	
$\sigma_{v1} * L_{eb1} * \gamma_{soil}$	40,283	lb	
$N_{logssub2}$	1		Number of log type 2 (from detail)
Orientation$_2$**	Perpendicular		Perpendicular or Parallel to flow
L_{eb2}	40	ft	Length of log type 2 (from detail)
d_{bole2}	1.25	ft	Diameter of log type 2 (from detail)
D_{sub2}	3.5	ft	Depth of submerged soil above log 2
D_{dry2}		ft	Depth of dry soil above log 2
σ_{v2}	285	lb/ft^2	
$\sigma_{v2} * L_{eb2} * \gamma_{soil}$	14,241	lb	
$N_{logssub3}$	1		Number of log type 3(from detail)
Orientation$_3$**	Perpendicular		Perpendicular or Parallel to flow
L_{eb3}	15	ft	Length of log type 3 (from detail)
d_{bole3}	1.5	ft	Diameter of log type 3 (from detail)
D_{sub3}	2.2	ft	Depth of submerged soil above log 3
D_{dry3}		ft	Depth of dry soil above log 3
σ_{v3}	179	lb/ft^2	
$\sigma_{v3} * L_{eb3} * \gamma_{soil}$	4,028	lb	
$F_{passive}$	**-134,638**	**lb**	**Eqn 31**

** Eqns 33 through 35 represent the case where passive forces act

$$F_{passive} = -0.5 * K_p * \sum_i^n \sigma_{v_i} * L_{em_i} * d_{log_i}$$ Equ

$$K_p = \frac{1+\sin\phi}{1-\sin\phi}$$ Equ

$$\sigma_{v_i} = D_{sub_i} * (\gamma_{sat} - \gamma_{water}) + D_{dry_i} * \gamma_{soil}$$ Equ

D_{subi} = *depth of submerged soil above log i*
D_{dryi} = *depth of dry soil above log i*
L_{emi} = *embedded length of log i*
d_{logi} = *diameter of log i*

Sliding Calculations

Project: Tucannon - Channel Spanning
Project No.: Project Number

Analyst: ASD
Calculations Checked By: ASD
Latest Revision: 7/2/2021

6. Lateral Resistance from Piles ($F_{piles\text{-}h}$)

N_{piles}	4		Number of piles (Design)
d_{piles}	0.83	ft	Diameter of piles (Design)
L_{piles}	8	ft	Embedded length of piles below scour (Design)
Placement Method	Excavated		Method of pile placement
Placement Multiplier	0.25		See RBDG (P. 52)
Pile Placement Location	Bed		Bed or Bank
γ_{water}	62.4	lb/ft^3	Unit weight of water
γ_{soil}	137	lb/ft^3	Unit weight of soil
γ_e	74.6	lb/ft^3	Eqn 37
ϕ_{soil}	0.72	radians	Calculated for material pile is located
K_p	4.81		Eqn 38
h_{load}**	1.9	ft	Height above scour depth load is applied
$F_{piles\text{-}h}$	**-7,709**	**lb**	**Eqn 15**

*** Top 2' of pile embedment disregarded for calculation to account for vortex shedding.**

**** Analysis also assumes that the resultant force is located at half of the flow depth on the upstream side of the LWM structure to produce a conservative moment on the pile.**

$$F_{piles-h} = -N_{piles} * \frac{L_{pile}^3 * \frac{1}{2} * \gamma_e * d_{pile} * K_p}{h_{load} + L_{pile}} \quad \text{Equation 36}$$

N_{piles} = number of piles
L_{pile} = length of pile embedded below potential scour depth

$$\gamma_e = \gamma_s - \gamma_w \quad \text{effective unit weight of soil} \quad \text{Equation 37}$$

γ_s = dry unit weight of the soil

γ_w = unit weight of the soil
d_{pile} = diameter of the pile
h_{load} = height above the potential scour depth the load is applied

$$K_p = \frac{1+\sin\phi}{1-\sin\phi} \quad \text{Equation 38}$$

Factor of Safety

$FOS_{sliding}$ =	$(F_{hd} + F_f + F_{piles\text{-}h} + F_{passive}) / (F_d + F_{hu} + F_i)$		
F_d	13,023	lb	
F_{hu}		lb	
F_{hd}		lb	
F_i	14,414	lb	
F_f	-35,382	lb	
$F_{passive}$	-134,638	lb	
$F_{piles\text{-}h}$	-7,709	lb	
$FOS_{sliding}$	**6.48**		**STABLE FOR SLIDING**

Summary Comments:

Rotation Calculations

Project:	Tucannon - Channel Spanning	**Analyst:**	ASD
Project Number:	Project Number	**Calculations Checked By:**	ASD
		Latest Revision:	7/2/2021

Spreadsheet Description

Purpose: The spreadsheet below is used to calculate the Factor of Safety against LWM structure horizontal rotation.

Assumptions:
1) The LWM structue behaves as a single structure under the design load.
2) The effect of soil in back of the structure is negligible.
3) The structure will be submerged during the design event
4) This LWM structure experiences the largest loads. All LWM structures on site will be designed based on this LWM structure's loadings

Input (Cells Requiring Input from Structure Detail)
Input (Cells requiring Input from Hydraulic Model)
Input (Cells requiring input from a dropdown list)
Input (Cells automatically populated from Input to Interface Tab)
Output (Cells that are automatically updated are this color)
Output (Cells that are automatically updated with previously calculated values are this color)

FBD and Equations:

$$FOS_{rotation} = \frac{MR_{rotation}}{MD_{rotation}}$$ **Equation 45**

Table 4. Minimum recommended factors of safety.

Public Safety Risk	Property Damage Risk	Stability Design Flow Criteria	$FOS_{sliding}$	$FOS_{bouyancy}$	$FOS_{rotation}$ $FOS_{overturning}$
High	High	100-year	1.75	2.0	1.75
High	Moderate	50-year	1.5	1.75	1.5
High	Low	25-year	1.5	1.75	1.5
Low	High	100-year	1.75	2.0	1.75
Low	Moderate	25-year	1.5	1.75	1.5
Low	Low	10-year	1.25	1.5	1.25

*** PROJECT NAME has a "XXXX" Public Safety Risk Factor and a "XXXX" Property Damage Risk Factor. The Design Rotation Factor of Safety ($FOS_{rotation}$) for this structure is #.# per Table 4 "Minimum Recommended Factors of Safety".**

1. Resistance to Rotation ($MR_{rotation}$ and $MD_{rotation}$)

$$MD_{rotation} = (F_i + F_d + F_{hu}) * \left(\frac{L_{sp}+L_{ebp}}{2}\right)$$ **Equation 42**

L_{sp} = length of wood structure from tip to point of rotation measured perpendicular to flow

L_{ebp} = embedded length of wood structure measured perpendicular to flow

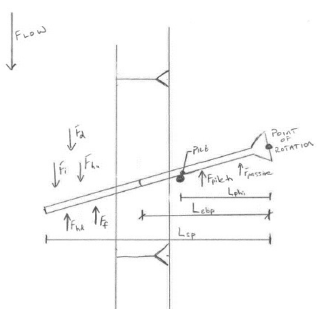
$$MR_{rotation} = \left| F_{hd} * \left(\frac{L_{sp}+L_{ebp}}{2}\right) + F_{passive} * \frac{L_{ebp}}{2} + F_f * \frac{L_{sp}}{2} + \sum_{i}^{n} F_{pile-h_i} * L_{ph_i} \right|$$ **Equation 43**

$$F_{pile-h_i} = \frac{F_{piles-h}}{N_{piles}}$$ **Equation 44**

L_{phi} = distance from pile 'i' to the point of rotation measured perpendicular to flow

Driving:

L_{sp}	50	ft	Length of wood structure from tip to point of rotation measured perpendicular to flow
L_{ebp}	36	ft	Embedded length of wood structure measured perp. to flow
F_i	14,414	lb	Impact Forces (Calc'd in Sliding)
F_d	13,023	lb	Drag Forces (Calc'd in Sliding)
F_{hu}		lb	Upstream Hydrostatic Forces (Calc'd in Sliding)
$MD_{rotation}$	**1,179,786**	**lb*ft**	**Eqn 42**



Resisting:

F_{hd}		lb	Downstream Hydrostatic Forces (Calc'd in Sliding)
$F_{passive}$	-134,638	lb	Passive Forces (Calc'd in Sliding)
F_f	-35,382	lb	Friction Forces (Calc'd in Sliding)
F_{pile-h}	-7,709	lb	Lateral Resistance from Piles (Calc'd in Sliding)
$F_{pile-hi}$	-1,285	lb	Lateral Resistance from Piles (Calc'd in Sliding)
N_{piles}	6		Number of Piles (Design)
L_{phi}	25	ft	Distance from pile to the point of rotation measured perp. to flow
$MR_{rotation}$	**3,500,758**	**lb*ft**	**Eqn 43**

Factor of Safety

$FOS_{rotation}$ =	*$MR_{rotation}$ / $MD_{rotation}$*		
$MD_{rotation}$	1,179,786	lb	
$MR_{rotation}$	3,500,758	lb	
$FOS_{rotation}$	**2.97**		**STABLE FOR ROTATION**

Summary Comments:

TUCANNON RIVER PROJECT AREA 27/28
COLUMBIA COUNTY, WA

The Confederated Tribes of the Umatilla Indian Reservation (CTUIR)
6411 Timine Way
Pendleton, Oregon 97801

CONSTRUCTION SPECIFICATIONS
SPECIAL PROVISIONS

JULY 2021
80% DESIGN

(This page intentionally left blank)

Contents

INTRODUCTION

This Contract shall be constructed in accordance with the 2021 Standard Specifications for Road, Bridge, and Municipal Construction.

INTRODUCTION TO THE STANDARD AMENDMENTS

There are no amendments to the 2021 WSDOT Standard Specifications.

INTRODUCTION TO THE SPECIAL PROVISIONS

Several types of Special Provisions are included in this contract; General, Region, Bridges and Structures, and Project Specific. Special Provisions types are differentiated as follows:

(date)	General Special Provision
(******)	Notes a revision to a General Special Provision and also notes a Project Specific Special Provision.
(Regions[1] date)	Region Special Provision

General Special Provisions are similar to Standard Specifications in that they typically apply to many projects, usually in more than one Region. Usually, the only difference from one project to another is the inclusion of variable project data, inserted as a “fill-in”.

Region Special Provisions are commonly applicable within the designated Region. Region designations are as follows:

Regions[1]	
ER	Eastern Region
NCR	North Central Region
NWR	Northwest Region
OR	Olympic Region
SCR	South Central Region
SWR	Southwest Region
WSF	Washington State Ferries Division

Project Specific Special Provisions normally appear only in the contract for which they were developed.

Division 1
General Requirements

1-01 DESCRIPTION OF WORK

DESWORK1.FR1
(March 13, 1995)

This Contract provides for the improvement of ***Tucannon River Area 27/28*** and other work, all in accordance with the attached Contract Plans, these Contract Provisions, and the Standard Specifications.

1-02 Bid Procedures and Conditions

1-02.1 Prequalification of Bidders

(April 2, 2018)
Vacant

1-04 Scope of the Work

1-04.4 Changes

(April 30, 2020)
Change Orders will be transmitted electronically to the Contractor for signature. The Contractor shall apply all signatures electronically using the software provided by the Contracting Agency. Within 21 days of execution of the Contract, the Contractor shall submit a Type 1 Working Drawing consisting of the names, email addresses, and text-message capable phone numbers for the authorized change order signers and shall bear the name, phone number and email of the officer providing this authorization. Delegation of authority to sign Change Orders shall be by the officer authorized to sign the Contract in accordance with Section 1-02.1.

1-07 Legal Relations and Responsibilities to the Public

1-07.1 COVID-19 Health and Safety Plan (CHSP)

(May 13, 2020)
In response to COVID-19, the Contractor shall prepare a project specific COVID-19 health and safety plan (CHSP) in conformance with Section 1-07.4(2) as supplemented in these specifications, **COVID-19 Health and Safety Plan (CHSP)**.

(May 13, 2020)
COVID-19 Health and Safety Plan (CHSP)
The Contractor shall prepare a project specific COVID-19 health and safety plan (CHSP). The CHSP shall be prepared and submitted as a Type 2 Working Drawing prior to beginning physical Work. The CHSP shall be based on the most current State and Federal requirements. If the State or Federal requirements are revised, the CHSP shall be updated as necessary to conform to the current requirements.

The Contractor shall update and resubmit the CHSP as the work progresses and new activities appear on the look ahead schedule required under Section 1-08.3(2)D. If the conditions change on the project, or a particular activity, the Contractor shall update and resubmit the CHSP. Work on any activity shall cease if conditions prevent full compliance with the CHSP.

The CHSP shall address the health and safety of all people associated with the project including State workers in the field, Contractor personnel, consultants, project staff, subcontractors, suppliers and anyone on the project site, staging areas, or yards.

COVID-19 Health and Safety Plan (CHSP) Inspection

The Contractor shall grant full and unrestricted access to the Engineer for CHSP Inspections. The Engineer (or designee) will conduct periodic compliance inspections on the project site, staging areas, or yards to verify that any ongoing work activity is following the CHSP plan. If the Engineer becomes aware of a noncompliance incident either through a site inspection or other means, the Contractor will be notified immediately (within 1 hour). The Contractor shall immediately remedy the noncompliance incident or suspend all or part of the associated work activity. The Contractor shall satisfy the Engineer that the noncompliance incident has been corrected before the suspension will end.

1-07.5 Environmental Regulations

(September 20, 2010)

Environmental Commitments

The following Provisions summarize the requirements, in addition to those required elsewhere in the Contract, imposed upon the Contracting Agency by the various documents referenced in the Special Provision **Permits and Licenses**. Throughout the work, the Contractor shall comply with the following requirements:

(August 4, 2014)

The Contractor shall submit a written notification to the Engineer no later than 10 calendar days prior to beginning any ground disturbing activities near the Tucannon River grading areas. The Contractor shall not commence any such ground disturbing activities until the monitor is present.

(April 1, 2019)

No *** refueling activity *** is allowed within *** 150 *** feet of *** sensitives areas like waters of the state and wetlands ***.

1-07.5(2) State Department of Fish And Wildlife

(April 2, 2018)

The Contractor may begin Work below the Ordinary High Water Line on *** July 15*** and must complete all the Work by *** August 30 ***.

1-07.5(3) State Department of Ecology

(April 1, 2019)

Stormwater, dewatering water, or other authorized non-stormwater discharges that has come into contact with pH modifying substances such as concrete rubble, cast concrete or amended soils, need to be maintained between 6.5 – 8.5 standard units (su). If pH exceeds 8.5 su, the Contractor shall immediately discontinue work and initiate treatment to prevent discharges outside the acceptable range from occurring. All neutralization methods used shall be in accordance with the permit. Work may resume once treatment has been implemented and pH of the stormwater or authorized non-stormwater discharge is between 6.5 - 8.5 su or it can be demonstrated that high pH waters will not discharge to surface waters.

Stormwater, dewatering water, and other authorized non-stormwater discharges are monitored weekly for compliance with the turbidity benchmark (25 nephelometric turbidity units (ntu)) and the phone reporting trigger value (250 ntu) by the Contracting Agency. When the turbidity benchmark is breached, the best management practices (BMPs) installed on-site are not working adequately and need to be adapted, maintained or more BMPs shall be installed. When the turbidity phone reporting trigger value is breached, immediate action is required in order to lower the turbidity to ≤25 ntu or to eliminate the discharge. Daily follow-up discharge samples will be collected at all locations where a discharge of 250 ntu or higher was collected unless the discharge was stopped or eliminated.

(April 2, 2018)
All costs to comply with this special provision are incidental to the Contract and are the responsibility of the Contractor. The Contractor shall include all related costs in the associated bid prices of the Contract.

1-08.1 Prosecution and Progress

(******)
This section is supplemented with the following:

This project shall be physically completed according to the construction sequencing and dewatering shown on the Plans.

The contractor shall provide submittals for items including but not limited to:

Submittal	**Schedule / Milestone**
Construction Schedule	Pre-construction meeting
Site Access Plan	Pre-construction meeting
Environmental Protection Plan	Pre-construction meeting
Equipment and Fuels Mgmt. Plan	Pre-construction meeting
Temporary Stream Diversion Plan	Pre-construction meeting
Erosion and Sediment Control Plan	Pre-construction meeting

Product Data/Samples/Certificates	
Turbidity Curtain	4 weeks prior to installation
Wood Habitat Structure Logs	4 weeks prior to installation
Native Wetland Seed Mix	4 weeks prior to installation
Native Upland Seed Mix	4 weeks prior to installation
Wattles	4 weeks prior to installation
Mulches	4 weeks prior to installation

Division 2
Earthwork

2-01 Clearing, Grubbing, and Roadside Cleanup

2-01.1 Description

Section 2-01.1 is supplemented with the following:

(March 13, 1995)
Clearing and grubbing on this project shall be performed within the following limits:

As shown on the Plans and as approved by the Owner's Representative.

2-01.3 Construction Requirements

Section 2-01.3 is supplemented with the following:

(******)
The Contractor shall collect and stockpile sufficient quantities of woody debris from within the limits of clearing for the purpose of constructing Wood Habitat Structures throughout the project limits within the project area. Rootwads shall remain intact during removal, transport, and storage. See Special Provision **8-27 WOOD HABITAT STRUCTURES.**

Salvaged logs: logs salvaged during onsite clearing and grubbing may be used for additional floodplain habitat, subject to approval from the Owner's Representative or Engineer. Salvaged onsite logs shall not be subject to size and length requirements of Keyed, Footer, Floodplain, Buried and Pin Logs.

(******)
Logs salvaged during onsite clearing and grubbing may be used for additional floodplain habitat or slash, subject to approval from the Owner's Representative. Salvaged onsite logs shall not be subject to size and length requirements of keyed, footer, floodplain, buried or pinned logs.

2-01.5 Payment

(******)

Salvaging logs and slash is considered incidental to Clearing, Grubbing, and Roadside Cleanup.

2-03 Excavation and Embankment

2-03.1 Description

(******)
Add the following section:

The Work described in this section, includes excavation of the high ground terrace, swales, berms, and placement of excavated material in the main stem Tucannon to the lines and grades shown on the plans. Finished grades shall be verified in the field by the Owner's Representative.

2-03.3(14)C Compacting Earth Embankments

(March 13, 1995)
All embankments, except waste embankments, shall be compacted using Method A.

2-03.4 Measurement

(March 13, 1995)
Only one determination of the original ground elevation will be made on this project. Measurement for roadway excavation and embankment will be based on the original ground elevations recorded previous to the award of this contract. Control stakes will be set during construction to provide the Contractor with all essential information for the construction of excavation and embankments.

If discrepancies are discovered in the ground elevations which will materially affect the quantities of earthwork, the original computations of earthwork quantities will be adjusted accordingly.

Earthwork quantities will be computed, either manually or by means of electronic data processing equipment, by use of the average end area method or by the finite element analysis method utilizing digital terrain modeling techniques.

Division7
Drainage Structures, Storm Sewer, Sanitary Sewers, Water Mains, and Conduits

(******)
Section 7-06 is replaced by the following:

7-06 Temporary Stream Diversion

7-06.1 Description
This work shall include designing, installing, operating, maintaining, removing, and disposing of dewatering systems, environmental compliance and other Work as detailed in these Specifications.

7-06.2 Materials
All materials shall be as detailed in the Contractor's Temporary Stream Diversion Plan (TSDP).

7-06.3 Construction Requirements
7-06.3(1) General

The Work shall include compliance with Washington State Water Quality Standards in WAC 173-201A, project permits, environmental commitments and these Provisions.

Dewatering systems may be either a gravity or a pumped system. Pump screens must comply with the requirements in Section 7-06.3(4) of these Special Provisions. Once a pumped diversion begins, the pump must run continuously until it is no longer necessary to bypass flows. The Contractor shall have back-up pumps on site and shall provide twenty-four hour monitoring of the pumping operation. Monitoring can be achieved by providing monitoring personnel on site or through remote sensing and instrumentation to verify operation of the bypass. If the Contractor elects to monitor by remote sensing and instrumentation, a Type 2 Working Drawing shall be submitted outlining how system operation will be monitored, how alerts will be made and how personnel will respond to a diversion system failure. Pumping for dewatering excavations may be stopped and started as needed so long as the conditions needed for material placement and compaction are maintained.

All elements of the diversion systems including water that is retained by the system shall be located within the permitted impact areas as shown in the Plans. The water diversion structures shall be constructed to a height sufficient to prevent stream flow from entering the work area. Scour protection shall be provided at the outfall of the dewatering systems to prevent flow entering or re-entering a stream channel from mobilizing streambed and embankment sediments. When a dewatering system is located in or near an intertidal zone the dewatering system design shall take tidal influence into consideration.

For each dewatering system the Contractor shall arrange a meeting with the Engineer prior to implementation of the DSP. At this meeting the Contractor shall explain to the Engineer the Work to be completed for the dewatering system. The meeting shall be a minimum of 7 calendar days prior to start of the dewatering system work.

The Dewatering System shall be operational prior to performing any other work below the Ordinary High Water Line.

7-06.3(2) Temporary Stream Diversion Plan

7-06.3(2)A General Plan Requirements

The Contractor shall submit a Temporary Stream Diversion Plan (TSDP) in accordance with the requirements of a Type 2E Working Drawing and these Specifications. A separate TSDP shall be prepared and submitted for each dewatering system that is required. The TSDP shall consist of a narrative and drawings detailing all dewatering system requirements and shall encompass and protect all the areas affected by the Contractor's dewatering system Work.

The Contractor shall fully implement the TSDP throughout the duration of the associated Work. The Contractor shall update the TSDP throughout project construction to reflect actual site conditions and the Contractor's Work. Changes to plan shall comply with WAC 196-23-020. At the request of the Engineer an updated TSDP shall be submitted as a Type 2E Working Drawing. A copy of the DSP shall be on the project site at all times.

The TSDP shall describe measures that will be taken to comply with Washington State Water Quality Standards in WAC 173-201A, applicable permits, environmental commitments and these Provisions.

The Contractor shall incorporate the Diversion Schedule and Sequence into their Progress Schedule.

7-06.3(2)B Stream Flows

Minimum Stream Flows

At all times of operation, the Contractor's dewatering system for the Tucannon Diversion shall be designed to convey the following minimum flow rate of water in cubic feet per second:

*** 15 CFS***

During all phases of the bypass installation and decommissioning, the Contractor shall maintain flows downstream of the project site.

7-06.3(2)C Plan Requirements

The TSDP shall provide the following information in the following order:

1. Description and Location of all diversion systems

    a. Identify the name of the water body where the diversion system will be placed. Provide a description of the diversion system.

b. Provide drawings showing the location of the diversion system, including proposed access routes and equipment to be used to construct the diversion.

2. Schedule and Sequence

a. Provide a sequence of Work, dates, and durations for when the following will occur, in accordance with the in-water work window in the Special Provisions:

i. Fish exclusion & salvage (performed by the Contractor).

ii. TSDP Implementation Meeting

iii. Diversion System installation.

iv. Dewatering of the isolated Work area.

v. Restoration and stabilization of the dewatering system Work area to prevent erosion.

vi. Any relocations of the dewatering system to accommodate the Work sequence (if needed).

vii. Channel rewatering.

viii. Turbidity management plan.

ix. Removal of the Diversion System.

x. Fish exclusion removal (performed by Contractor after Owner approval).

b. Include other Work that needs to be coordinated with the Dewatering System (e.g., temporary erosion control).

3. Calculations and Materials

a. Detail all elements of the dewatering system; including but not limited to pipes, pumps, and other equipment.

b. Calculations shall demonstrate the diversion system conveys the minimum peak flow specified by the Owner and include tidal influence where applicable.

c. Dewatering system shall include a water conveyance system to be used for dewatering and rewatering that is capable of conveying the flow required for the dewatering system.

d. Methods for anchoring dewatering system pipe and associated hardware; include calculations to demonstrate the devices ability to anchor the pipe and associated hardware.

e. Specifications for all materials and equipment to be used as part of the diversion including pump or diversion capacities and hose sizes. For example, provide the type, profile, and size of pipe.

f. Provide the size of fish screens (mesh size and surface area) to be used, in accordance with Section 7-06.3(5) of these Special Provisions.

4. Stream Flow Blocking and Dewatering

a. Provide the method(s), including locations and details (narrative and drawings) for blocking both the upstream and downstream ends of the diversion. Describe how minor leakage from upstream and downstream will be addressed.

b. Include provisions for scour protection at the dewatering system outfalls.

c. Identify the means and methods for dewatering water and disposal of the water.

5. Inspection and Maintenance

a. Provide the schedule and frequency for inspection of the dewatering system; include weekends and holidays.

b. Describe how maintenance will be conducted when inspections identify deficiencies in the dewatering system. These include, but are not limited to removal and disposal of trapped sediment or debris and repairing leaks.

c. The Contractor shall keep a record of all inspections and maintenance of the dewatering system.

6. Rewatering the Stream Channel

a. Detail how the stream channel will be rewatered to comply with water quality requirements.

b. Identify measures that will prevent the stranding of fish during rewatering (i.e. describe methods, rates, and durations of the rewatering process knowing that flows downstream of the fish block must be maintained to protect fish).

7. Removal of the Diversion system

a. Describe the sequence that will be used for removing the dewatering system and methods to prevent water quality impacts.

b. Describe how disturbed soil will be permanently stabilized.

c. Describe any temporary pipes to remain (requires approval of the Engineer): their type, pipe class, size, location, and plugging procedure.

8. Other Work required for the Contractor's dewatering system

7-06.3(3) Fish and Aquatic Species Exclusion and Notifications

Prior to installing a diversion system, the Contractor shall allow 7 calendar days after the beginning of the in-water work window defined in the Special Provisions, in their schedule for the following activities: (1) to install fish block nets upstream and downstream of the in-water Work area; and (2) safely capture and relocate any fish and other aquatic organisms that become trapped between the block nets. No Work within the limits of the Ordinary High Water Line will be allowed prior to installation of fish block nets and completion of fish exclusion activities.

The Owner, CTUIR, and other partners will contribute the following manpower and equipment to assist the Contractor with implementation of the Fish Salvage Plan which is a required component of the Dewatering System & Plan:

(******)

Fish exclusion and salvage to be performed in accordance with the provisions of the Hydraulic Project Approval (HPA) permit.

Fish Exclusion and salvage shall be directed by a Designated Lead Fish Moving Biologist and the work shall be carried out by Trained Personnel. Experience and qualifications for these personnel area as follows:

Requirements for Designated Lead Fish Moving Biologist (Directing Biologist)

- Completion of a minimum of a two day electrofishing class.
- Training in fish ecology and identification
- 100 hours of electrofishing experience in the Pacific Northwest, at least 20 hours of which should have been in the last 5 years in the PNW.
- Possession of a current CPR certification
- Possession of a current first aid certification
- Demonstrated understanding of aquatic invasive species and the appropriate decontamination methods necessary to prevent introducing aquatic invasive species into the work area.
- Demonstrated ability to interpret contract plan sheets/specification, contactor schedule and plans prepared by the contractor (e.g. Temporary Steam Diversion
- Plan and Spill Prevention Control and Countermeasure Plan)
- Ability to move fish per the most current version of the "WSDOT Fish
- Exclusion Protocols and Standards"
- Must develop and deliver on site field training for individuals assisting with fish moving.

Requirements for Trained Personnel

- Possess training, knowledge, skills and ability to ensure safe handling of fish and

- to ensure the safety of staff conducting the operations.
- Have a current first aid certification.
- Training must be conducted on site by the Designated Lead Fish Moving
- Biologist prior to initiation of the fish moving and must cover the following:
    - Review of site specific pre- activity safety plan
    - A site specific job site analysis and fish exclusion plan.
    - A discussion of roles, responsibilities, permit requirements, and species expected.
    - Review of electrofishing guidelines and equipment manufactures recommendations.
    - Definitions of basic terminology (galvanotaxis, narcosis, and tetany) and an explanation of how electrofishing attracts fish.
    - A demonstration and discussion of the proper use of electrofishing equipment (including an explanation of how gear can injure fish and how to recognize signs of injury) and the role of each crew member.
    - A demonstration of proper fish handling including proper netting, sorting by size, keeping buckets cool, releasing small and large fish in different pools, not overcrowding buckets, avoiding sunscreens/ insect repellants etc on hands moving fish.
    - A review of common mistakes.
    - A discussion of the use of personal floatation devices.
    - A discussion of aquatic invasive species and the decontamination methods necessary to prevent introducing aquatic invasives into the work area.

7-06.3(4) Dewatering Work Area

Dewatering the isolated in-water Work area (between the upstream and downwater management system dams) shall occur at a rate slow enough to allow the Contractor to safely capture and relocate all fish species and other aquatic organisms to avoid stranding, as determined by the Engineer.

All pumps used for dewatering shall have an intake covered with a fish screen, operated, and maintained in accordance with RCW 77.57.010 and RCW 77.57.070. Appropriate fish screens are as follows:

1. Perforated plate: 0.094 inch (maximum opening diameter);

2. Profile bar: 0.069 inch (maximum width opening); or

3. Woven wire: 0.094 inch (maximum opening measured on the diagonal).

The minimum open area for all types of fish screens is twenty-seven percent. The screened intake facility must have enough surface area to ensure that the velocity through the screen is less than 0.4 feet per second. The fish screen must remain in place whenever water is withdrawn until the Owner Biologists confirm all fish have been removed. At that point, the Contractor may remove the fish screen to finish dewatering the work area.

7-06.3(5) Inspection and Maintenance

At a minimum, the Contractor shall perform the following activities once per day (including weekends and holidays):

1. Check for and correct leaks;

2. Ensure the fish block nets remain sealed to the channel substrate.

The fish block nets shall be kept clear of debris that could jeopardize the integrity of the nets. The Contractor shall perform the following activities a minimum of three times per day or when requested by the Engineer. On working days, these activities shall be performed at the start, middle, and at the end of the working day. On non-working days, these activities shall be performed between 6:00 am and 8:00 am, between 11:00 am and 1:00 pm, and between 4:00 pm and 6:00 pm:

1. Inspect the upstream and downstream fish block nets and remove debris;

2. Inspect the upstream fish block net and all screens and similar facilities for impinged fish;

    a. The Contractor shall immediately notify the Owner when impinged fish are discovered.

    b. Removal of impinged fish will be performed by the Owner.

The Contractor shall maintain a written record of all inspection and maintenance activities; record to be available at the request of the Engineer.

7-06.3(6) Rewatering the Stream Channel

The Contractor shall notify the Engineer a minimum of 7 calendar days in advance of rewatering the stream channel.

The Contractor shall introduce water to the new stream channel section and trap sediments until the stream section meets the requirements of these Provisions. Rewatering shall occur at a rate to avoid loss of surface water downstream while the new channel section is rewatered.

(******)
Section 7-06.3(6) is supplemented with the following:

Re-watering excavated channels must be performed according to the HIPIII Staged Rewatering Notes listed on the Plans.

7-06.3(7) Removal of the Diversion system

The Contractor shall notify the Engineer two business days in advance of beginning the diversion system removal sequence.

Once the water in the new stream channel will meet the applicable turbidity standards the Contractor may begin removal of the dewatering system and the stream channel opened to flows.

The Contractor shall immediately take all corrective actions necessary to prevent the water from exceeding the turbidity standards should the stream turbidity increase. All Work within the channel, except for removal of the temporary erosion control items, shall be completed before the dewatering system is removed. The Contractor must finish all construction activities within the limits of the Ordinary High Water Line, including but not limited to culvert installation and creek bed channel restoration, before the Owner will remove the fish block nets.

All materials used for the diversion shall become the property of the Contractor and removed from the project limits, with the exception of any materials supplied by the Owner, unless otherwise specified by the Engineer.

7-06.5 Payment

Payment will be made for the following Bid items when included in the proposal:

"Temporary Stream Diversion and Plan", lump sum.

The lump sum Contract price for "Dewatering System and Plan" shall be full payment to perform the Work as specified. Progress payments for the lump sum item "Dewatering system" will be made as follows:

1. Twenty-five percent of the bid amount will be paid following completion of the TDSP including resolution of all OPR review comments.

2. The remaining seventy-five percent of the bid amount shall be paid in accordance with Section 1-09.9.

Activities and materials necessary to meet the specified requirements for Fish and Aquatic Species Exclusion and Notifications are incidental to the "Temporary Stream Diversion and Plan".

Division 8
Miscellaneous Construction

8-01 Erosion Control and Water Pollution Control

8-01.3(1) General

(January 25, 2010)
Erodible Soil Eastern Washington
Erodible soil not being worked whether at final grade or not, shall be covered within the following time period using an approved soil cover practice:

July 1 through September 30	30 days
October 1 through June 30	15 days

8-01.3(2) Seeding, Fertilizing and Mulching

8-01.3(2) Seeding and Fertilizing

(******)

Delete the word "fertilizer" from this section. No fertilizer shall be used.

The second sentence of the second paragraph is replaced with the following:

(******)

Seed shall be sown by Method 1 (hydro seeding).

Section 8-01.3(2)B is supplemented with the following:

(******)

Seed mixes are shown on the plan sheets.

Replace section 8-01.3(9)C including the header with the following:

8-01.3(9)C Floating Turbidity Curtain

Additional work required for pollution control on this project includes installation of a Type II Turbidity Curtain in the locations indicated on the plans. The turbidity curtain shall be installed prior to beginning construction and maintained in working order for the duration of construction according to the manufacturer's specifications.

Other turbidity management devices may be used as approved by the Owner's Representative and must comply with Washington State Water Quality Standards in WAC 173-201A, applicable permits, environmental commitments and these Provisions.

8-01.5 Payment

Section 8-01.5 is supplemented with the following:

(******)

"Floating Turbidity Curtain"

Payment for the Floating Turbidity Curtain or other approved turbidity management device shall be considered incidental to Erosion and Water Pollution Control

8-27 Wood Habitat Structures

8-27.1 Description

Work consists of placing wood habitat structures (WHSs) in accordance the Plans and these Special Provisions.

8-27.2 Materials

Logs with Rootwads shall consist of the following:

Shall be Douglas fir, full length logs, and have Rootwad intact unless otherwise shown on the Plans.

Log sourcing shall be the Contractor's responsibility unless agreed upon by the Owner's Representative or Engineer prior to delivery to the site.

Contractor is responsible for haul and transport of logs to the site.

Multiple WHS log types, such as pin logs, may be generated from a single imported log.

Keyed, footer, and floodplain logs shall diameters and lengths as shown on the plans.

8-27.3 Construction Requirements

WHSs shall be installed as shown on the Plans. The Contractor shall vary the plan view orientation of the logs within the limits shown and as directed by the Engineer. Number of logs in each WHS is shown in the Plans. The Contractor shall install and position the WHS to the satisfaction of the Engineer prior to the placement and compaction of native backfill. Rootwads shall generally be installed facing upstream (north), with exceptions as shown on the Plans or as needed for natural variability in the WHSs.

WHSs shall be installed after final grades have been met prior to final surface preparation, compost blanket and soil amendment application, seeding, or placement of mulch.

Key WHS trunks into the bank to a minimum embedment as shown on the Plans. Excavate trenches to install wood into the bank and backfill with native material, or alternately sharpen the end of the log and push into the existing grade to the final intended positioning as shown on the Plans. Compact the backfill over the WHS to a firm and unyielding condition. Scarify surface of backfill and graded areas to facilitate revegetation.

All undesirable growth from WHSs shall be treated so as to remove and/or prevent growth, including sprouts, suckers and roots prior to installation in the wetland area in accordance with the approved Weed and Pest Control Plan. All attached root systems shall only be pruned if designated by the Engineer.

Where shown on the Plans, pier logs shall secure footer or keyed logs in place as generally shown on the Plans. All pier logs shall be driven at a slight angle towards the footer log to resist floatation of the footer log. Ensure log-to-log contact between pier logs and footer logs. Reposition logs and redrive pier logs if necessary to achieve log-to-log contact. Sharpen the driven end of the pier logs prior to driving. Pier logs shall be driven into the ground to a minimum depth of 6 feet or as shown on the plans, whichever is deeper. Trim the tops of pier logs such that they extend a maximum of 24 to 48 inches above the top of the footer log as shown to ensure adequate overlap.

Contractor shall paint a line on the pier logs where minimum embankment depths are to be obtained as shown on the Plans to verify burial depths are achieved.

All attached root systems shall not be pruned unless designated by the Engineer. Prune limbs on the top half of the logs as directed by the Engineer or Owner's Representative to facilitate installation. When pruning leave approximately two (2) feet of the limbs extending from the trunk to facilitate seating of the logs into the wetland surface. Place all trimmed limbs in a natural manner (small brush pile) along the creek above and around the logs after final placement of the logs.

Streambed Boulders

Place native (sourced on-site) streambed boulders in WHS Type 7 as shown on the Plans to ballast and secure logs in place. Boulders shall meet all requirements of Section 9-03.11 Streambed Aggregates.

Boulders shall be placed in such a manner that all relatively large stones shall be essentially in contact with each other, and all voids filled with the native cobbles to provide a well graded compact mass.

When placing rock, care shall be used to avoid disturbing the underlying material.

a) Boulders shall be placed as shown on the Plans.

b) Place boulders by excavator bucket. Placement of rock by end-dumping shall not be allowed. Use the back of the excavator bucket to form, smooth, and slope the surface of the boulders and native streambed backfill to ensure rock-to-rock contact and so that all rocks are resistant to overturning or movement from flows and wave action.

Final placement shall be as directed and approved by the Contracting Agency. Acceptance of placed boulders shall be prior to completion of this Work.

8-27.4 Measurement

Wood Habitat Structures will be measured per each structure installed in the project area. One to two additional logs may be put into a structure based on log availability per Engineer's request in the field.

Streambed Boulders shall be incidental to the WHS Type 7 – Channel Spanning Jam structure.

8-27.5 Payment

Wood Habitat Structure Logs, per each structure installed.

The unit Contract price per each for Wood Habitat Structure shall be full pay for installing the large wood debris as specified including excavation, backfill and compaction, and any required vegetative control measures.

Division 9
Materials

9-03.11 Streambed Aggregates

Supplement Section 9-03.11(3) with the following:

(******)

Streambed Boulders shall be sourced on-site during excavation activities and be two man with a minimum 18” diameter.

9-40 Logs with Rootwads

Logs with rootwads shall consist of the following:

All logs used as pin logs, footer logs, keyed logs, floodplain logs, buried logs for Wood Habitat Structures and Floodplain Structures shall be Douglas fir, full length logs, and have rootwad intact, unless otherwise shown on the Plans. Log sourcing shall be the Contractor’s responsibility unless agreed upon by the Owner’s Representative and Engineer prior to delivery to the site. Contractor is responsible for haul and transport of logs to the site, and installing logs.

Keyed, Footer, and Floodplain Logs: shall have a minimum 8-inch diameter at breast height (DBH) and a maximum 24-inch DBH. These logs shall have a minimum length of 40 feet and no maximum length. Large logs sourced for WHS Type 3 (Spanning Large w/ Rootwad) shall be a minimum length of 50 feet and a minimum diameter of 18-inches.

Pier logs: shall have minimum 10-inch diameter and minimum length of 20 feet.

Log types, dimensions, and quantities shall be per the table below:

Log Type	Length/ DBH	Quantity	Unit
SPANNING LARGE W/ ROOTWAD	MIN 50' / 18-24"	27	EA
LARGE W/ ROOTWAD	MIN 40' / 18-24"	183	EA
MEDIUM W/ ROOTWAD	MIN 35' / 12-18"	174	EA
SMALL W/ ROOTWAD	MIN 25' / 8-12"	31	EA
PIER LOG	MIN 20' / MIN 10"	238	EA
RACKING	MIN 15' / MIN 6"	345	EA
SLASH		748	CY
NATIVE BOULDER	MIN DIAM 18"	15	EA

PROJECT: TUCANNON RIVER Phase 0.5-1
80% DESIGN COST ESTIMATE
DATE: 07/2021 AJ

	Costs				
Item	**Qty**	**Unit**	**Unit Cost**	**Total**	**Notes**
MOBILIZATION	1	LS	$ 49,000	$ 49,000	8% OF DIRECT ITEM CONSTRUCTION COSTS
TEMPORARY STREAM DIVERSION & PLAN	1	LS	$ 15,000	$ 15,000	ENGRS ESTIM, INCL COFFER DAM BULK BAGS
EROSION & WATER POLLUTION CONTROL	1	LS	$ 19,000	$ 19,000	3% OF DIRECT ITEM CONSTRUCTION COSTS, INCL TURBIDITY CURTAIN
CLEARING AND GRUBBING	2	AC	$ 3,500	$ 7,000	INCL GRADING AREAS, LOG SALVAGE, STOCKPILE, PLACEMENT
EARTHWORK EXCAVATION	3,600	CY	$ 11	$ 39,600	INCL ONSITE HAUL, PLACEMENT, GRADING, AND SIDE CASTING FOR DITCH RESHAPING
NATIVE WETLAND SEEDING	3.0	AC	$ 2,000	$ 6,000	INCL. PROCURMENT AND PLACEMENT IN UPSTREAM GRADING AREAS AND SWALES
NATIVE UPLAND SEEDING	7.0	AC	$ 1,500	$ 10,500	INCL. PROCURMENT AND PLACEMENT IN ACCESS, STAGING, AND UPLAND GRADING AREAS
WHS TYPE 1 - LARGE APEX JAM	9	EA	$ 14,100	$ 126,900	INCL. LOG PROCURMENT, DELIVERY, PLACEMENT, BALLAST, AND EXCAVATION
WHS TYPE 2 - SMALL APEX JAM	9	EA	$ 5,300	$ 47,700	INCL. LOG PROCURMENT, DELIVERY, PLACEMENT, BALLAST, AND EXCAVATION
WHS TYPE 3 - MARGIN DEFLECTOR JAM	40	EA	$ 5,000	$ 200,000	INCL. LOG PROCURMENT, DELIVERY, PLACEMENT, BALLAST, AND EXCAVATION
WHS TYPE 4 - FLOODPLAIN WOOD	34	EA	$ 1,000	$ 34,000	INCL. LOG PROCURMENT, DELIVERY, PLACEMENT, BALLAST, AND EXCAVATION
WHS TYPE 5 - FLOODPLAIN WOOD	30	EA	$ 2,000	$ 60,000	INCL. LOG PROCURMENT, DELIVERY, PLACEMENT, BALLAST, AND EXCAVATION
WHS TYPE 6 - HABITAT LOG	27	EA	$ 500	$ 13,500	INCL. LOG PROCURMENT, DELIVERY, PLACEMENT, BALLAST, AND EXCAVATION
WHS TYPE 6A - PINNED HABITAT LOGS	2	EA	$ 4,200	$ 8,400	INCL. LOG PROCURMENT, DELIVERY, PLACEMENT, BALLAST, AND EXCAVATION
WHS TYPE 7 - CHANNEL SPANNING JAM	3	EA	$ 18,600	$ 55,800	INCL. LOG PROCURMENT, DELIVERY, PLACEMENT, BALLAST, AND EXCAVATION
TOTAL CONSTRUCTION COST				**$ 693,000**	(ROUNDED UP)