1. Applicant organization.

Washington Department of Fish and Wildlife

2. Organization purpose

WDFWs vision - Conservation of Washington's fish and wildlife resources and ecosystems.

WDFWs mission - Preserve, protect and perpetuate fish, wildlife and ecosystems while providing sustainable fish and wildlife recreational and commercial opportunities.

3. Project manager (name, address, telephone, email, facsimile)

Todd Hillson
Environmental Planner 5
ESA/Anadromous Fish Investigations Unit Lead
5525 South 11th Street
Ridgefield WA 98642
(360) 906-6730
Hillsth@dfw.wa.gov

4. Project Title

Eagle Island chum spawning channel construction

5. Summary of Project Pre-Proposal

This project addresses multiple criteria identified as factors to consider when reviewing and funding projects (Section 3 of the Aquatic Funds – Strategic Plan and Administrative Procedures, 2005). The specific criteria addressed in this proposal are presented in the bullets.

- ACC shall evaluate Proposals based upon: (1) "benefit to fish recovery throughout the North Fork Lewis River, with priority to ESA-listed species", (2) "support the reintroduction of anadromous fish throughout the basin", and (3) "enhance fish habitat in the Lewis River Basin, with priority given to the NF Lewis River".

Based on historical commercial landings and habitat availability, it has been estimated that between 0.5-1 million chum salmon returned annually to the Lower Columbia River (LCR) and its tributaries (Johnson et al. 1997). A combination of several factors (loss & degradation of spawning and rearing habitats, changes to estuary ecology and habitat, altered mainstem and tributary hydrology, and harvest) resulted in a significant decline in chum salmon abundance beginning in the 1940s. The decline continued through the 1950s even after the harvest pressure was removed. In 1999, LCR chum salmon populations were listed as threatened under the auspices of the Endangered Species Act. Of the 17 historic LCR chum salmon populations, 90% are considered extirpated or nearly so.

LCR chum salmon's current distribution is very limited with 99% of the total LCR annual adult return concentrated in only three populations in Washington State: the Grays/Chinook, the Washougal (adults spawning in the mainstem Columbia River along the Washington shoreline), and the Lower Gorge (combination of spawning in the mainstem and tributaries of the Columbia River near Bonneville Dam). The combined recent 10 year average adult return for these three populations is approximately 15,000 adults. Outside of these three viable populations, average annual returns of the remaining 14 populations are estimated to range from zero to less than 100 adults annually. This would include the Lewis population, which historically would have been a huge component of the overall Columbia River return, likely numbering in excess of one hundred thousand adults annually.

Recent adult returns of LCR chum salmon to the Lewis Basin are estimated to be less than 25-50 adults annually. This compares to estimated historical return sizes between 120,000 and 300,000 adults (LCFRB North Fork Lewis Subbasin Plan, 2010) The Lewis, Cowlitz and Sandy chum salmon populations are identified as the primary recovery populations within the Cascade strata of the LCR chum salmon ESU (NMFS 2013). Recovery plan goals include increasing the Lewis basin population viability from low (current state) to high, decreasing population risk from high (current state) to low, and reaching a target adult abundance level of 1,300 annually. De-listing requires at least two primary populations within each of the ESUs strata be "recovered". Due to the low smolt-to-adult survival rates that LCR chum salmon experience, significant increases in freshwater productivity in this population will be necessary to achieve recovery plan goals.

Section 3.2.4 (page 3-31) of the LCR salmon recovery plan states "Chum habitats have been reduced by 75% or more for the majority of the populations by changes or loss of low elevation reaches and off-channel areas due to channel stabilization, loss of floodplain connectivity and function, and sedimentation due to land use activities throughout the entire watershed.". (LCFRB 2010) This statement is especially true in the areas of the Lewis River basin that chum salmon historically utilized. Additionally, there is a hydropower/flow regulation component on the North Fork Lewis River further reducing the likelihood of natural habitat processes creating the productive side- and off-channel spawning habitat types that chum salmon need within the basin.

This project is in alignment with WDFWs regional chum salmon recovery plan objectives which are to 1) protect, restore, or create protected high quality off-main channel spawning habitats to increase fresh-water productivity (egg-to-fry survival), 2) supplement existing populations using a genetically appropriate donor stock to jumpstart usage of the new habitat and begin local adaptation of donor stock, 3) monitor adult and juvenile outmigrant monitoring at the spawning channel to estimate egg-to-fry survival rates by marking all fish produced via Parental Based Tagging (PBT; Anderson and Garza 2005) so that channel-origin adults can be identified, and 4) adaptively manage the project by using results of prior chum salmon monitoring activities within, and from outside, the basin to inform future decisions.

The project is located inside the geographic scope of the Aquatic Fund boundary (Figure 1, Aquatic Funds – Strategic Plan and Administrative Procedures, 2005). While outside (between) reaches identified in the Lewis River Aquatic Fund Priority Reaches document, the Eagle Island chum spawning channel project is located in a reach (Lewis 4B) of the North Fork Lewis River considered high priority (Tier 1) in the Lower Columbia Fish Recovery Board's (LCFRB) habitat strategy (SalmonPort web site).

- ACC shall consider factors that reflect the feasibility of projects and give priority to resource projects that are more practical to implement. ACC shall consider following factors: (i) "whether the activity may be planned and initiated within one year", (ii) "whether the activity will provide long-term benefits", (iii) "whether the activity will be cost-shared with other funding sources", (iv) "probability of success", and (v) anticipated benefits relative to cost".

The Eagle Island chum salmon spawning channel (spawning channel) project has a long history. In 2010, a scoping project, funded by the Bonneville Power Administration (BPA) through the LCR chum salmon BiOp project (2008-710-00), was initiated to identify potential chum salmon spawning channel sites within the East Fork Lewis and North Fork Lewis river basins. Over the course of several years, multiple sites in both basins were monitored and evaluated. At the end of this process, it was determined that the Eagle Island site had the highest potential for a successful spawning channel (Lewis Basin Groundwater Investigations and Spawning Channel Design chapter). A mixture of funding sources (BPA, the Odessa Water Withdrawal mitigation fund, and WA State) have been used over the last four to five years to complete the spawning channel project up to the construction phase. We have final designs and all the necessary State, local, and Federal construction permits including ESA coverage and a completed cultural resources review (106 permit) in hand. In 2018, we applied for and received a $100K grant through the LCFRBs Salmon Funding Recovery Board (SFRB) (project ID 18-1413) to use towards construction of the spawning channel. In the fall of 2018, the access road to the site was improved and approximately $450K of construction materials (rock, spawning gravel, and logs), purchased through BPA project 2008-710-00, were moved on-site and the out-of-water section of the spawning channels alignment was cleared. Our plan, if all the necessary funding can be secured, is to complete construction of the spawning channel in the late spring and summer of 2020. As of the date that this proposal was submitted, the intent is to use staff from WDFWs Construction and Asset Management Program (CAMP) to accomplish the construction of the spawning channel.

Egg-to-fry survival rates in similarly constructed chum salmon spawning channels in the LCR have documented average egg-to-fry survival rates in the 50-55% range (Hillson and Ronne, 2016) compared to similarly estimated egg-to-fry survival rates from run-of-the-river spawners which can vary from near zero to 22% depending on the year (Salo 1991). Adults who utilize the spawning channel will realize a significant boost in Productivity (egg-to-fry survival) compared to adults spawning in the mainstem Lewis River.

6. Project location (include location map, River/Stream and Lat/Long coordinates if available).

Lat/Long coordinates of approximate middle of proposed project area are:
45.936124, -122.68610.

7. Objectives and conceptual design (Please attach drawings).

Provide 1) a brief description of the site and the site problems contributing to limiting factors

The actual site where the spawning channel will be built is currently a wooded riparian bench with a few small areas of wetland habitat. As mentioned in the Summary of Project Pre-Proposal section above, of the 17 historic LCR chum salmon populations, 90% are considered extirpated or nearly so. The Lewis population of chum salmon falls into the "nearly so" group. This population is considered to be at high risk as a result of low population size, low productivity due to loss of preferred/ needed spawning habitat, low diversity, and limited temporal and spatial distribution.

Due to hydropower regulation on the North Fork Lewis River, we can't rely on natural processes habitat restoration to create the spawning habitat needed for chum salmon. Creating this spawning channel will give chum salmon a place to build a secure foothold in the basin from where they can expand into other suitable created or restored habitat in the future.

2) Specific goals and objectives for addressing the problems

Create protected high quality off-main channel spawning habitat that can support at least 500 spawner pairs and be expected to reliably provide egg-to-fry survival rates of ~50% or greater annually.

> 3) Conceptual project design with a description of the design and plan view drawing on scaled site plans including an indication of bankfull width and approximate dimensions of proposed project elements, and a brief description of short term and long term benefits.

As mentioned above, this project is past the conceptual phase and can be considered "shovel ready". A copy of the completed design report and permit drawings are included in our application package.

In the short term, this project will create ~18,200 square feet of groundwater fed high quality off-main channel spawning habitat for chum salmon. At optimal chum salmon spawner densities (2-2.5 square meters per female), this channel has the capacity for ~700 pairs of spawners. It will provide protected and reliable high productivity spawning habitat for Lewis population natural-origin adults. Additionally, it will provide the same benefits to adults produced from reintroduction/enhancement efforts fostering local adaptation of progeny from those efforts. In the long term, this spawning channel will give locally adapted chum salmon a place to build out from and take advantage of created or restored habitat as opportunity allows in the future. As a result of the increased productivity within the population, abundance is expected to increase thereby increasing diversity and species spatial and temporal distribution, which will reduce the extinction risk to the population. A long term goal of the WDFWs regional chum salmon recovery strategy is to use a healthy and stable Lewis population as a donor stock for reintroduction/enhancement programs in other Cascade strata populations.

8. Benefits of proposed Project to: 1) Focal Reintroduction Species with Emphasis on Spring Chinook OR 2) bull trout.

While this project is chum-centric there are several potential benefits to Focal Reintroduction species. It is possible that the project will indirectly benefit Focal Reintroduction species by providing a source of cooler water and rearing space in the lower river in the summer for juveniles. The channel could be used by juveniles to escape short-term high water events during the winter & spring months. Adults other than chum salmon could use the constructed channel for spawning (small numbers of coho salmon adults use the Hamilton Springs spawning channel annually). The LWD structure that will be built over the infiltration gallery will provide some in-stream complexity and juvenile rearing habitat. Chum salmon outmigrate as fry and if fully seeded the spawning channel will produce around 500K annually. While outmigrating, there will likely be some level of predation on these fry by other salmonid juveniles providing a food source.

9. Project partners and roles.

Bonneville Power Administration, funding source
LCFRB SFRB, funding source
Lower Columbia Fish Enhancement Group, partner on SFRB grant
Washington Department of Fish and Wildlife, landowner

10. Attach signed landowner(s) acknowledgment form(s), if applicable (**Attachment C**).

11. Community involvement (to date and planned).

Multiple meetings with adjacent landowners since the scoping project started in 2010.

12. Procedure for monitoring and reporting on results.

Once completed the spawning channel will be added to the existing LCR chum salmon monitoring program framework. In brief, it will be surveyed by WDFW staff at least on a weekly basis during times of possible adult presence. A carcass weir with fingers could be installed to help detect usage in the initial years when abundance is still very low. DNA samples will be collected from all carcasses recovered in the spawning channel and during mainstem river surveys. When usage is detected, juvenile outmigrant monitoring will be initiated using a fence-panel and live box design to estimate the channels performance (egg-to-fry survival rates). Beginning in the year when the first possible returns of spawning channel-origin adults, as age-3 adults, we will initiate a Parental Based Tagging analysis to determine origins. This combined with adult and juvenile estimates will allow for estimates of productivity (progeny-per-parent) and smolt-to-adult survival rates (SARs) for channel-origin chum salmon. Results would be reported in progress reports as well as through WDFWs Score web site (adult estimates by origin) and Juvenile Migrant Exchange websites.

Please note, funds being sought through this ACC grant application are not for any of the monitoring described above. This application is for spawning channel construction actions only.

13. Project schedule (anticipated start date, major milestones, completion date).

- Late spring 2020 – Mobilize and begin working in "out-of-water" elements, essentially everything except the channels entrance and infiltration gallery.
- August 2020 – Complete the in-water elements during the in-water work window.
- September 2020 – If needed, complete any work remaining on out-of-water elements, complete clean up and re-vegetation actions.

14. Funding requested (estimated cost for project design, permitting (including necessary resource surveys), construction, signage, monitoring and administrative/insurance. Insurance limits to be determined based upon PacifiCorp's evaluation of the project risks.

We are requesting $175K. This amount is ~10% of the expected overall start to finish project cost and is ~20% of the estimated construction cost ($800K). See below for more details.

15. Type and source of other contributions (Identify cash (C) and/or in-kind (IK), and status, pending (P) or confirmed (Co)).

Spent to date (scoping, groundwater monitoring, design, permits, and construction materials purchased)

- Cash – Bonneville Power Administration - ~$575K
- Cash – Odessa Water Withdrawal mitigation fund - ~$215K
- In-kind – WDFW Fish Management, Habitat and Engineering staff - ~$100K

Confirmed

- Cash – LCFRB SFRB grant - $100K

Pending

- Cash – $525K – WDFW is seeking the remaining construction cost from other funding sources including the Bonneville Power Administration.

16. If you have technical assistance needs for this project, please briefly describe such needs.

No technical assistance needs

17. If any boating hazards/public safety are an issue please note if any signage requirements.

No boating hazards or public safety issues once construction is complete. We will have to use temporary weirs/dykes while completing the in-water elements. However, these will be highly visible (white super-sacks), right along the river bank and will not be located in boat usage/traffic lanes.

Attachment C

Landowner Acknowledgement Form

Landowner Information

☐ Mr. ☐ Ms. Title: WDFW Region 5 Regional Director

First Name: Kessina Last Name: Lee

Contact Mailing Address:

5525 South 11TH Street Ridgefield WA 98642

Contact E-Mail Address:

Kessina.Lee@dfw.wa.gov

Property Address or Location:

Plot has no situs address. Clark County Assessors Parcel ID # 252022000

I certify that the Washington Department of Fish and Wildlife *(Landowner or Organization)* is the legal owner of property described in this grant application to the Lewis River Aquatic Fund. I am aware the project is being proposed on my property or access across my property is needed. **My signature authorizes the applicant listed below to seek funding for project implementation, however, it does not represent authorization of project implementation pending my final approval of plans and specifications and signature on a formal landowner access agreement.**

[signature] 9/25/19

Landowner Signature Date

Project Applicant Information

Project Name: Eagle Island Chum Salmon Spawning Channel Construction

Project Applicant Contact Information:

☐ Mr. ☐ Ms. Title: Environmental Planner 5, ESA/Anadromous Fish Investigations Unit Lead

First Name: Todd Last Name: Hillson

Mailing Address: 5525 South 11TH Street Ridgefield WA 98642

E-Mail Address: Todd.Hillson@dfw.wa.gov

Lead Entity Organization: PacifiCorp and Cowlitz PUD

Eagle Island Chum Spawning Channel

FINAL DESIGN REPORT

Prepared by **INTER-FLUVE, INC.**

October 2013

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Eagle Island Chum Spawning Channel
FINAL DESIGN REPORT

Prepared for

Washington Department of Fish & Wildlife
2108 Grand Boulevard
Vancouver, WA 98661

Prepared by

INTER-FLUVE, INC.
501 Portway Ave, Suite 101
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(541) 386.9003
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October 2013

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INTRODUCTION

Overview

This design report describes the investigative analysis and the elements of design for the construction of a chum salmon spawning channel (chum channel) in the floodplain of the lower North Fork Lewis River near Eagle Island. Analysis and design of the chum channel is being conducted for the Washington Department of Fish & Wildlife (WDFW) as part of their chum salmon recovery program for the Columbia River. The chum salmon recovery program aims to recover self-sustaining populations of chum salmon in key lower Columbia tributary basins. The Lewis River, which is believed to have historically supported a thriving chum salmon population, is a high priority for chum salmon recovery under this program.

Purpose

The overall goal of this design effort is to increase the availability of high quality spawning conditions for chum salmon in the lower Lewis River through construction of a chum spawning channel in the floodplain of the mainstem Lewis River near Eagle Island. Specific project objectives, presented in the form of project Design Criteria, are presented later in this document.

Project Area

The project area is located in the river-left (south) floodplain of the South Channel of the Lewis River at river mile (RM) 11.5 in the Eagle Island area. The property is owned by WDFW. A location and site map are presented in Figure 1.

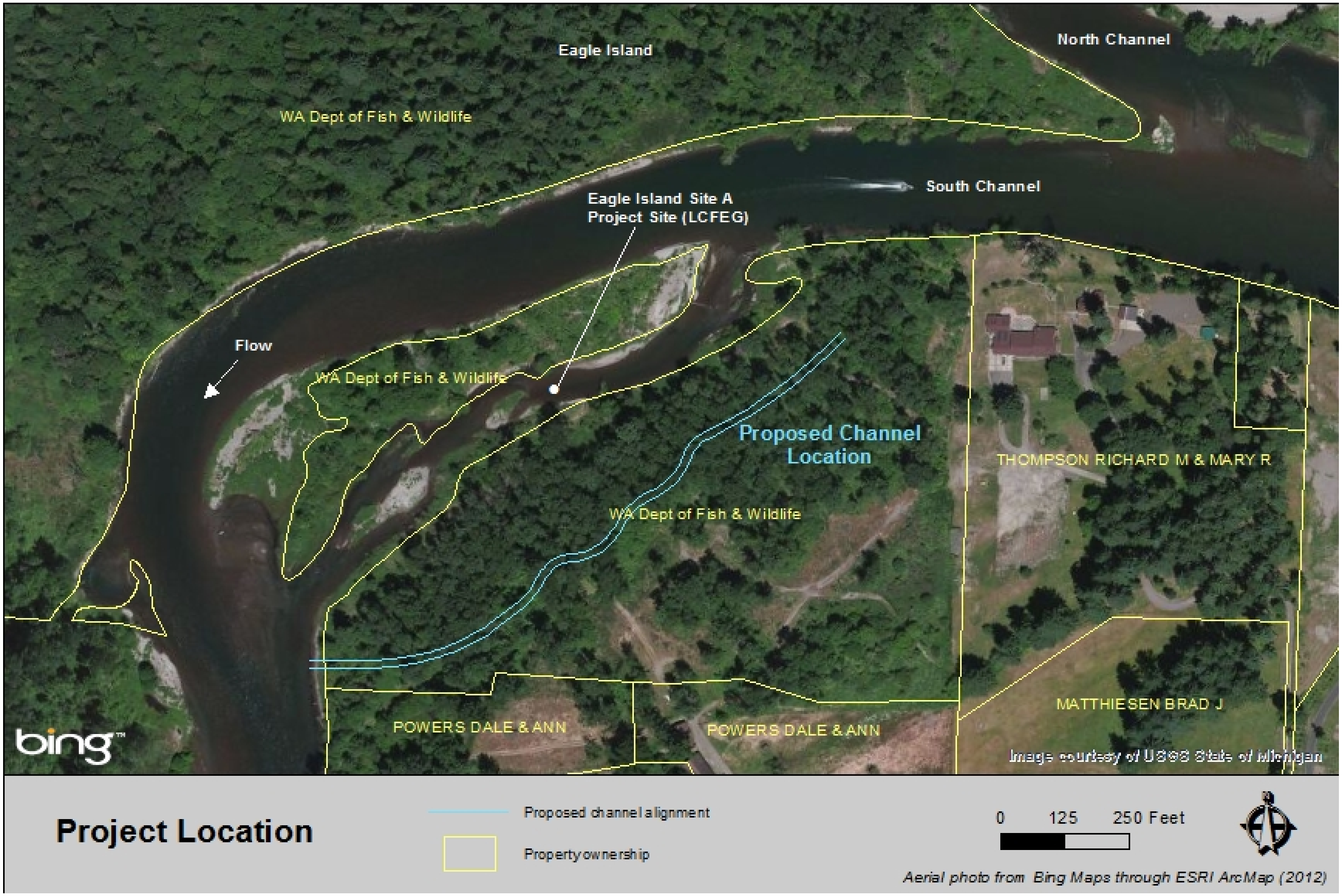

Figure 1. Project location map.

Coordination with Other Efforts

The Eagle Island area is also the site of other nearby restoration and assessment efforts, some that have already been completed and some that are in the planning or design phases. This effort is being coordinated with these other efforts and potential impacts of other efforts on the function and effectiveness of the chum channel are being considered as part of project design. Other nearby efforts include habitat restoration conducted by the Cowlitz Tribe at Eagle Island Sites A, B, and C in the South Channel. Site A (directly adjacent to project site) was completed in 2011 and included placement of log jams in a side-channel of the South Channel at RM 11.5. Sites B and C include log jams and off-channel enhancement work adjacent to and just downstream of the project site. These projects are in planning and design stages. The Eagle Island North Channel Design project, which is being conducted by the Lower Columbia Fish Enhancement Group, is designing a strategy for providing increased flow in the North Channel during the fall Chinook outmigration. Coordination with these other efforts is considered very important for this project. Close coordination is facilitated by all of these efforts having the same design engineering consulting firm (Inter-Fluve). The North Channel Design effort also has a technical oversight group composed of several staff from WDFW, which helps to further ensure coordination of these efforts.

Background and Site Selection

This site was selected as the highest priority site among several sites that were investigated as a preliminary phase of this effort. Preliminary site investigations were conducted for WDFW by Inter-Fluve in 2011 at four sites in the Lewis River Basin; two sites on the East Fork Lewis and two sites on the North Fork Lewis. These four sites were selected from a larger suite of potential sites on the East Fork, North Fork, and lower mainstem Lewis (downstream of the East Fork confluence) based on their geomorphic setting and potential to provide the upwelling conditions necessary for chum spawning. The four sites that received field investigation included: (1) Eagle Island – this project site, (2) Haapa – NF Lewis RM 14.5, (3) Pioneer – EF Lewis RM 6.5, and (4) Daybreak – EF Lewis RM 10. Site investigations at the four sites included groundwater pump tests, installation of surface and groundwater monitoring stations, geomorphic characterization, and select topographic survey. Based on the results of the site investigations, the Eagle Island site was identified as having the greatest potential for providing the groundwater flow conditions (i.e. upwelling) needed to support a chum spawning channel.

OBJECTIVES AND DESIGN CRITERIA

A set of project objectives and design criteria were developed based on consideration of the project goals and based on discussions with WDFW staff. These criteria and objectives are used to guide design components to ensure the goals of the project will be met.

General objectives and criteria

- Increase habitat quantity and quality for chum salmon spawning through the creation of an off-channel spawning channel.

- Maximize groundwater upwelling within the channel to the extent practicable given site conditions. If groundwater flow is determined to be insufficient to provide the required habitat criteria (e.g. depth and velocity), supplement with surface diversion (from the mainstem) or infiltration galleries (preferred due to less potential for introduction of fines).
- Protect the channel from scouring flows associated with relatively frequent mainstem flood events (i.e. less than the 5-yr flood).
- Protect banks from toe erosion and sloughing of fine sediment that can cause sedimentation of chum spawning areas.
- Discourage extensive periods of backwater inundation from the mainstem that may contribute high levels of fine sediment.
- Provide a substrate size composition that is preferred by chum salmon for spawning but that will also provide the necessary stability given anticipated scour conditions derived through hydraulic analysis; alternatively, provide other means of grade-control or control measures that will retain spawning gravels within the channel.
- Utilize available in-situ substrate material for the bed material composition to the extent possible.
- Incorporate features (e.g. control weirs) that will allow for operational flexibility to manage for potential flow variations during the spawning, incubation, and early rearing periods.
- Install a structure near the channel outlet to allow for WDFW fish trapping and monitoring operations.
- Establish access routes and locations to allow for long-term monitoring and maintenance.
- Avoid creation of habitat for species known to prey on juvenile chum salmon, in particular, coho fry and pre-smolts.
- Discourage colonization by invasive aquatic and riparian plant species.
- To the extent possible, minimize long-term maintenance requirements.
- Consider the existing and future potential effects of other nearby restoration efforts (i.e. Eagle Island North Channel Design and Eagle Island Sites A, B, & C).

PROJECT SITE INVESTIGATIONS

Topographic Data

Topographic survey data is utilized for site investigation and design. Survey data is used for the following: (1) as input for the hydraulic model, (2) to calibrate surface and groundwater monitoring stations to real elevations, (3) to develop a grading plan, and (4) to determine the location of key features such as trees, channel depressions, bankline locations, etc.

Site topographic data was acquired through site surveys and through the use of existing LiDAR (Light Detection and Ranging) data. Preliminary site surveys were conducted in October 2011 as part of the initial investigations of the four sites described above. More detailed follow-up surveys were conducted in August 2012 (see Figure 2). Surveys were conducted using survey grade GPS (RTK) equipment and Total Station survey instruments. Other existing survey datasets from nearby projects, including ground survey data and channel bathymetry data, were also utilized as appropriate.

LiDAR data were obtained through the National Oceanic and Atmospheric Administration (NOAA) Digital Coast Data Server. These data were collected in 2009/2010 for the US Army Corps of Engineers as part of a regional LiDAR effort in the Lower Columbia. These LiDAR data supersede previous LiDAR data collected by Clark County in 2002. The LiDAR data were collected to represent bare earth data within a 0.07 m tolerance. A hillshaded relief map created using the LiDAR data is included in Figure 2.

Due to potential known errors in LiDAR data due to the effects of vegetation and water, the ground survey data were used as the primary topographic data source but were supplemented with LiDAR "bare earth" data at the outer limits of the project site or where ground survey data were not collected (e.g. private property) or was collected at low densities.

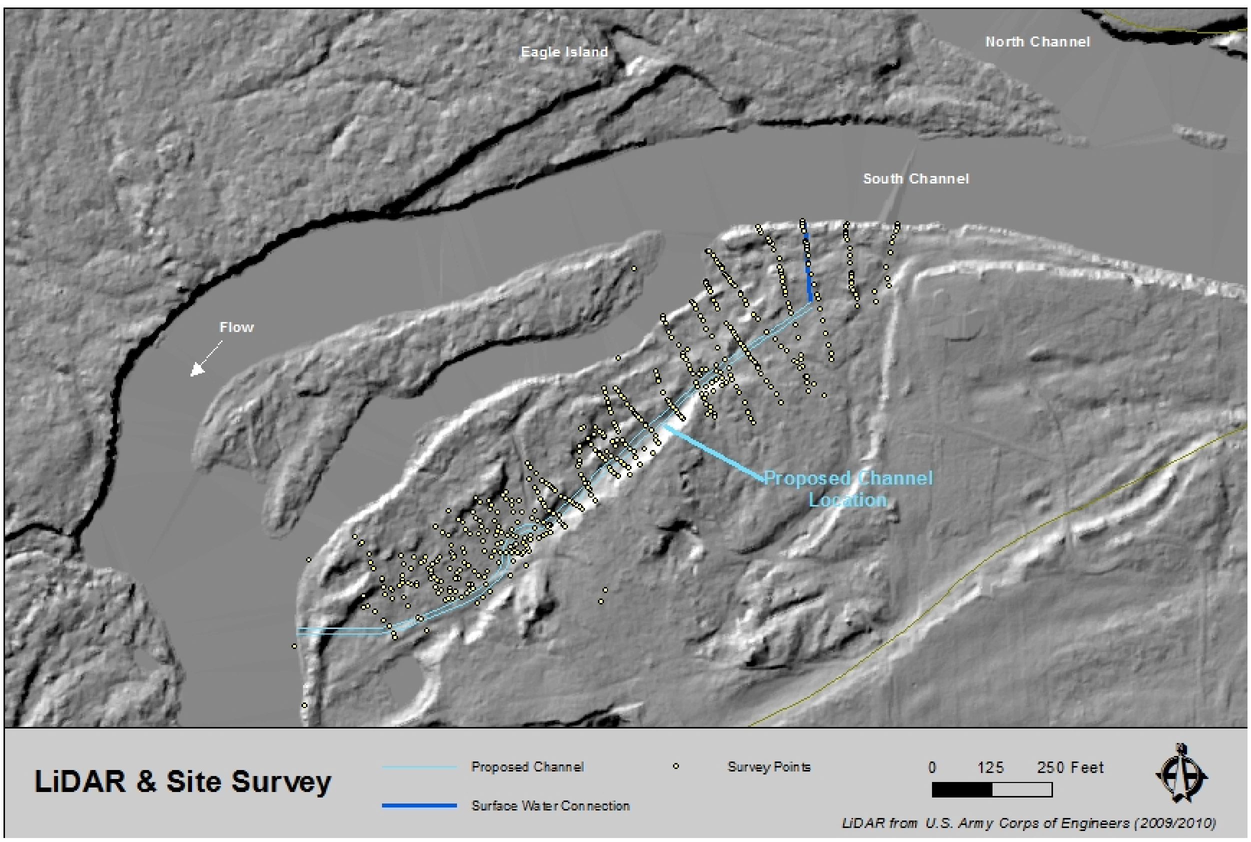

Figure 2. LiDAR hillshade map and site topographic survey points. Additional survey data of the North and South channels were also available and used for this project.

Geomorphology

The project site lies within the floodplain of the Lewis River and is underlain by river alluvium. The Lewis River in this area has been very laterally dynamic over the historical aerial photo record. The earliest aerial photos are from the late 1930s and show a very different configuration of the Lewis River in this area. The photo record shows that the mainstem of the Lewis River occupied this area as recently as 1948. In the 1950s and 60s there was considerable earthwork conducted at the project site, potentially related to both excavation for gravel extraction and fill for flood protection. Since the 1970s, conditions have been relatively stable in the project area, with the most change occurring as erosion of the river-right channel boundary of the South Channel at RM 11.4. Over the past few decades, there has also been a general trend in shifting flow from the North Channel to the South Channel. This channel shifting has been observed by WDFW fish biologists and can be seen in the photo record. Loss of flow to the North Channel has potential implications to salmonid habitat availability in this reach. As part of the Eagle Island North Channel Design project, this issue is being assessed and strategies are being developed to address the issue.

Human uses impacting the project site include flow management associated with the Lewis River hydro-system, interruption of bedload and wood transport due to the hydro-system, past removal of wood from the river (Inter-Fluve et al. 2009), past instream gravel mining, riparian clearing, and human development of floodplains and riparian areas. These practices have generally served to simplify habitats and reduce channel dynamics.

Although channel shifting has occurred in this area in the past, channel conditions have been relatively stable for the past few decades, particularly with respect to the outlet location of the proposed chum channel, which has remained in the same location at least since 1974.

Hydrology

Overview of Lewis River hydrology

The lower Lewis River experiences high flows from winter rains, rain-on-snow events, and spring/summer snowmelt. Flows in the lower river are further influenced by flow regulation from the Lewis River hydro-system, which consists of 3 dams on the mainstem Lewis River. The project site is located at RM 11.5, which is 8 miles below the most downstream dam, Merwin Dam (RM 19.5).

Flood flow magnitudes were developed for various flood recurrence intervals to be input into hydraulic modeling and design calculations (Table 1). The 10-, 50-, and 100-year flood flow magnitudes were obtained from the Lewis River Hydroelectric Projects Flood Management Technical Report (FLD-1) (PacifiCorp 2004b) (Table 2). The flows for the flow scenario "Regulated flows with 70,000 acre-feet dependable flood control storage" at Woodland, WA were utilized. These flows are conservative (i.e. higher) estimates of floods for the project site because Woodland is located downstream of the project area (RM 6-7); however, there are no significant tributaries between the project site and Woodland.

The FLD-1 study did not provide 2-year event flows for Woodland, WA but provided 2-year event floods for Ariel (USGS Station #14220500) for the scenario “Regulated flows with actual historic flood control storage". Because a major tributary, Cedar Creek, enters the Lewis River downstream of Ariel, these flows were corrected for the subwatershed boundary (from LCFRB 2010) closest to the project area (RM 8.8 just downstream of Eagle Island). This was accomplished by calculating Cedar Creek flows as 17% of the East Fork near Heisson (USGS Station #14222500) flows, which is consistent with the methods outlined in the FLD-1 Study. The remainder of the tributary flows between Ariel and RM 8.8 were calculated using the USGS regional regression equations (Sumioka et al. 1998). Cedar Creek and other tributary flows were added to the 2-year flows at Ariel in order to obtain the 2-year event flows for the project area.

Table 1. Recurrence interval flows used for the project area.

Return Interval	Flow (cfs)
2-year	24,800
10-year	65,600
50-year	92,600
100-year	98,400
500-year	150,500

Table 2. Table of recurrence interval flows reproduced from PacifiCorp FLD-1 Study (reproduced from PacifiCorp 2004b).

Location	Drainage Area (sq mi)	Flow Quantile (cfs) by Return Period (yrs)				
		2	10	50	100	500
Unregulated flows						
Near Ariel	731	42,000	71,900	99,100	111,000	140,000
Regulated flows with 70,000 acre-feet dependable flood control storage						
At Ariel	731	n/a	60,000	85,000	90,000	140,000
At Woodland	820	n/a	65,600	92,600	98,400	150,500
At mouth	1,046	n/a	85,400	119,400	128,200	187,600
Regulated flows with actual historic flood control storage						
At Ariel	731	22,000	60,000	n/a	n/a	n/a

Note: Analyses based on the period of record 1912-2000.

PacifiCorp is required, as part of their hydropower license, to maintain minimum flows in the lower river below Merwin Dam for specific seasons in order to support key fish life-stages. Table 3 gives the flow requirements for each period. These requirements provide relatively reliable low-end flow discharges for specific times of the year that are used to help guide the design of the spawning channel. Figure 3 shows a hydrograph of daily median, 10% exceedances, and 90% exceedance flows as well as the primary period of fall Chinook outmigration.

Table 3. Minimum flow requirements for the lower river below Merwin Dam.

Time period	Minimum flow requirement (cfs)
July 31 through October 15	1,200
October 16 through October 31	2,500
November 1 through December	4,200
December 16 through March 1	2,000
March 2 through March 15	2,200
March 16 through March 30	2,500
March 31 through June 30	2,700
July 1 through July 10	2,300
July 11 through July 20	1,900
July 21 through July 30	1,500

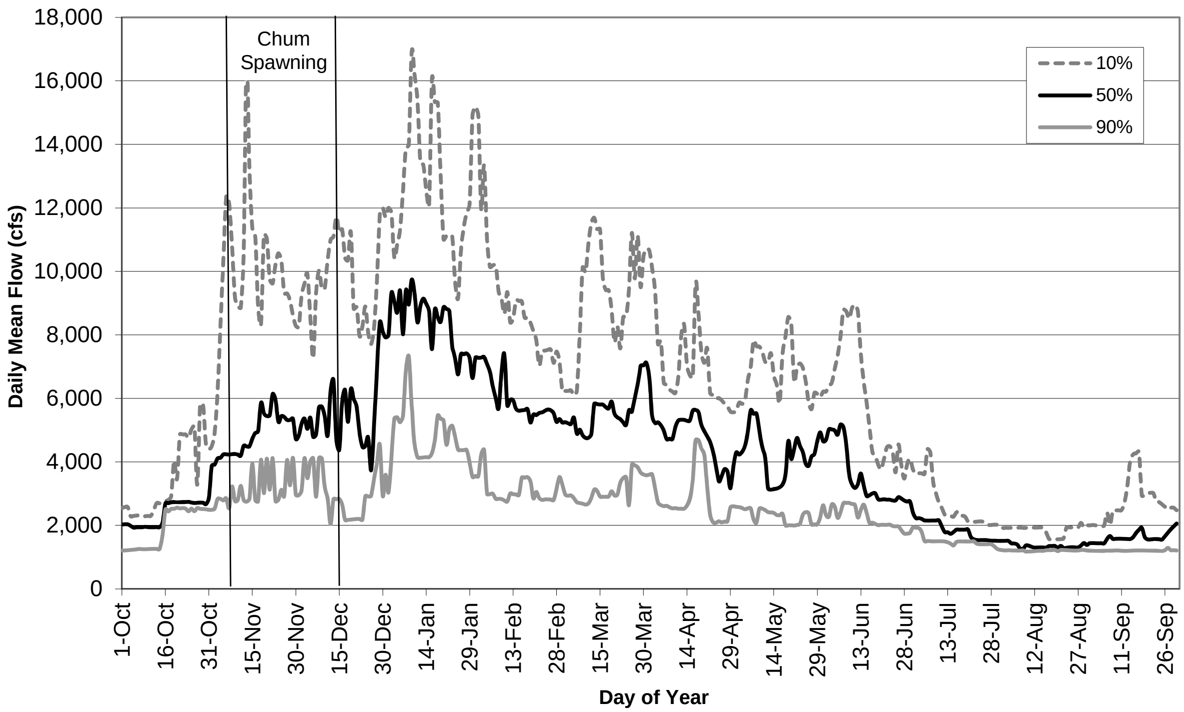

Figure 3. Hydrograph showing daily median flows and 10% and 90% exceedances flows for the period 2002 to 2011.

Water level monitoring

A total of 4 water level monitoring stations were installed at the site to track groundwater levels and their relationship to stage of the Lewis River. Water temperature was also collected at these sites. The sites included a groundwater monitoring well (piezometer) at the location of the pump test (described in the section below) (Piezometer 1), a second piezometer at the lower end of the potential chum channel alignment (Piezometer 2), and a third piezometer (Piezometer 3) in the middle of the potential chum channel alignment. A river monitoring station was installed on the river-left side of the South Channel (River Station) at the upstream end of the project site. A map of the monitoring stations is included in Figure 4. Continuously recording pressure transducers and temperature monitors were placed at each of the monitoring stations and were monitored for the period August 21, 2012 to March 20, 2013. Additionally, water level monitoring was performed from November 2011 to April 2012 at all of these locations with the exception of Piezometer 3, which was installed in August of 2012. These results are presented in Figure 5.

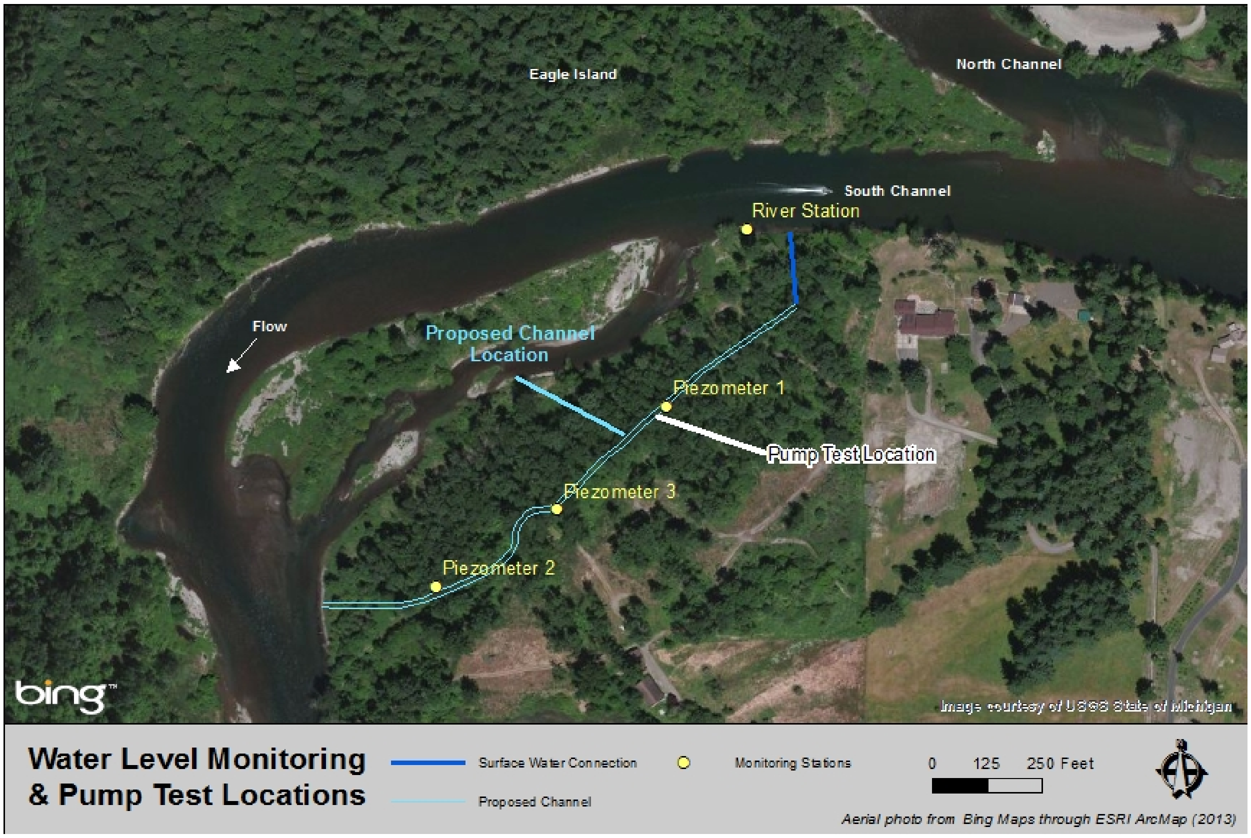

Figure 4. Location of water level and temperature monitoring stations and pump test.

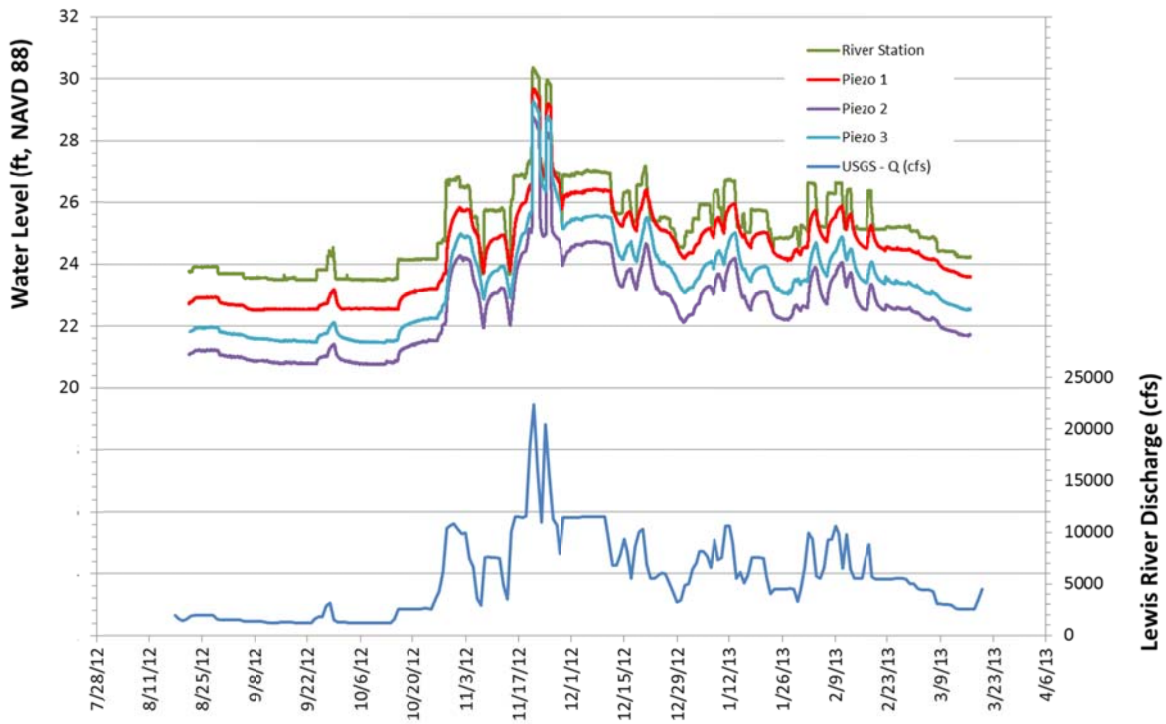

Figure 5. Water level monitoring data compared to river flow from the Ariel Gage (USGS #14220500)

Pump test

A pump test was performed on Oct 13, 2011 in order to evaluate groundwater flow conditions. Flow at the Ariel Gage (USGS #14220500) was 2,680 cfs on the day of the test. The pump test was performed at the location identified in Figure 4. An approximately 50 foot long by 5 foot wide trench was excavated below static groundwater level (Figure 6). A pump was used to draw down the water level in the trench for 2 -3 hours to achieve a drawdown in the groundwater gradient adjacent to the trench. The pumping rate was then adjusted until the pump outflow reached equilibrium with a new static water surface, at which point the pump discharge and static water elevation were measured. Surrounding ground topography, trench elevations, and water surface elevations were surveyed in order to determine static groundwater gradient. The depth of excavation was relatively shallow and the initial results suggested sufficient groundwater flow to provide upwelling during the spawning and incubation season. However, as discussed later in this document, groundwater flow alone is not expected to be able to also provide the depth and velocity requirements for chum spawning; for this reason, flow augmentation using an infiltration gallery collection system is incorporated into the design. The results of the pump test are included in Table 4. A pump rate of 0.17 cfs was measured. Based on a proposed channel length of 1,400 ft, it is estimated that this would equate to a flow of somewhere between 4 and 11 cfs at the channel outlet during the low flow period.

Figure 6. (A) looking upstream in the trench during the pump test. (B) The transition from soil to sand and to alluvium can be seen in the wall of the trench.

Table 4. Pump test results.

Metric	Value
Length of Proposed Channel (ft)	1,400
Gradient of Proposed Channel (%)	0.19%
Pump Test Result (cfs)	0.17
cfs/Lineal Foot	0.00311
cfs/ft^2	0.000518
Pump Test Excavation Depth (ft)	6
Trench Width (ft)	6

Hydraulics

Hydraulic modeling and analysis was conducted for the North Lewis River as well as for the proposed chum channel itself. Hydraulic analysis for the Lewis River was conducted in order to investigate the following: (1) the potential impact of flood flows overtopping the proposed chum channel, which has implications for scour and/or sediment deposition in the constructed channel, and (2) the likely extent and duration of backwatering from the channel outlet that may result in fine sediment deposition in the channel. Additionally, hydraulics of the proposed chum channel were evaluated to ensure that design criteria were achieved.

Lewis River hydraulics

In order to support multiple assessment and restoration efforts in the Eagle Island area, a two-dimensional hydraulic model was developed for the Lewis River in the project area. The detailed topographic survey of the project area, as well as topographic and bathymetric data collected for other nearby projects, was used for the model geometry. The 2D model extends upstream and downstream of Eagle Island, and includes the area of the proposed chum spawning channel. The extent of the model domain and site topography is shown in Figure 7.

A 2-D model calculates hydraulic parameters within a mesh (or grid) laid over the river and surrounding landscape. A 10 meter square grid was used for this model to optimize model resolution and computational time. The grid used for the hydraulic model is shown with an overlay of the 100-year recurrence interval flood inundation (the largest magnitude flow modeled) in Figure 8. For more information on the 2-D model setup and calibration, see the Lewis River – Eagle Island North Channel Habitat Restoration Design Report (Inter-Fluve 2013).

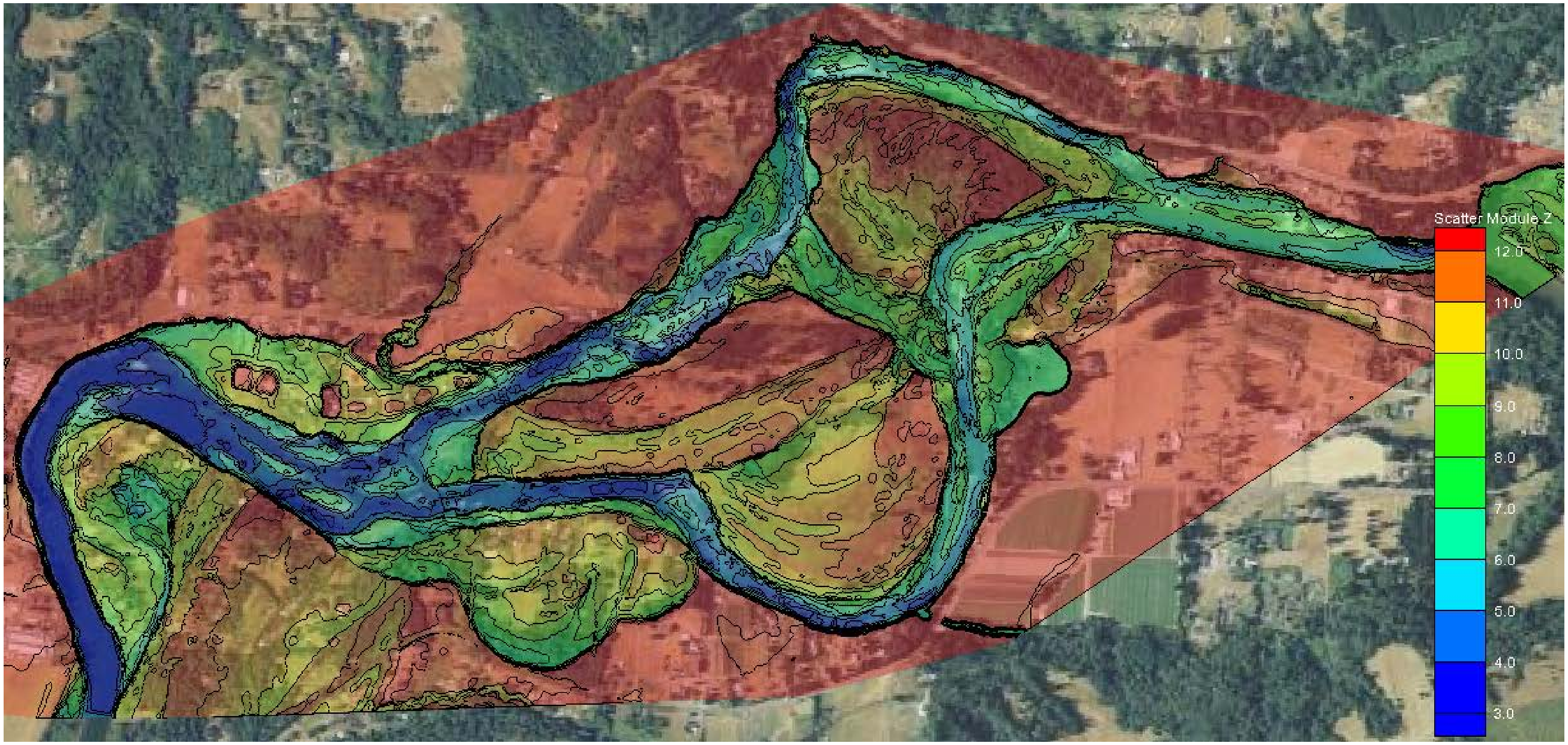

Figure 7. Existing topography (topography displayed in meters)

Figure 8. 10 meter grid, 100-yr flood.

Flood flow conditions were input into the model, including the 2-yr, 10-yr, 50-yr, and 100-yr floods. A low flow of 2,200 cfs was also used in the model. Preliminary results for the 2D model are presented in the Eagle Island North Channel Design Report. These results show that at low flows, the location of the chum channel is not currently connected by surface flows to the mainstem, but that there is surface water connectivity at the 2-yr flood. At the 2-yr flood, velocity is low (mostly <2.2 ft/s) in the vicinity of the project area and the direction of flow is generally parallel to the proposed chum channel. At the 10-yr event and larger, the flow is mainly less than 3.9 ft/s at the project area and the flow direction continues to remain generally parallel to the proposed channel except for at the downstream end where flow direction changes to the south as flows increase.

These modeling results have implications to the design of the chum channel. At relatively frequent flood flows (i.e. 2-yr event), the proposed chum channel would receive overland flow from the mainstem Lewis River. This overland flow has the potential to create scour of the channel banks as it enters the constructed channel. For this reason, it will be necessary to ensure there is adequate channel bank stability as well as floodplain roughness in order to limit flow energy. Floodplain roughness will also reduce the velocity of overland flow before it enters the constructed channel, which will reduce the potential for delivery of mainstem sediment (suspended load and wash load) to the channel. In most of the floodplain area between the Lewis River and the proposed chum channel, there is adequate floodplain roughness provided by existing vegetation and downed large wood. The design calls for adding floodplain roughness in the form of floodplain large wood placements near the upstream end of the constructed channel as this area will receive considerable vegetation disturbance during construction.

Hydraulic analysis was also used to investigate the potential extent and duration of backwater inundation of the constructed channel that will result from an increase in stage of the mainstem Lewis at the channel outlet. This analysis is used to inform the design slope of the channel since minimizing the backwater effect needs to be balanced with the need to reduce channel slope to achieve depth requirements for chum spawning. The water surface data collected at the site was used in conjunction with 1-D modeling of the proposed channel (described in the next section) for this analysis. Stage data collected on-site was believed to be better than the 2D model output because it is based on real and extrapolated empirical data.

The water surface monitoring station at the site is located along the river-left channel margin of the South Channel at the upstream end of the project area (see Figure 4). Because we are interested in the stage at the channel outlet for this analysis, we simulated stage at the outlet by applying the mainstem channel slope between the two locations. This slope was based on the average of two water surface slope calculations obtained during two different field surveys. This simulated stage data was then plotted against flow at the Ariel Gage (USGS #14220500) in order to provide a simulated stage-discharge relationship (Figure 9) that allows for estimating stage over a broad range of flows and for creating stage-duration curves. A stage-duration curve was created for the chum spawning period (Nov 8 – Dec 15) in order to assess the potential impact of backwater conditions on spawning (Figure 10). A stage exceedence plot was also generated for the simulated outlet gage (Figure 11). These data sources were used to provide values for the downstream boundary condition for hydraulic modeling of the chum channel itself (described in the next section) as well as to determine channel elevations and dimensions as discussed later in the Elements of Design section.

Any potential changes to flow in the South Channel as a result of the North Channel design project (LCFEG project) could affect backwater conditions in the constructed channel; however, these effects would only be expected to reduce the amount of backwater, and so the effect on sedimentation can be mostly dismissed.

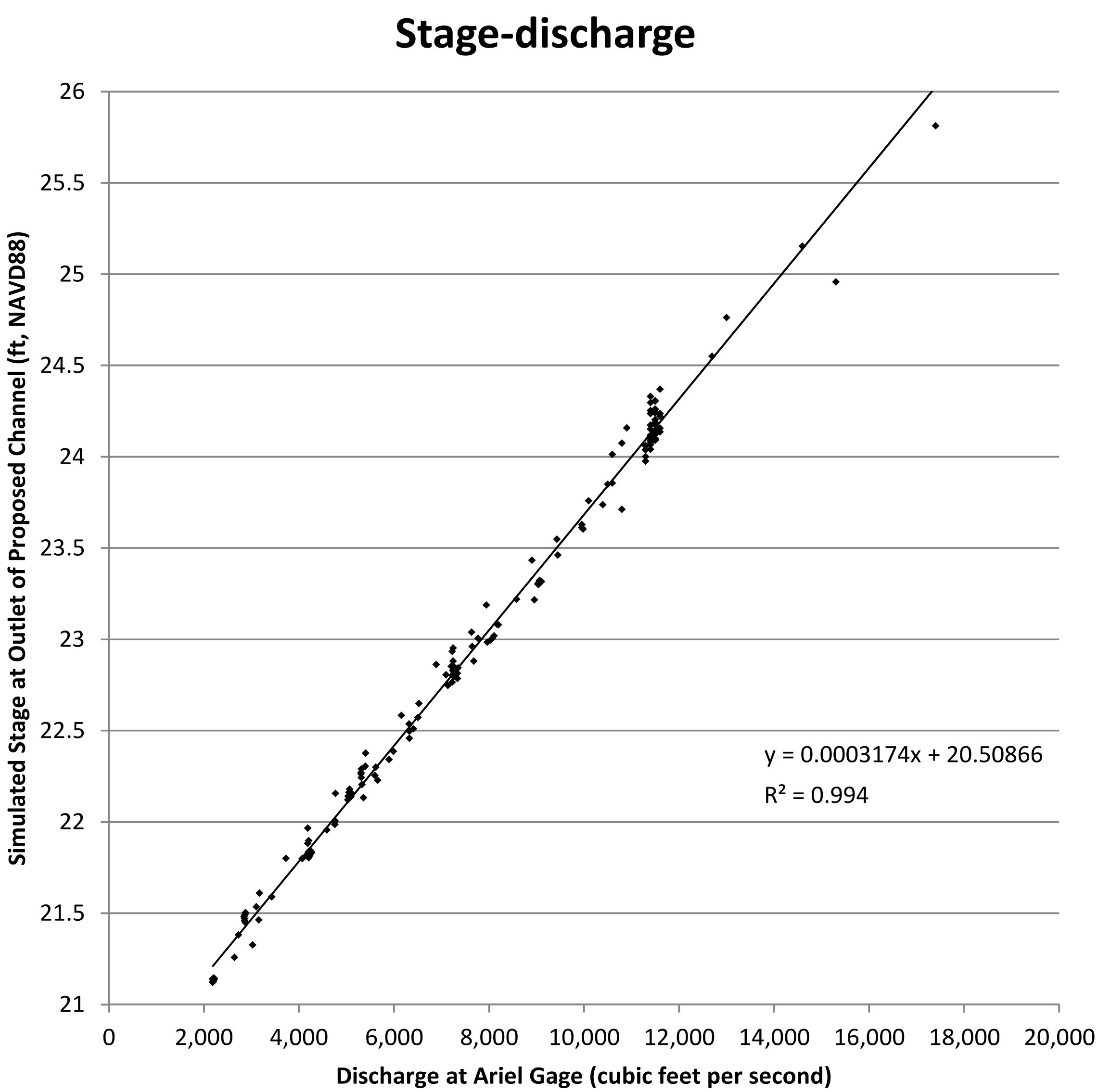

Figure 9. Stage-discharge relationship at the outlet of the proposed chum channel. Stage at the outlet was extrapolated using water level monitoring data from the upstream end of the site (see text).

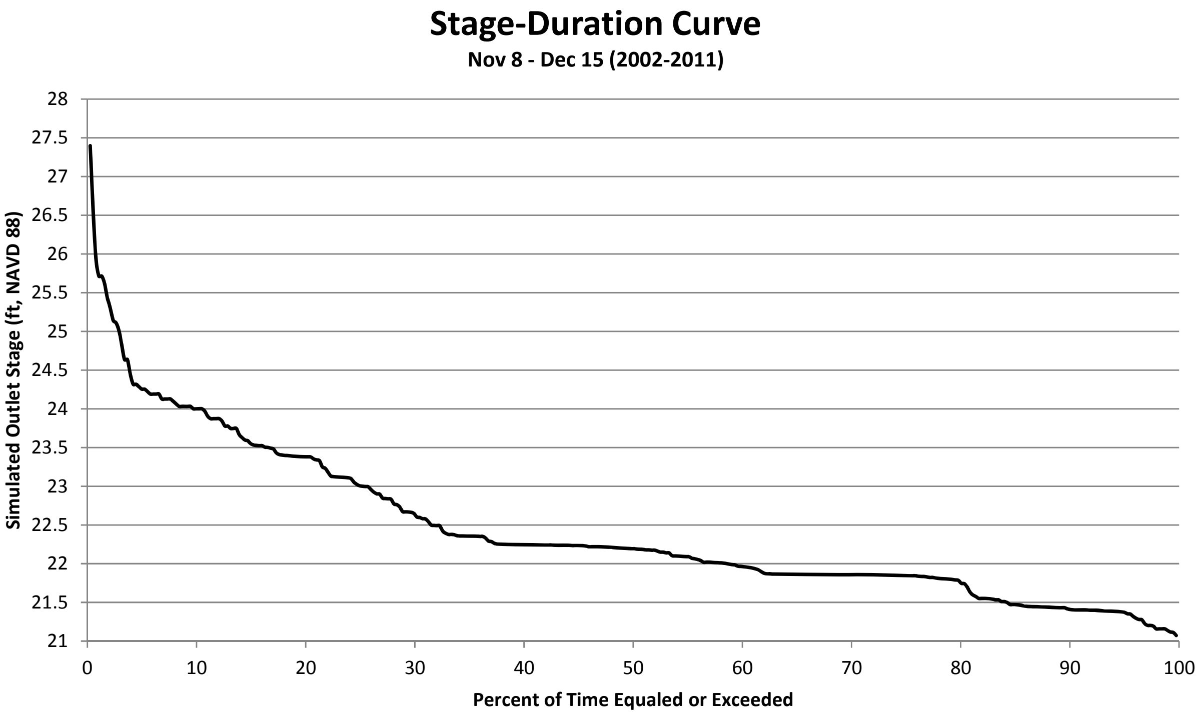

Figure 10. Stage-duration curve for the chum spawning period for the Lewis River (South Channel) at the outlet of the proposed chum channel. Stage at the outlet was extrapolated using water level monitoring data from the upstream end of the site and the relationship with flow at the Ariel USGS Gage (see text and Figure 9). Data from the Ariel Gage from the last 10 years (2002 – 2011) was used for development of the stage-duration curve.

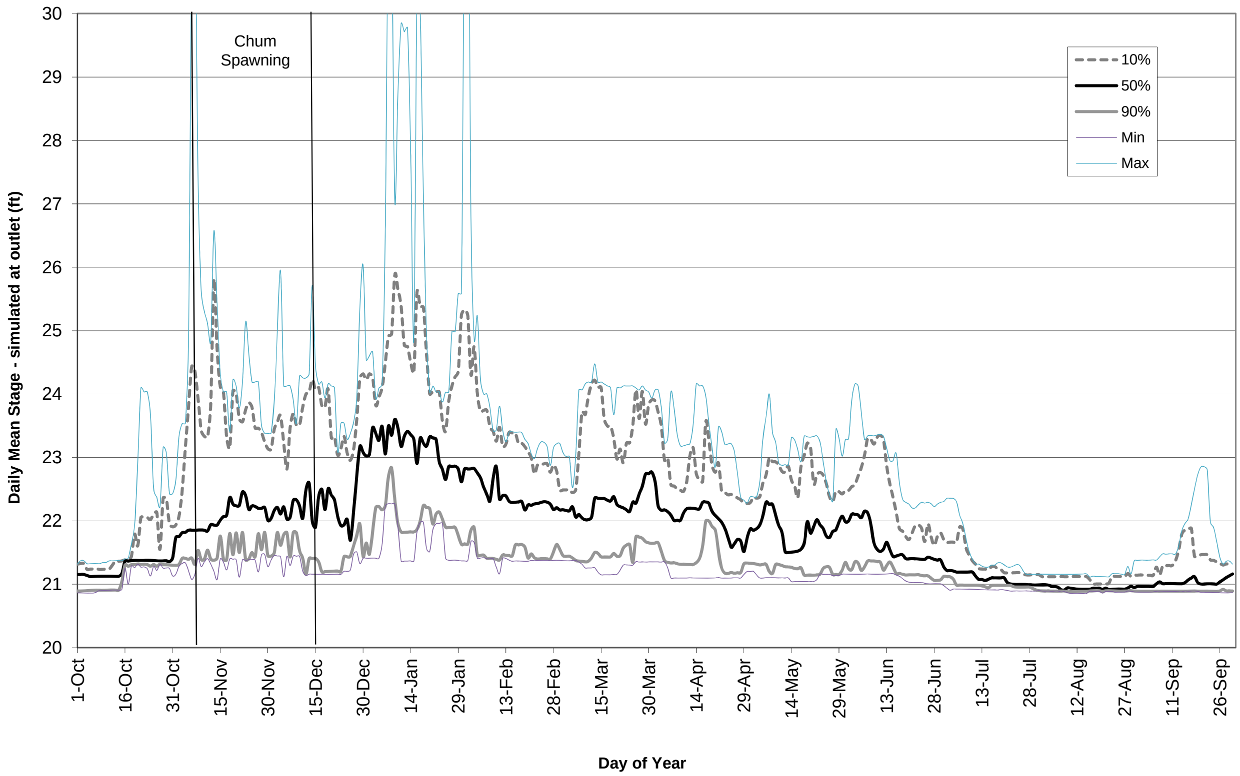

Figure 11. Stage exceedence plot for the simulated gage at the proposed channel outlet. This was developed by simulating gage data at the outlet based on the piezometer data at the upstream end of the project site, then applying the stage-discharge relationship with the Ariel Gage to develop exceedence values. Flow values include the latest 10 years of data (2002 – 2011) from the Ariel Gage.

Proposed chum channel hydraulics

Proposed hydraulic conditions of the chum spawning channel were analyzed for non-flood flow conditions to ensure the design of the channel will achieve habitat criteria during the fish use period, including chum spawning, incubation, and rearing. Hydraulic modeling was conducted using the U.S. Army Corps of Engineers Hydraulic Engineering Center River Analysis System (HEC-RAS 4.1.0). HEC-RAS is a 1-dimensional hydraulic model that was used to perform hydraulic computations including estimates of water depth, velocity, and shear along the channel length. The objective of modeling the proposed channel was to determine appropriate channel dimensions and slope that would be most likely to provide desired habitat conditions (depth, velocity, and shear) under estimated flow conditions. Desired habitat conditions are described later in this report under .

Model hydrology

The hydrologic analysis for the site included a pump test in the area of the proposed channel. The methods and results of this test are described previously in the Pump test section. The pump test provided estimates of low flow discharge supplied by groundwater, which will be expected to sustain spawning and incubating conditions in the channel. Results of the groundwater pump test suggest that groundwater gains over the length of the proposed channel will result in an outflow volume of 4 to 9 cfs. In addition to groundwater inputs, the current design includes a supplemental source of inflow that takes water from the Lewis River via an infiltration gallery collection system and piping. This is necessary to provide the required depth and velocities to support chum spawning, which would not be supported by groundwater flow alone. The model was run with the entire range of estimated flows derived from groundwater inflow and additional flows from flow augmentation. A groundwater inflow of 4 cfs was used as a conservative estimate, which is based on the lowest groundwater inflow volumes determined by the pump test. Flow augmentation at the top of the proposed channel is currently designed for a flow of approximately 5 cfs during average mainstem flow conditions. Therefore, flow was modeled with 5 cfs at the upstream end with steadily increasing flow accumulating to 9 cfs in the channel near the downstream end.

Model geometry

Ground survey using total station and RTK survey equipment was used as the primary source of topographic data. LiDAR data was used to supplement topography at the far extent of the model domain. From the combined survey and LiDAR data, a 3-dimensional surface was constructed in AutoCAD and the proposed channel was graded into the existing topography. In AutoCAD, a total of 27 cross-sections were cut along the 1,345-foot proposed channel. Sections were evenly spaced at 50-ft intervals, with supplemental sections at the two proposed control weirs. The modeled geometry for the proposed channel is a simple rectangular channel. Channel geometry was simplified in order to facilitate multiple iterations of channel width. Widths were varied from 15 to 8 ft in order to determine the optimal width to acheive desired habitat conditions with assumed flows. Channel slope was an additional variable that was iteratively varied to determine the optimal slope to provide sufficient depth, velocity, and shear stress. Slope was varied between 0.2% and 0.06% during the modeling process.

Model boundary conditions

Model boundary conditions consisted of a normal depth boundary at the top of the model and a known water surface elevation boundary at the downstream end of the model. The known water surface boundary was developed through hydrologic analysis of the mainstem Lewis River as described previously under the Hydraulics – Lewis River section and summarized in Figure 9. Figure 9 is a stage-duration curve that provides estimated mainstem river stage at the outflow of the proposed channel. Eight separate model runs were conducted with a range of downstream boundary conditions based on Lewis River flows expected during chum spawning. The range of discharge (and associated stage) in the Lewis River at the downstream end of the chum channel during spawning generally ranges from 2,000 cfs (21.14 ft) to 10,000 cfs (23.68 ft). At the high stage of 23.68 ft, the river creates a backwater condition at the outlet of the proposed channel. At the low stage of 21.14 ft, the downstream boundary condition and the weirs control the hydraulics in the proposed channel. This flow represents very low mainstem flows.

Model results

Several iterations of flow conditions, slope, and channel geometry were carried out in order to achieve desired habitat conditions within optimal design parameters. The final modeled conditions include a channel that is 14 ft wide below the downstream control weir, 12 ft wide between the downstream and upstream control weirs, and 10 ft wide above the upstream control weir. The channel has near vertical side-slopes. A consistent channel slope of 0.06% was used along the length of the proposed channel. Channel invert elevations were adjusted to take maximum advantage of ambient hydraulic head gradients (i.e. intercepted groundwater), provide sufficient grade for sediment transport, and provide maximum water depth without significantly increasing backwater conditions at the downstream end (Figure 12). The resulting chum channel hydraulics achieve habitat criteria with sufficient depth (>0.6 ft depth) and velocity (>0.7 ft/s) up to a downstream boundary condition in the Lewis River of 37th percentile exceedance flow (5,500 cfs) indicating that the habitat criteria are achieved the majority of the time (i.e. 63% of the time). Average velocities in the chum channel are lower than the velocity criteria of 0.7 ft/sec for Lewis River flows above the 37th percentile due to the backwater conditions at the downstream end (Table 5). \

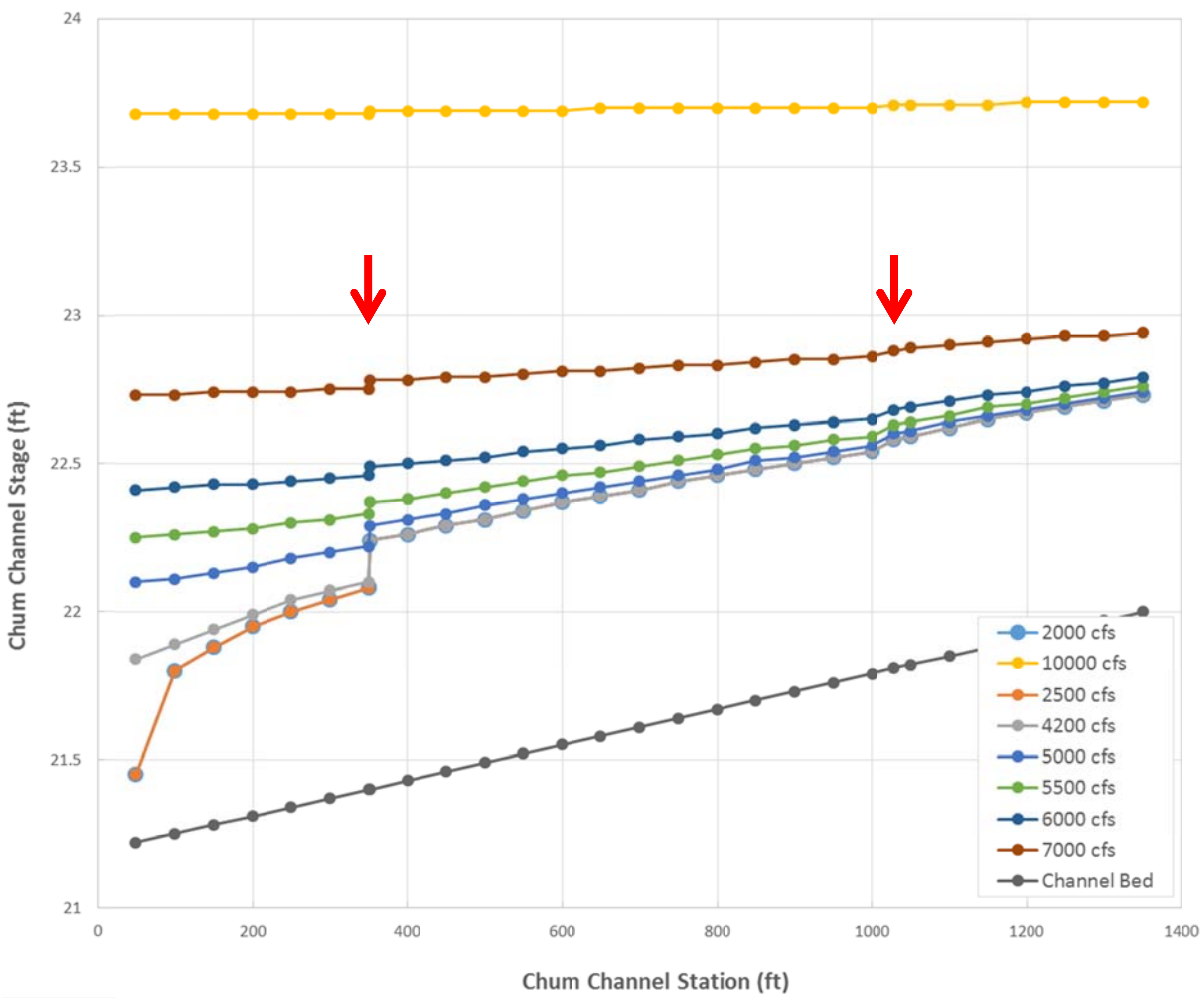

Figure 12. Water surface elevations along the proposed chum channel for varying flow rates in the Lewis River from low flow (2,000 cfs) up to the 14th percentile exceedance flow (10,000 cfs). Weirs are located at stn 3+53.08 and stn 10+27.06, and denoted by the red arrows.

Table 5. Average flow depth, velocity, and shear for the proposed chum channel at varying downstream boundary conditions.

Downstream Boundary Condition - Lewis River Flowrate (cfs)	Average Modeled Flow Depth (ft)	Average Modeled Velocity (ft/sec)	Average Modeled Shear (lb/ft^2)
2,000	0.75	0.77	0.0246
2,500	0.75	0.77	0.0246
4,200	0.76	0.76	0.0232
5,000	0.82	0.70	0.0192
5,500	0.88	0.66	0.0164
6,000	0.97	0.60	0.0134
7,000	1.20	0.48	0.0082
1,0000	2.07	0.27	0.0022

Substrate samples

Subsurface substrate samples were collected at two locations within the proposed alignment in order to assess how much of the in-situ material could be incorporated back into the constructed channel. Samples were collected at two locations; one approximately 100 feet upstream from the proposed outlet and one approximately midway along the proposed channel alignment. Samples were collected by hand digging holes down to static groundwater level and then collecting a representative substrate sample and delivering to the lab for sieve analysis. These results are presented in Figure 13 and Figure 14.

Subsurface material at the site consists of river alluvium ranging from silts to cobbles. The material distribution varies across the site and determining the specific make-up of the full amount of material to be excavated for the channel will not be possible. However, preliminary results indicate that possibly one-third to one-half of the material could be re-used as spawning gravel in the constructed channel, which would likely be sufficient to provide all of the required spawning gravel. Additional sampling of material is recommended prior to construction in order to further investigate the potential for re-use of in-situ gravels.

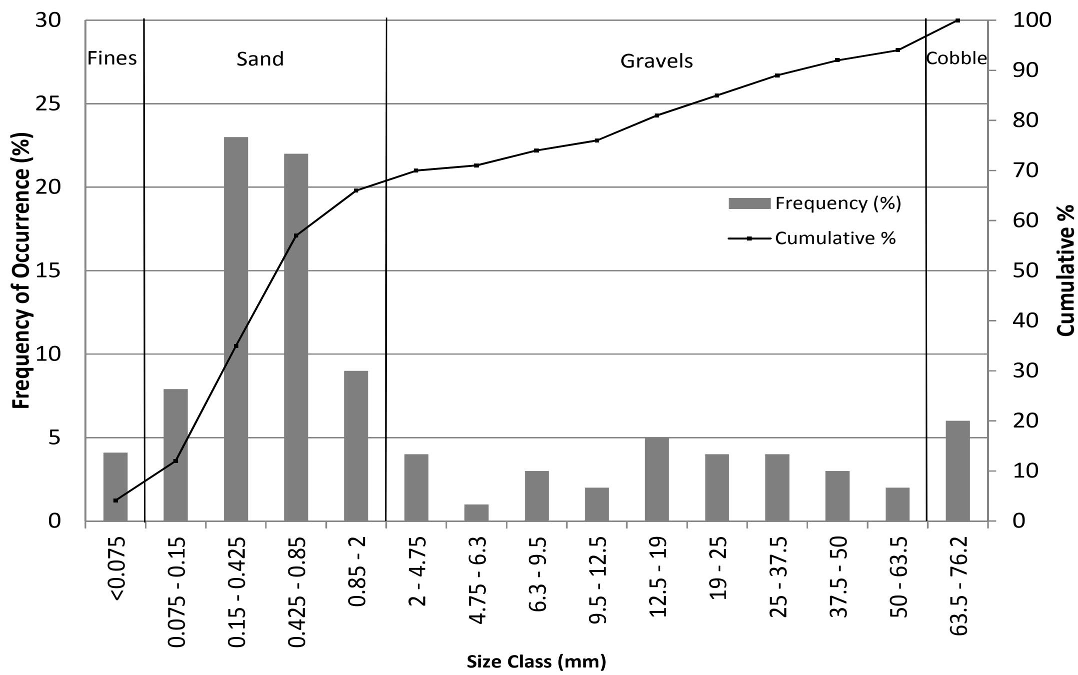

Figure 13. Subsurface bulk sample results at upstream sample site.

Table 6. Size classes and percent composition of subsurface material collected at the upstream sample site.

Size Class	Size percent finer than (mm)
D5	0.08
D16	0.18
D50	0.67
D84	23.00
D95	65.00
D100	<76.2

Material	Percent Composition
Fines	4%
Sand	62%
Gravel	28%
Cobble	6%
Boulder	0%

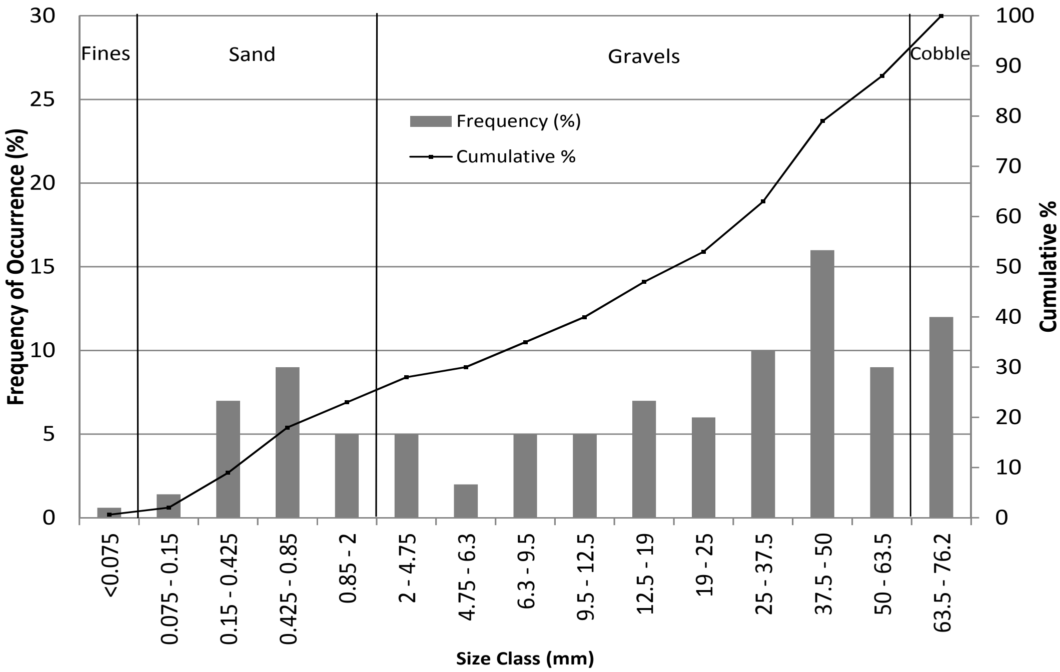

Figure 14. Subsurface bulk sample results at downstream sample site.

Table 7. Size classes and percent composition of subsurface material collected at the downstream sample site.

Size Class	Size percent finer than (mm)
D5	0.25
D16	0.71
D50	22.00
D84	58.00
D95	71.00
D100	<76.2

Material	Percent Composition
Fines	1%
Sand	22%
Gravel	65%
Cobble	12%
Boulder	0%

Chum salmon life history and habitat requirements

A summary of chum life history and habitat requirements were compiled from the literature in order to inform channel designs. Chum salmon typically enter the Lewis River in October and spawn in November and December. Fry emerge from late Feb to April and emigrate from the system in May and June. A life stage periodicity chart is included in . Chum salmon select spawning areas with upwelling groundwater (Groot and Margolis 1991; Bjornn and Reiser 1991), such as floodplain side-channels fed by hyporheic flow. These upwelling areas may have the advantage of improved aeration and metabolite removal (Schroder 1974). Additional habitat criteria are included in the section below in Table 8.

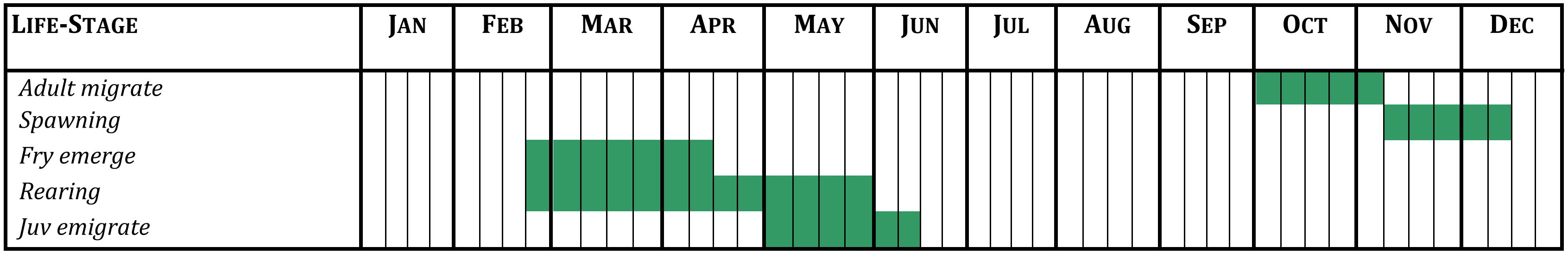

Figure 15. Life-stage periodicity chart for chum salmon in the Lewis River (reproduced from PacifiCorp 2004a).

Specific habitat criteria

The following specific habitat criteria (Table 8) were developed through consultation with various sources, which are listed in the table. These criteria are primarily expressed as ranges to allow for design flexibility in meeting criteria.

Table 8. Specific habitat criteria.

Metric	Value or Range	Notes and Sources
Channel width (ft)	12 - 40	Range recommended by Bell (1990) for artificial spawning channels.
Water depth (ft)	0.4 – 1.6	Lower range derived from chart in Quinn (2005). Upper range from Smith (1973, as cited in Bjornn and Reiser 1991). Consistent with “Use Areas” measured in Hamilton and Hardy Creek by Johnson et al. (2008)
Water velocity (ft/s)	0.7 – 3.3	Lower range from “Use Areas” in Hamilton Creek from Johnson et al. (2008). Upper range from Smith (1973)
Slope	0.0006 (0.06%)	Recommended value given by Bell (1990) for artificial spawning channels
Substrate size (inches)	80%: 0.5 – 2 20%: 2 - 4	Size distribution recommended by Bell (1990) for artificial spawning channels
Minimum flow (ft^3/s)	3.6	This was the minimum flow recorded in Hamilton Springs from Nov 2005 to May 2006 by Johnson et al. (2008).

ELEMENTS OF DESIGN

Planform

The location and planform pattern of the spawning channel was selected based on site topography, geomorphic considerations, landownership, and the location of existing trees. The channel generally follows a floodplain swale that was created by the historical position of the Lewis River. Former channel locations that form natural depressions in floodplains are frequently indicators of “paleo-channels” that convey groundwater/hyporheic flow more readily than other floodplain areas. This is particularly the case when these channels are formed across the inside of meander bends, which results in an increase in the groundwater gradient through the site. Utilizing a natural depression also limits excavation quantities. The channel pattern was also adjusted to limit the disturbance to existing mature timber and wetlands, which were surveyed and mapped during the site topographic survey. At the downstream end of the channel, the planform was further adjusted to avoid crossing private property. This will simplify construction and future monitoring and maintenance.

Profile

The elevation and slope of the channel was determined through a combination of hydraulic analysis, geomorphic considerations, and chum spawning requirements. The slope of the channel is 0.06%, generally slightly less than the groundwater slope (0.19%) as determined from piezometer data and site surveys. The elevation of the channel invert (base) at the outlet was selected to achieve sufficient depth while taking into account the extent of backwater influence from the Lewis River. A more detailed discussion of the hydraulic analysis used to determine channel geometry is included above in the Hydraulics – Proposed chum channel section.

Cross-section

Channel cross-section dimensions were determined through consideration of channel hydraulics, achieving habitat criteria, providing for bank stability, and for allowing growth of native riparian vegetation. Channel width varies 10 to 12 to 14 feet based on achieving the maximum width while still accomplishing depth criteria. Channel banks have near vertical sides of 2-3 feet height, and are held in place by logs laid parallel to the banks and fastened to log pilings buried vertically behind them. These toe logs are designed to prevent erosion and sloughing of the channel banks that can contribute fine sediment into the channel, and will be keyed into the streambed to prevent undermining by spawning fish. The toe logs will be backfilled with native river gravel acquired from site excavations to further reduce the potential for introduction of fine sediment. Above the vertical toe logs the banks are sloped back to a stable grade in order to facilitate establishment of riparian vegetation. The upper bank slope will be 2:1 with some variation based on matching existing topography and to accommodate existing trees.

Control weirs

The design includes three cross-channel control weirs that allow for operational flexibility to control channel gradient and hydraulics, as well as to allow for fish sampling. The most downstream weir is located 353 feet upstream from the channel outlet and is designed to accommodate attachment of a fyke net for capturing and sampling juvenile fish. Two other weirs are spaced along the length of the channel primarily as a means to regulate channel velocity and depth. Weirs will be constructed of sheet piles driven into the bed with a notched spillway set at the channel invert elevation. Flash boards can be installed for stage regulation, or screens can be installed to prevent fish passage. These weirs will provide the operational flexibility to ensure that channel depths and velocities are suitable to support chum spawning, incubation, and juvenile rearing for a broad range of flow conditions.

Channel bed substrate

Channel bed substrate of the appropriate size for chum spawning will be placed in the channel. The gravel mix will generally match the gravel sizes specified for spawning channels by Bell (1990) (Table 8). The specific mix, which is included in Table 9, has been developed and used with success over time by WDFW in other chum spawning channels.

Table 9. Spawning gravel mix.

Diameter of Gravel	Percent by Volume
4 – 6 Inch Rock	2
2.5 – 4 Inch Rock	13
1 – 2.5 Inch Rock	35
¾ -1 Inch Rock	35
3/8 –3/4 Inch Rock	10
No. 4 – 3/8 Inch Rock	5
No 10 – No 4 Material	0

Riparian planting

Riparian areas along the channel margin will be planted with native trees and shrubs in order to provide for long-term riparian functions and habitat. Woody riparian plantings will begin 5 feet from the channel edge in order to allow for ease of access to the channel for monitoring and maintenance activities. Existing open areas to be utilized for construction and material staging will be planted with upland coniferous tree species. Other disturbed areas (e.g. access roads) will be planted with an erosion control seed mix.

Channel stability and flood protection

Streambank stability within the chum channel is provided by the log toe construction. Upper banks will be protected via bank sloping and planting of woody riparian species. Stability along the mainstem Lewis River at the location of the infiltration gallery will be provided by a rock toe and large wood placements.. Logs and woody debris will be placed on the floodplain between the river and the constructed channel at the upstream end of the project area in order to provide hydraulic roughness in an area that will receive considerable disturbance to the existing vegetation conditions during construction. This floodplain roughness will help to limit the volume and erosive energy of flood flow entering the new channel.

Supplemental flow design

In order to ensure adequate flow conditions during the spawning, egg incubation, and early rearing periods, flow supplementation will be provided by drawing water from near the Lewis River. Flow supplementation was included because pump test results indicate that groundwater inputs will be less than needed to fully achieve habitat criteria (depth, velocity, width). The current design for flow supplementation includes an infiltration gallery water collection system located along the bank of the Lewis River near the upstream end of the project site. This system will collect and transmit water into the head of the spawning channel. Additionally, a control valve in the system will provide operational flexibility by regulating the flow rate into the channel, or shutting off flow if necessary. Furthermore, the supplemental flow system could also provide flushing flows for periodic channel maintenance (e.g. to flush fines from the channel or to scour vegetation).

The flow supplementation system will be composed of slotted pipe well screen. The well screen will be 16" PVC pipe with 0.125" wide slots spaced 0.25" apart to provide 133 sq-in open area per foot of pipe. The well screens will be installed near the riverbank. To improve transmission of water toward the well screen, the pipe will be surrounded by a blanket of drain rock. To provide erosion protection, the river bank soils will be replaced by erosion protection stone. Two 80' lengths of well screen will be installed to provide up to 7 cfs. The well screens will manifold at a 24" tee and flow through HDPE-S conveyance pipe to the head of the new channel. The pipe outlet will be fitted with a gate valve. A trash rack installed at the pipe outlet will prevent fish from entering the pipe. Riprap will be wrapped around the end of the channel at the pipe outlet zone to protect banks from scour and to create a small energy dissipation pool. A cleanout stand pipe will be installed to provide a back flush maintenance point in case the drain rock and well screen eventually become clogged by sediment.

A riverbank log structure installed over the top of the well screen area will provide additional erosion protection and create mainstem river habitat to replace trees removed for the well screen installation.

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ATTACHMENT 1

2D Hydraulic Model Graphical Outputs & HEC-RAS Tabu7lar Outputs

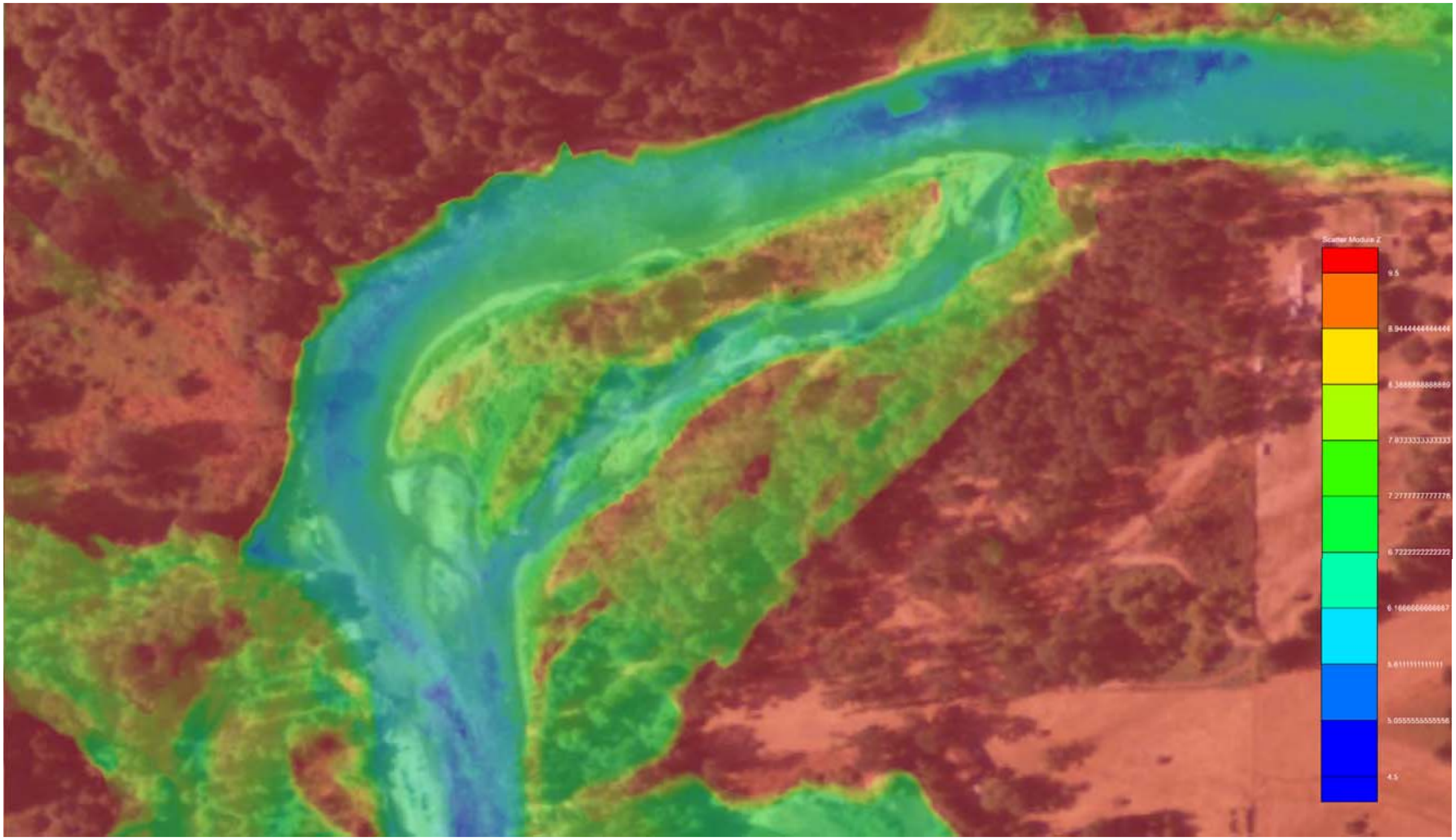

Figure 16. Existing Topography (m). Preliminary.

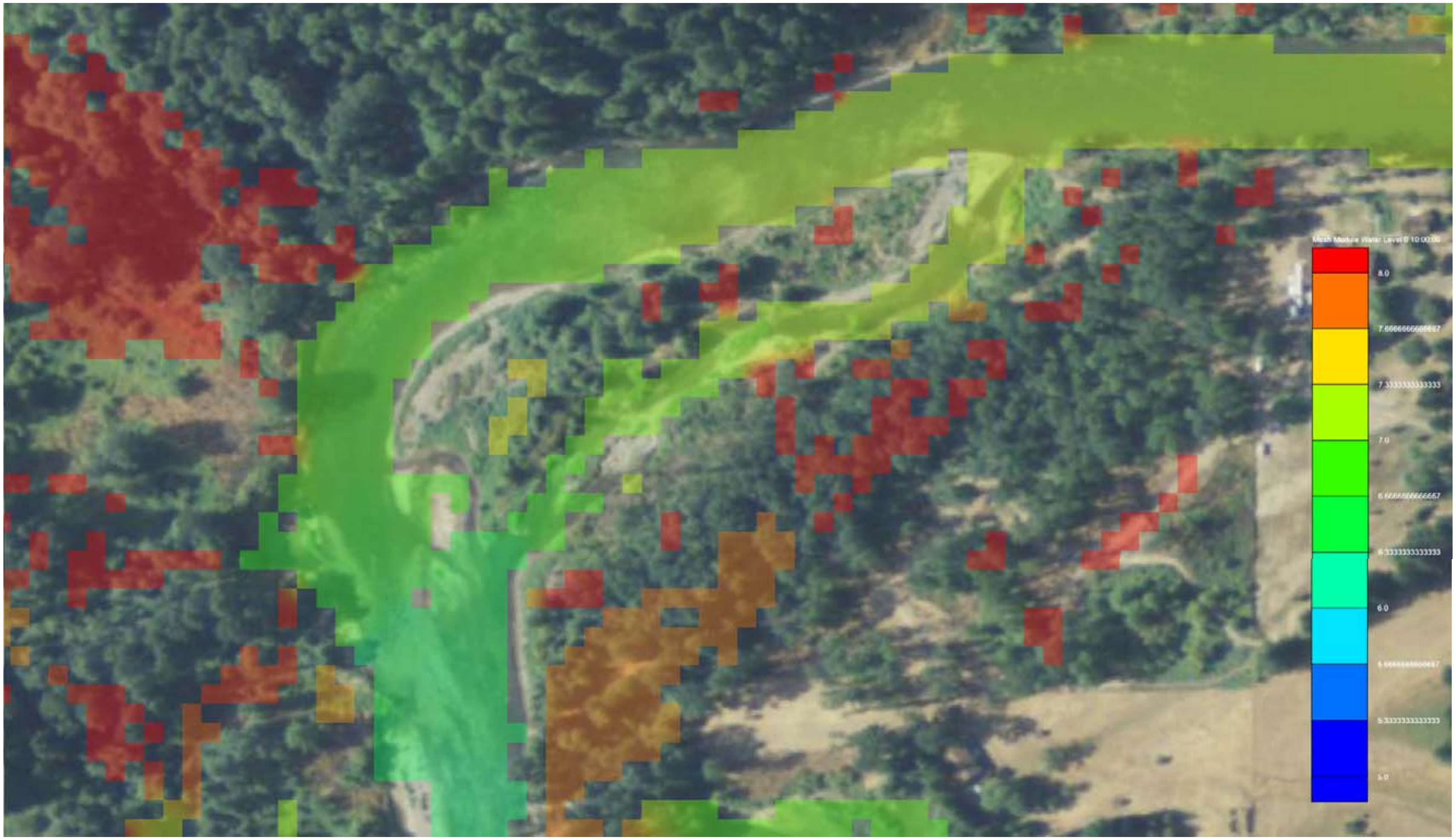

Figure 17. Low flow – water surface elevation (WSE) (m). Preliminary.

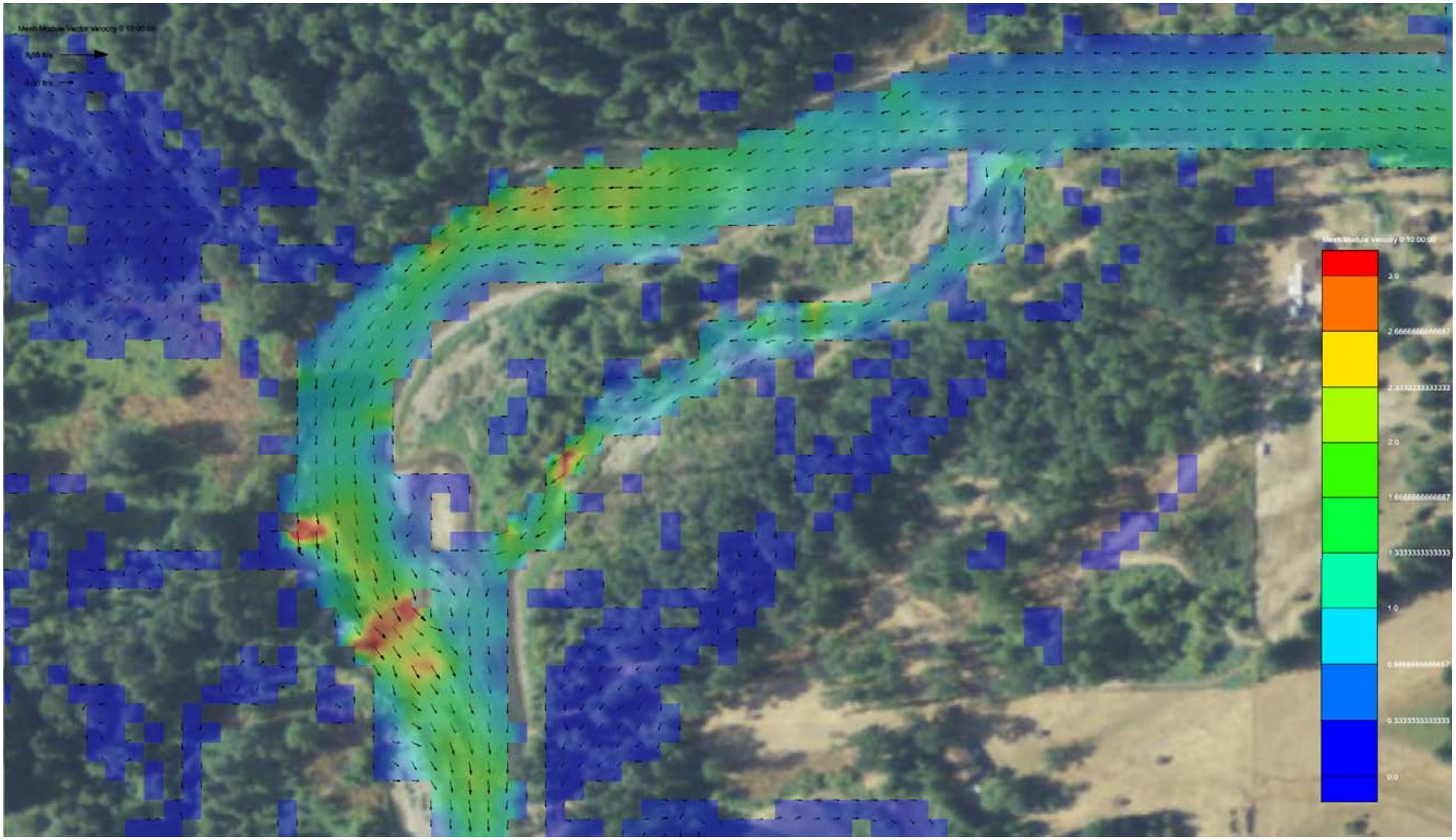

Figure 18. Low flow, Velocity (m/s). Preliminary.

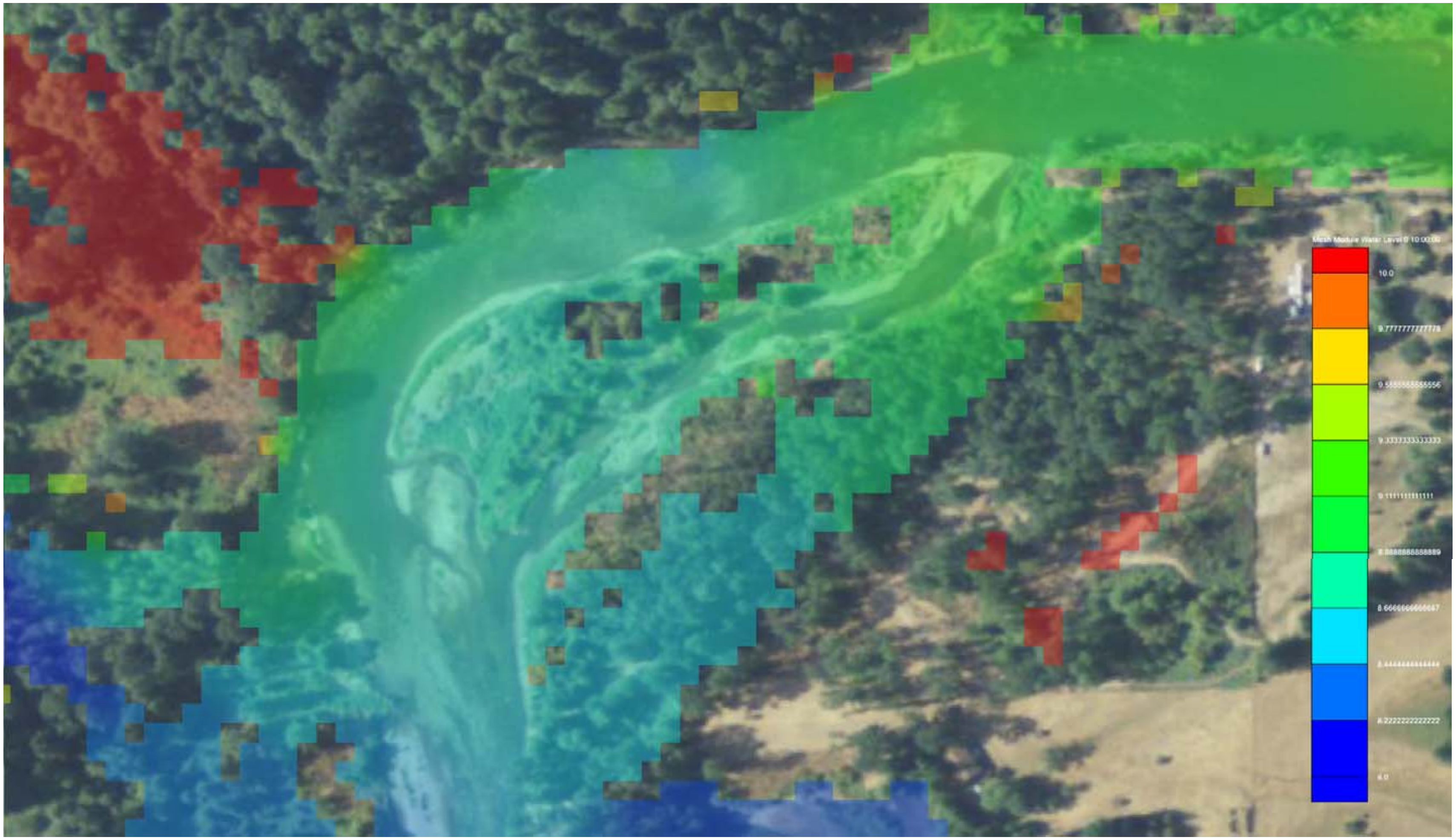

Figure 19. 2-yr flow, WSE (m). Preliminary

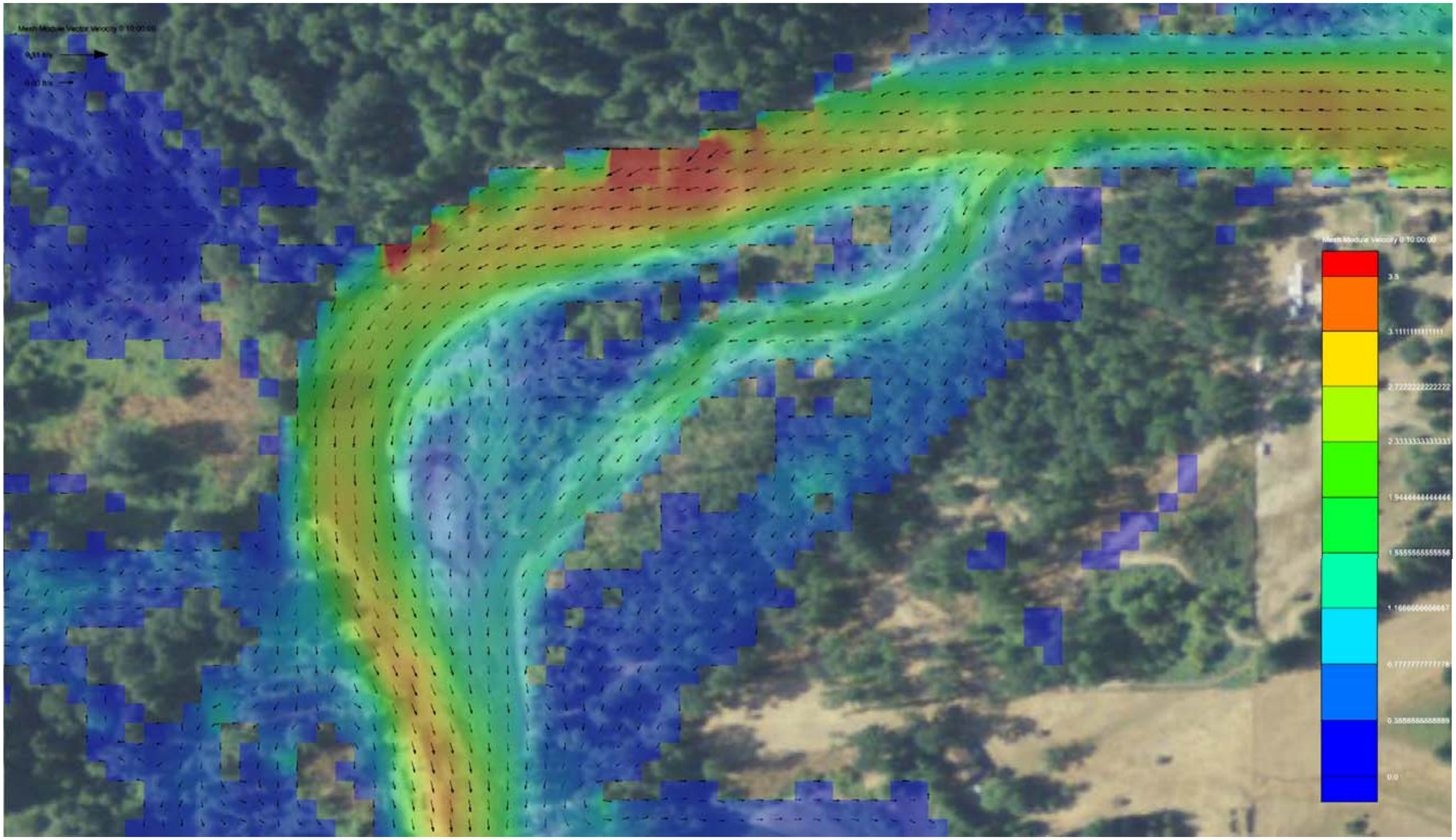

Figure 20. 2-yr flow, velocity (m/s). Preliminary.

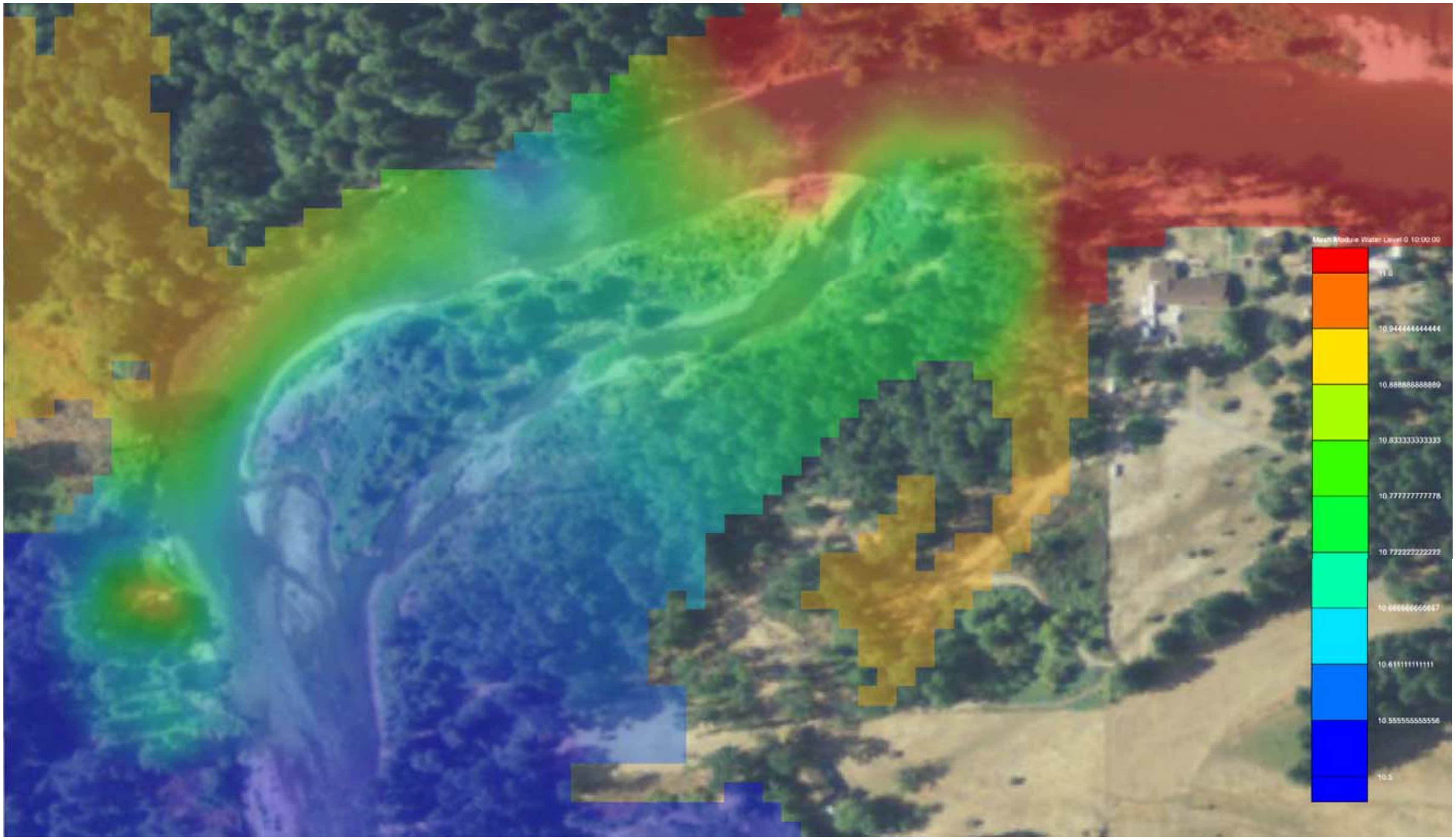

Figure 21. 10-yr flow, WSE (m). Preliminary.

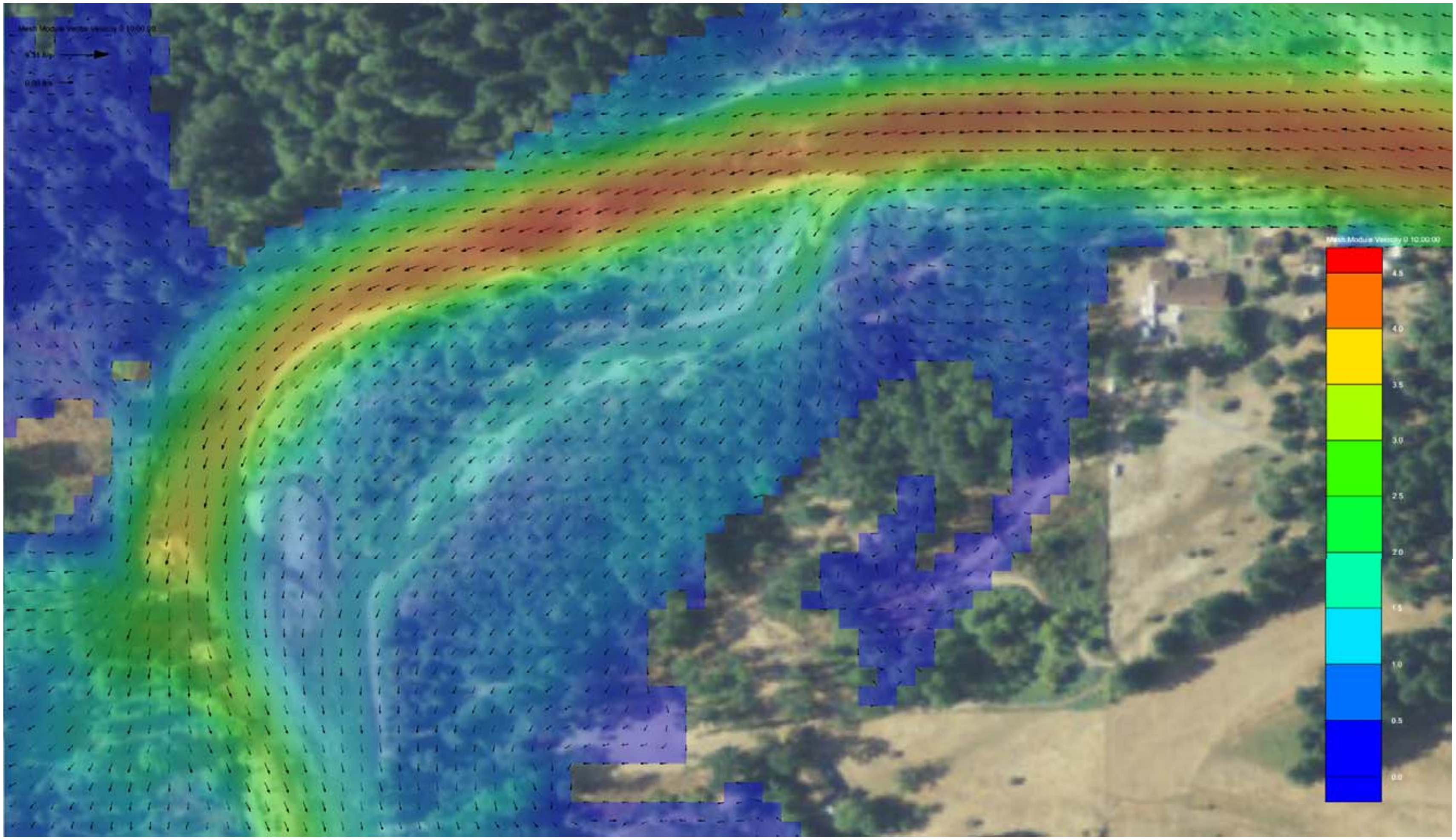

Figure 22. 10-yr flow, velocity (m/s). Preliminary.

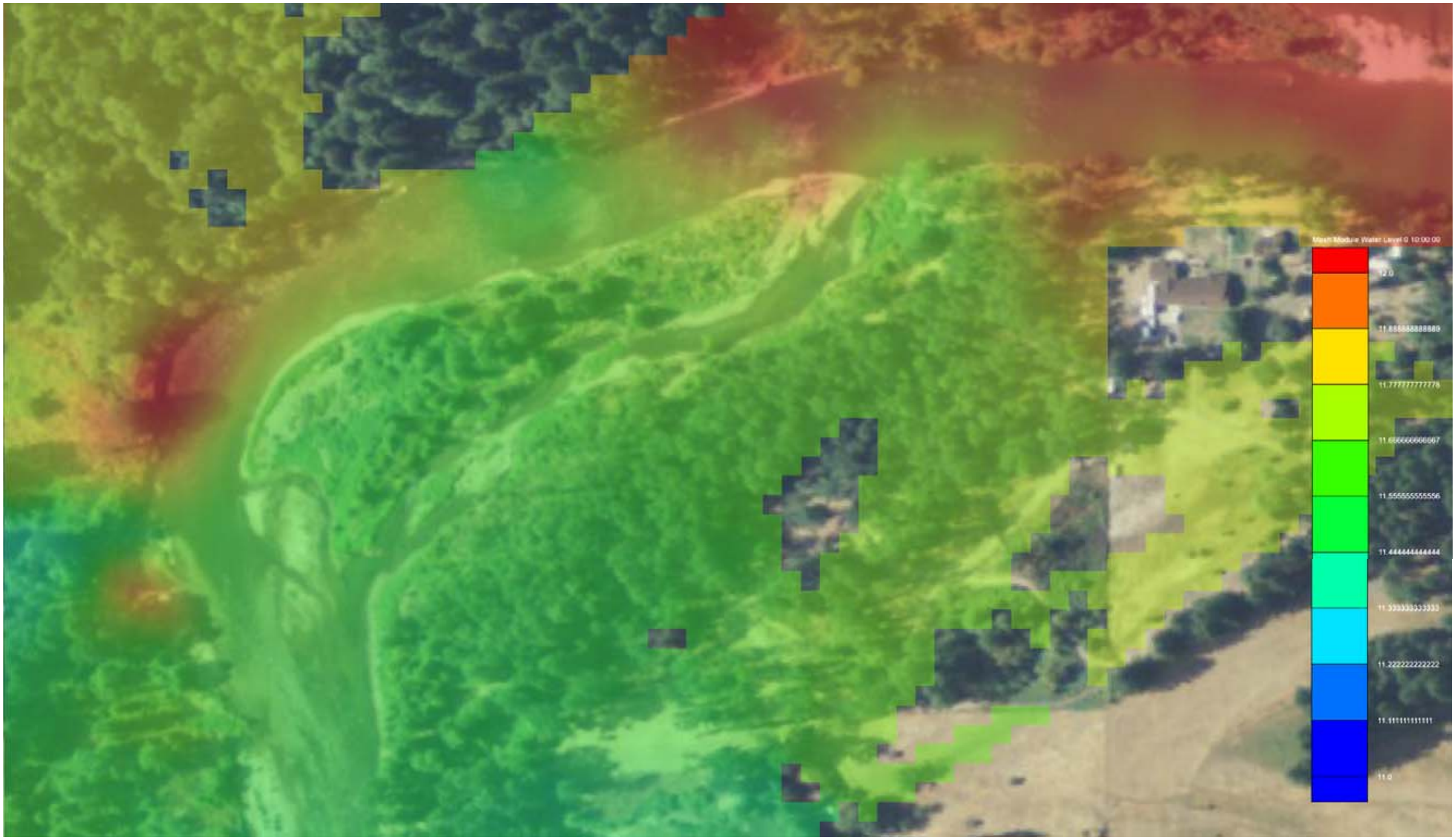

Figure 23. 50-yr flow, WSE (m). Preliminary.

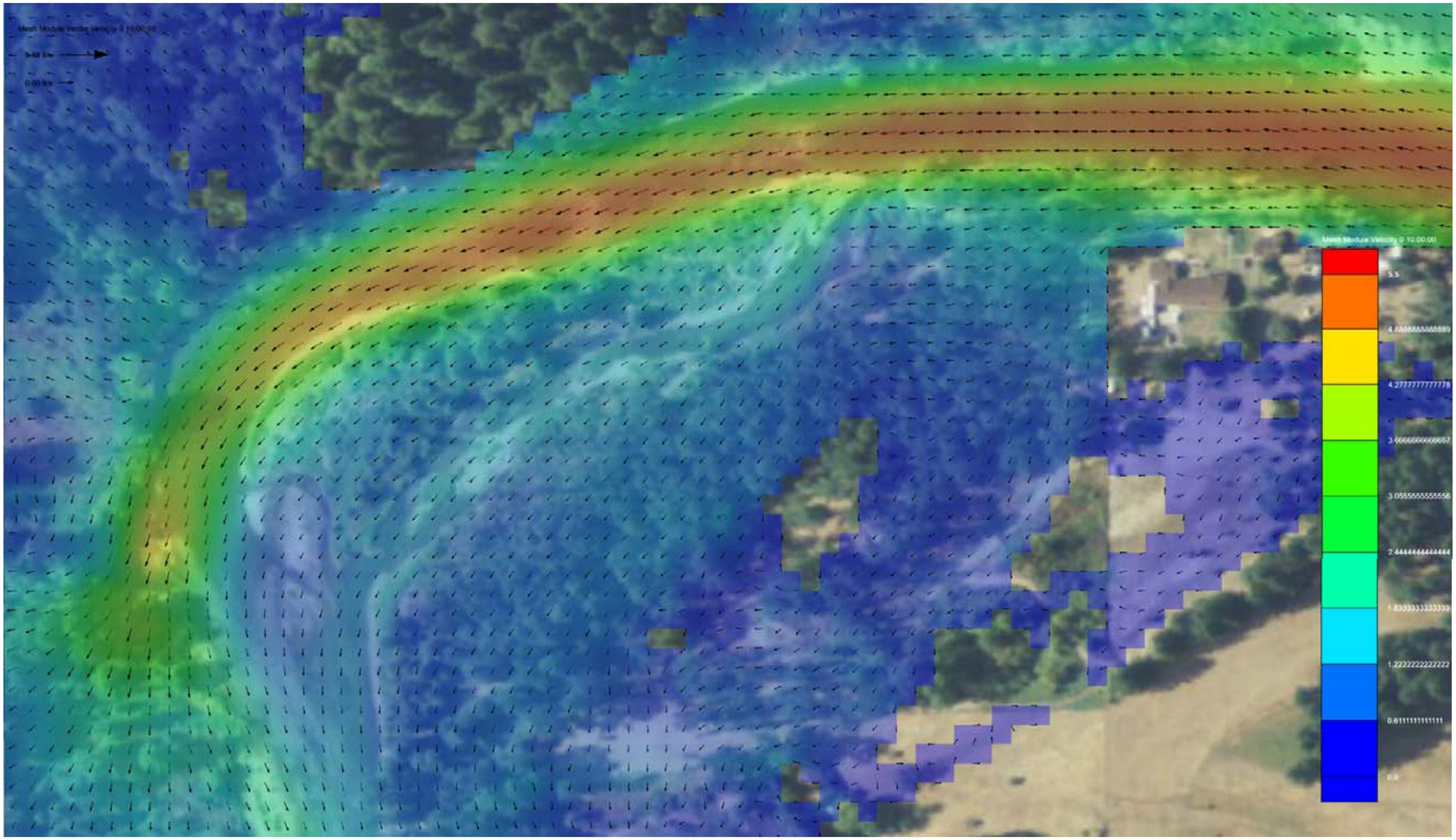

Figure 24. 50-yr flow, velocity (m/s). Preliminary.

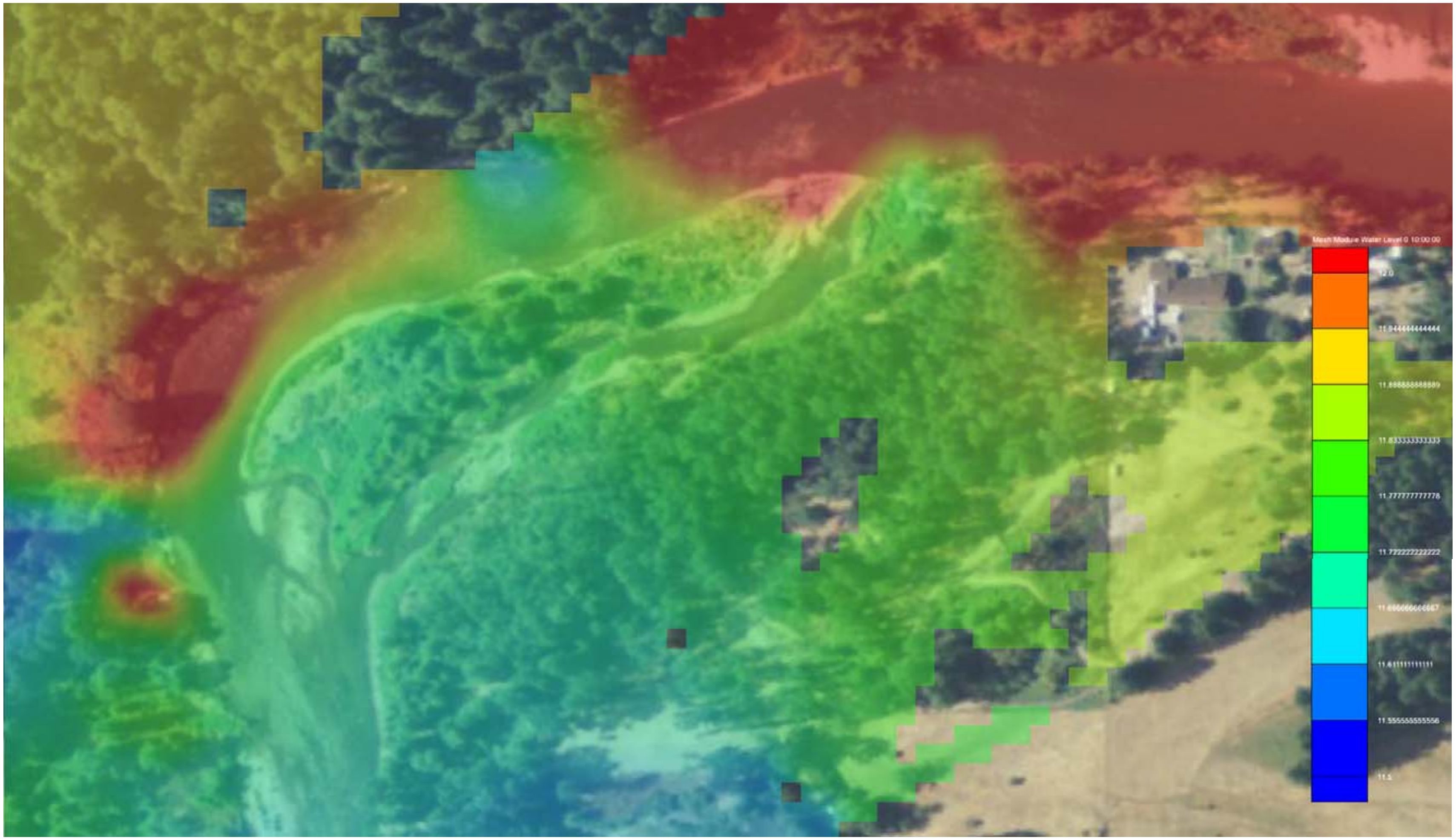

Figure 25. 100-yr flow, WSE (m). Preliminary.

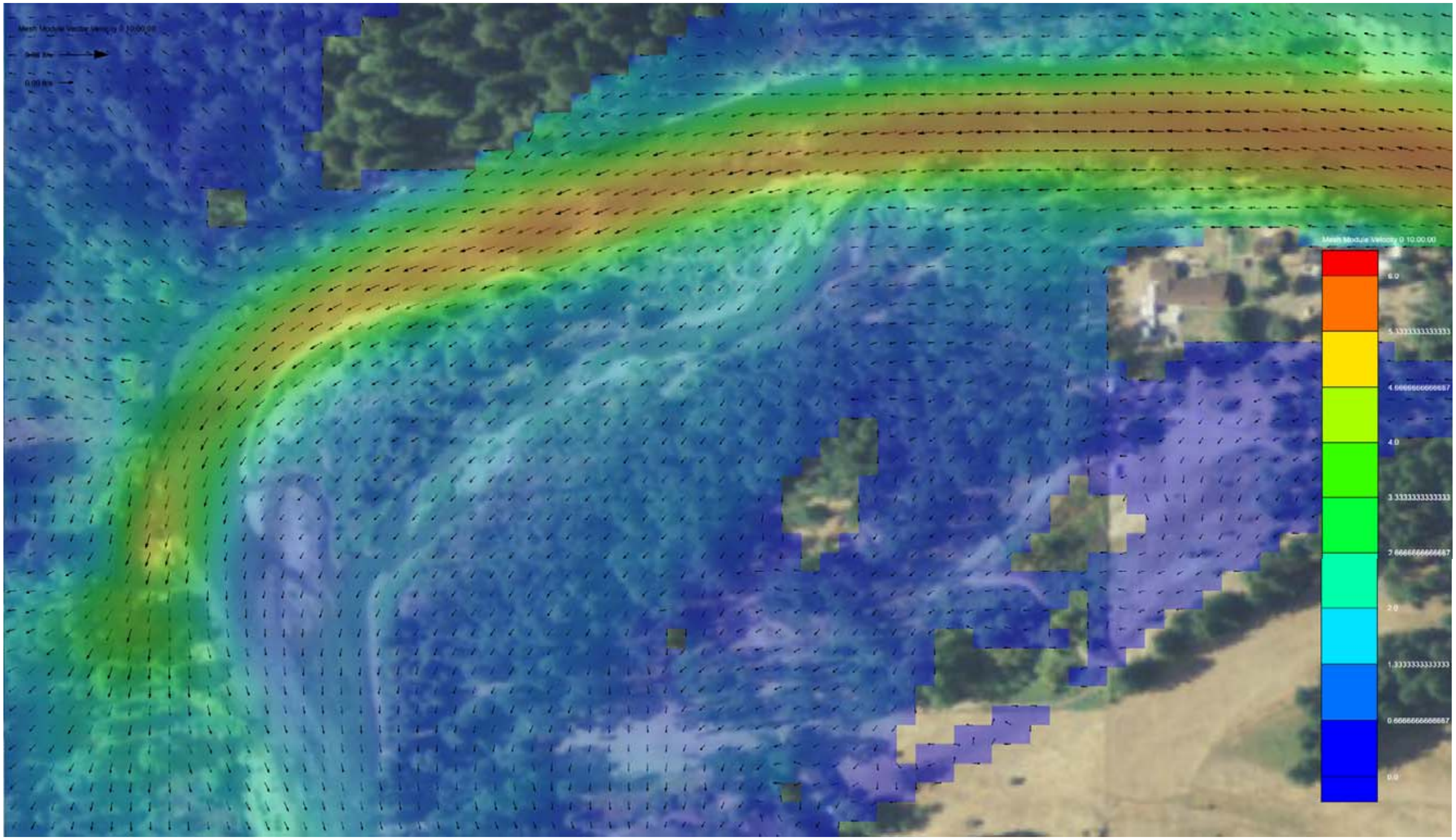

Figure 26. 100-yr flow, velocity (m/s). Preliminary

HEC-RAS Plan: Chum_Final_2000c River: PR BACKWATER Reach: cl4 Profile: PF 1

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Shear Chan
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(lb/sq ft)
cl4	1350	PF 1	5.00	22.00	22.73	22.20	22.74	0.000464	0.68	7.35	10.02	0.14	0.01856
cl4	1300	PF 1	5.00	21.97	22.71		22.72	0.000449	0.67	7.43	10.02	0.14	0.01814
cl4	1250	PF 1	5.00	21.94	22.69		22.70	0.000434	0.67	7.51	10.02	0.14	0.01768
cl4	1200	PF 1	5.00	21.91	22.67		22.68	0.000417	0.66	7.61	10.02	0.13	0.01719
cl4	1150	PF 1	5.00	21.88	22.65		22.66	0.000400	0.65	7.70	10.02	0.13	0.01669
cl4	1100	PF 1	6.00	21.85	22.62		22.63	0.000571	0.78	7.73	10.01	0.16	0.02385
cl4	1050	PF 1	6.00	21.82	22.59		22.60	0.000567	0.77	7.74	10.01	0.16	0.02376
cl4	1029.18	PF 1	6.00	21.81	22.58	22.03	22.59	0.000566	0.77	7.75	10.04	0.16	0.02370
cl4	1029.17		Inl Struct										
cl4	1000	PF 1	6.00	21.79	22.54		22.55	0.000497	0.72	8.34	11.09	0.15	0.02058
cl4	950	PF 1	6.00	21.76	22.52		22.53	0.000401	0.66	9.15	12.05	0.13	0.01695
cl4	900	PF 1	6.00	21.73	22.50		22.51	0.000384	0.65	9.28	12.05	0.13	0.01642
cl4	850	PF 1	6.00	21.70	22.48		22.49	0.000366	0.64	9.42	12.05	0.13	0.01587
cl4	800	PF 1	7.00	21.67	22.46		22.47	0.000485	0.74	9.50	12.05	0.15	0.02119
cl4	750	PF 1	7.00	21.64	22.44		22.44	0.000473	0.73	9.58	12.05	0.14	0.02080
cl4	700	PF 1	7.00	21.61	22.41		22.42	0.000460	0.72	9.66	12.05	0.14	0.02040
cl4	650	PF 1	7.00	21.58	22.39		22.40	0.000448	0.72	9.74	12.03	0.14	0.01999
cl4	600	PF 1	7.00	21.55	22.37		22.38	0.000432	0.71	9.85	12.05	0.14	0.01949
cl4	550	PF 1	8.00	21.52	22.34		22.35	0.000558	0.81	9.89	12.06	0.16	0.02523
cl4	500	PF 1	8.00	21.49	22.31		22.32	0.000553	0.81	9.92	12.05	0.16	0.02508
cl4	450	PF 1	8.00	21.46	22.29		22.30	0.000548	0.80	9.95	12.06	0.16	0.02491
cl4	400	PF 1	8.00	21.43	22.26		22.27	0.000541	0.80	9.98	12.05	0.16	0.02470
cl4	351.51	PF 1	8.00	21.40	22.24	21.62	22.25	0.000395	0.70	11.51	13.77	0.13	0.01845
cl4	351.50		Inl Struct										
cl4	350	PF 1	8.00	21.40	22.08		22.09	0.000767	0.85	9.37	13.84	0.18	0.02962
cl4	300	PF 1	8.00	21.37	22.04		22.05	0.000773	0.85	9.40	14.05	0.18	0.02956
cl4	250	PF 1	8.00	21.34	22.00		22.01	0.000809	0.86	9.27	14.04	0.19	0.03053
cl4	200	PF 1	9.00	21.31	21.95		21.96	0.001146	1.01	8.95	14.04	0.22	0.04190
cl4	150	PF 1	9.00	21.28	21.88		21.90	0.001369	1.06	8.47	14.04	0.24	0.04759
cl4	100	PF 1	9.00	21.25	21.80	21.48	21.82	0.001843	1.17	7.72	14.04	0.28	0.05884
cl4	50	PF 1	9.00	21.22	21.45	21.45	21.57	0.030583	2.75	3.27	14.02	1.01	0.43132

HEC-RAS Plan: Chum_Final_2500c River: PR BACKWATER Reach: cl4 Profile: PF 1

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Shear Chan
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(lb/sq ft)
cl4	1350	PF 1	5.00	22.00	22.73	22.20	22.74	0.000464	0.68	7.35	10.02	0.14	0.01856
cl4	1300	PF 1	5.00	21.97	22.71		22.72	0.000449	0.67	7.43	10.02	0.14	0.01814
cl4	1250	PF 1	5.00	21.94	22.69		22.70	0.000434	0.67	7.51	10.02	0.14	0.01768
cl4	1200	PF 1	5.00	21.91	22.67		22.68	0.000417	0.66	7.61	10.02	0.13	0.01719
cl4	1150	PF 1	5.00	21.88	22.65		22.66	0.000400	0.65	7.70	10.02	0.13	0.01669
cl4	1100	PF 1	6.00	21.85	22.62		22.63	0.000571	0.78	7.73	10.01	0.16	0.02385
cl4	1050	PF 1	6.00	21.82	22.59		22.60	0.000567	0.77	7.74	10.01	0.16	0.02376
cl4	1029.18	PF 1	6.00	21.81	22.58	22.03	22.59	0.000566	0.77	7.75	10.04	0.16	0.02370
cl4	1029.17		Inl Struct										
cl4	1000	PF 1	6.00	21.79	22.54		22.55	0.000497	0.72	8.34	11.09	0.15	0.02058
cl4	950	PF 1	6.00	21.76	22.52		22.53	0.000401	0.66	9.15	12.05	0.13	0.01695
cl4	900	PF 1	6.00	21.73	22.50		22.51	0.000384	0.65	9.28	12.05	0.13	0.01642
cl4	850	PF 1	6.00	21.70	22.48		22.49	0.000366	0.64	9.42	12.05	0.13	0.01587
cl4	800	PF 1	7.00	21.67	22.46		22.47	0.000485	0.74	9.50	12.05	0.15	0.02119
cl4	750	PF 1	7.00	21.64	22.44		22.44	0.000473	0.73	9.58	12.05	0.14	0.02080
cl4	700	PF 1	7.00	21.61	22.41		22.42	0.000460	0.72	9.66	12.05	0.14	0.02040
cl4	650	PF 1	7.00	21.58	22.39		22.40	0.000448	0.72	9.74	12.03	0.14	0.01999
cl4	600	PF 1	7.00	21.55	22.37		22.38	0.000432	0.71	9.85	12.05	0.14	0.01949
cl4	550	PF 1	8.00	21.52	22.34		22.35	0.000558	0.81	9.89	12.06	0.16	0.02523
cl4	500	PF 1	8.00	21.49	22.31		22.32	0.000553	0.81	9.92	12.05	0.16	0.02508
cl4	450	PF 1	8.00	21.46	22.29		22.30	0.000548	0.80	9.95	12.06	0.16	0.02491
cl4	400	PF 1	8.00	21.43	22.26		22.27	0.000541	0.80	9.98	12.05	0.16	0.02470
cl4	351.51	PF 1	8.00	21.40	22.24	21.62	22.25	0.000395	0.70	11.51	13.77	0.13	0.01845
cl4	351.50		Inl Struct										
cl4	350	PF 1	8.00	21.40	22.08		22.09	0.000767	0.85	9.37	13.84	0.18	0.02962
cl4	300	PF 1	8.00	21.37	22.04		22.05	0.000773	0.85	9.40	14.05	0.18	0.02956
cl4	250	PF 1	8.00	21.34	22.00		22.01	0.000809	0.86	9.27	14.04	0.19	0.03053
cl4	200	PF 1	9.00	21.31	21.95		21.96	0.001146	1.01	8.95	14.04	0.22	0.04190
cl4	150	PF 1	9.00	21.28	21.88		21.90	0.001369	1.06	8.47	14.04	0.24	0.04759
cl4	100	PF 1	9.00	21.25	21.80	21.48	21.82	0.001843	1.17	7.72	14.04	0.28	0.05884
cl4	50	PF 1	9.00	21.22	21.45	21.45	21.57	0.030583	2.75	3.27	14.02	1.01	0.43132

HEC-RAS Plan: Chum_Final_4200c River: PR BACKWATER Reach: cl4 Profile: PF 1

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Shear Chan
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(lb/sq ft)
cl4	1350	PF 1	5.00	22.00	22.73	22.20	22.74	0.000464	0.68	7.35	10.02	0.14	0.01858
cl4	1300	PF 1	5.00	21.97	22.71		22.72	0.000450	0.67	7.43	10.02	0.14	0.01816
cl4	1250	PF 1	5.00	21.94	22.69		22.70	0.000434	0.67	7.51	10.02	0.14	0.01770
cl4	1200	PF 1	5.00	21.91	22.67		22.68	0.000418	0.66	7.60	10.02	0.13	0.01721
cl4	1150	PF 1	5.00	21.88	22.65		22.66	0.000401	0.65	7.70	10.02	0.13	0.01671
cl4	1100	PF 1	6.00	21.85	22.62		22.63	0.000572	0.78	7.72	10.01	0.16	0.02389
cl4	1050	PF 1	6.00	21.82	22.59		22.60	0.000569	0.78	7.74	10.01	0.16	0.02380
cl4	1029.18	PF 1	6.00	21.81	22.58	22.03	22.59	0.000568	0.77	7.75	10.04	0.16	0.02374
cl4	1029.17		Inl Struct										
cl4	1000	PF 1	6.00	21.79	22.54		22.55	0.000499	0.72	8.33	11.09	0.15	0.02062
cl4	950	PF 1	6.00	21.76	22.52		22.53	0.000402	0.66	9.14	12.05	0.13	0.01699
cl4	900	PF 1	6.00	21.73	22.50		22.51	0.000385	0.65	9.27	12.05	0.13	0.01645
cl4	850	PF 1	6.00	21.70	22.48		22.49	0.000367	0.64	9.41	12.05	0.13	0.01591
cl4	800	PF 1	7.00	21.67	22.46		22.47	0.000487	0.74	9.49	12.05	0.15	0.02124
cl4	750	PF 1	7.00	21.64	22.44		22.44	0.000475	0.73	9.56	12.05	0.14	0.02086
cl4	700	PF 1	7.00	21.61	22.41		22.42	0.000462	0.73	9.65	12.05	0.14	0.02046
cl4	650	PF 1	7.00	21.58	22.39		22.40	0.000450	0.72	9.73	12.03	0.14	0.02006
cl4	600	PF 1	7.00	21.55	22.37		22.38	0.000434	0.71	9.84	12.05	0.14	0.01956
cl4	550	PF 1	8.00	21.52	22.34		22.35	0.000561	0.81	9.87	12.06	0.16	0.02533
cl4	500	PF 1	8.00	21.49	22.31		22.32	0.000556	0.81	9.90	12.05	0.16	0.02519
cl4	450	PF 1	8.00	21.46	22.29		22.30	0.000551	0.81	9.92	12.06	0.16	0.02503
cl4	400	PF 1	8.00	21.43	22.26		22.27	0.000545	0.80	9.96	12.05	0.16	0.02483
cl4	351.51	PF 1	8.00	21.40	22.24	21.62	22.24	0.000398	0.70	11.48	13.77	0.13	0.01856
cl4	351.50		Inl Struct										
cl4	350	PF 1	8.00	21.40	22.10		22.11	0.000684	0.82	9.71	13.84	0.17	0.02728
cl4	300	PF 1	8.00	21.37	22.07		22.08	0.000674	0.82	9.81	14.05	0.17	0.02678
cl4	250	PF 1	8.00	21.34	22.04		22.05	0.000686	0.82	9.75	14.05	0.17	0.02713
cl4	200	PF 1	9.00	21.31	21.99		22.01	0.000924	0.94	9.57	14.04	0.20	0.03590
cl4	150	PF 1	9.00	21.28	21.94		21.96	0.001011	0.97	9.30	14.04	0.21	0.03831
cl4	100	PF 1	9.00	21.25	21.89		21.90	0.001145	1.01	8.95	14.05	0.22	0.04188
cl4	50	PF 1	9.00	21.22	21.84	21.45	21.85	0.000921	0.89	15.13	35.11	0.20	0.03281

HEC-RAS Plan: Chum_Final_5000c River: PR BACKWATER Reach: cl4 Profile: PF 1

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Shear Chan
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(lb/sq ft)
cl4	1350	PF 1	5.00	22.00	22.74	22.20	22.75	0.000444	0.67	7.45	10.02	0.14	0.01800
cl4	1300	PF 1	5.00	21.97	22.72		22.73	0.000429	0.66	7.54	10.02	0.13	0.01754
cl4	1250	PF 1	5.00	21.94	22.70		22.71	0.000412	0.66	7.63	10.02	0.13	0.01705
cl4	1200	PF 1	5.00	21.91	22.68		22.69	0.000395	0.65	7.73	10.02	0.13	0.01654
cl4	1150	PF 1	5.00	21.88	22.66		22.67	0.000379	0.64	7.84	10.02	0.13	0.01603
cl4	1100	PF 1	6.00	21.85	22.64		22.65	0.000537	0.76	7.88	10.01	0.15	0.02281
cl4	1050	PF 1	6.00	21.82	22.61		22.62	0.000530	0.76	7.92	10.01	0.15	0.02259
cl4	1029.18	PF 1	6.00	21.81	22.60	22.03	22.61	0.000527	0.76	7.93	10.04	0.15	0.02248
cl4	1029.17		Inl Struct										
cl4	1000	PF 1	6.00	21.79	22.56		22.57	0.000461	0.70	8.54	11.09	0.14	0.01950
cl4	950	PF 1	6.00	21.76	22.54		22.55	0.000370	0.64	9.39	12.05	0.13	0.01600
cl4	900	PF 1	6.00	21.73	22.52		22.53	0.000352	0.63	9.54	12.05	0.12	0.01543
cl4	850	PF 1	6.00	21.70	22.51		22.51	0.000334	0.62	9.69	12.05	0.12	0.01486
cl4	800	PF 1	7.00	21.67	22.48		22.49	0.000440	0.71	9.80	12.05	0.14	0.01974
cl4	750	PF 1	7.00	21.64	22.46		22.47	0.000425	0.71	9.90	12.05	0.14	0.01926
cl4	700	PF 1	7.00	21.61	22.44		22.45	0.000410	0.70	10.02	12.05	0.14	0.01877
cl4	650	PF 1	7.00	21.58	22.42		22.43	0.000396	0.69	10.13	12.03	0.13	0.01829
cl4	600	PF 1	7.00	21.55	22.40		22.41	0.000379	0.68	10.27	12.05	0.13	0.01773
cl4	550	PF 1	8.00	21.52	22.38		22.39	0.000483	0.77	10.35	12.06	0.15	0.02274
cl4	500	PF 1	8.00	21.49	22.36		22.37	0.000472	0.77	10.42	12.06	0.15	0.02237
cl4	450	PF 1	8.00	21.46	22.33		22.34	0.000460	0.76	10.51	12.06	0.14	0.02197
cl4	400	PF 1	8.00	21.43	22.31		22.32	0.000448	0.75	10.60	12.06	0.14	0.02153
cl4	351.51	PF 1	8.00	21.40	22.29	21.62	22.30	0.000323	0.65	12.26	13.77	0.12	0.01594
cl4	351.50		Inl Struct										
cl4	350	PF 1	8.00	21.40	22.22		22.22	0.000424	0.71	11.28	13.84	0.14	0.01935
cl4	300	PF 1	8.00	21.37	22.20		22.20	0.000395	0.69	11.59	14.06	0.13	0.01825
cl4	250	PF 1	8.00	21.34	22.18		22.18	0.000379	0.68	11.74	14.06	0.13	0.01771
cl4	200	PF 1	9.00	21.31	22.15		22.16	0.000467	0.76	11.84	14.06	0.15	0.02199
cl4	150	PF 1	9.00	21.28	22.13		22.14	0.000454	0.75	11.94	14.06	0.14	0.02157
cl4	100	PF 1	9.00	21.25	22.11		22.12	0.000440	0.75	12.06	14.06	0.14	0.02108
cl4	50	PF 1	9.00	21.22	22.10	21.45	22.10	0.000260	0.58	24.12	35.25	0.11	0.01267

HEC-RAS Plan: Chum_Final_5500c River: PR BACKWATER Reach: cl4 Profile: PF 1

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Shear Chan
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(lb/sq ft)
cl4	1350	PF 1	5.00	22.00	22.76	22.20	22.77	0.000414	0.66	7.63	10.02	0.13	0.01709
cl4	1300	PF 1	5.00	21.97	22.74		22.75	0.000397	0.65	7.72	10.02	0.13	0.01660
cl4	1250	PF 1	5.00	21.94	22.72		22.73	0.000380	0.64	7.83	10.02	0.13	0.01608
cl4	1200	PF 1	5.00	21.91	22.70		22.71	0.000363	0.63	7.95	10.02	0.12	0.01553
cl4	1150	PF 1	5.00	21.88	22.69		22.69	0.000345	0.62	8.07	10.02	0.12	0.01499
cl4	1100	PF 1	6.00	21.85	22.66		22.67	0.000485	0.74	8.14	10.01	0.14	0.02121
cl4	1050	PF 1	6.00	21.82	22.64		22.65	0.000474	0.73	8.20	10.01	0.14	0.02085
cl4	1029.18	PF 1	6.00	21.81	22.63	22.03	22.64	0.000469	0.73	8.23	10.04	0.14	0.02068
cl4	1029.17		Inl Struct										
cl4	1000	PF 1	6.00	21.79	22.59		22.60	0.000406	0.67	8.89	11.10	0.13	0.01776
cl4	950	PF 1	6.00	21.76	22.58		22.58	0.000323	0.61	9.80	12.05	0.12	0.01448
cl4	900	PF 1	6.00	21.73	22.56		22.57	0.000305	0.60	9.98	12.05	0.12	0.01390
cl4	850	PF 1	6.00	21.70	22.55		22.55	0.000287	0.59	10.17	12.06	0.11	0.01333
cl4	800	PF 1	7.00	21.67	22.53		22.53	0.000375	0.68	10.31	12.06	0.13	0.01758
cl4	750	PF 1	7.00	21.64	22.51		22.52	0.000359	0.67	10.45	12.06	0.13	0.01703
cl4	700	PF 1	7.00	21.61	22.49		22.50	0.000343	0.66	10.60	12.06	0.12	0.01648
cl4	650	PF 1	7.00	21.58	22.47		22.48	0.000328	0.65	10.75	12.04	0.12	0.01594
cl4	600	PF 1	7.00	21.55	22.46		22.47	0.000311	0.64	10.93	12.06	0.12	0.01535
cl4	550	PF 1	8.00	21.52	22.44		22.45	0.000391	0.72	11.07	12.06	0.13	0.01950
cl4	500	PF 1	8.00	21.49	22.42		22.43	0.000377	0.71	11.20	12.06	0.13	0.01899
cl4	450	PF 1	8.00	21.46	22.40		22.41	0.000362	0.71	11.34	12.06	0.13	0.01845
cl4	400	PF 1	8.00	21.43	22.38		22.39	0.000347	0.70	11.49	12.06	0.13	0.01790
cl4	351.51	PF 1	8.00	21.40	22.37	21.62	22.38	0.000247	0.60	13.33	13.77	0.11	0.01315
cl4	351.50		Inl Struct										
cl4	350	PF 1	8.00	21.40	22.33		22.33	0.000284	0.63	12.79	13.85	0.11	0.01450
cl4	300	PF 1	8.00	21.37	22.31		22.32	0.000260	0.61	13.22	14.07	0.11	0.01349
cl4	250	PF 1	8.00	21.34	22.30		22.31	0.000245	0.59	13.47	14.06	0.11	0.01293
cl4	200	PF 1	9.00	21.31	22.28		22.29	0.000295	0.66	13.68	14.06	0.12	0.01579
cl4	150	PF 1	9.00	21.28	22.27		22.28	0.000280	0.65	13.90	14.06	0.11	0.01522
cl4	100	PF 1	9.00	21.25	22.26		22.26	0.000265	0.64	14.14	14.07	0.11	0.01463
cl4	50	PF 1	9.00	21.22	22.25	21.45	22.25	0.000146	0.48	29.57	35.33	0.08	0.00821

HEC-RAS Plan: Chum_Final_6000c River: PR BACKWATER Reach: cl4 Profile: PF 1

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Shear Chan
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(lb/sq ft)
cl4	1350	PF 1	5.00	22.00	22.79	22.20	22.80	0.000367	0.63	7.92	10.02	0.13	0.01566
cl4	1300	PF 1	5.00	21.97	22.77		22.78	0.000350	0.62	8.04	10.02	0.12	0.01512
cl4	1250	PF 1	5.00	21.94	22.76		22.76	0.000332	0.61	8.18	10.02	0.12	0.01457
cl4	1200	PF 1	5.00	21.91	22.74		22.75	0.000314	0.60	8.32	10.02	0.12	0.01400
cl4	1150	PF 1	5.00	21.88	22.73		22.73	0.000297	0.59	8.47	10.02	0.11	0.01345
cl4	1100	PF 1	6.00	21.85	22.71		22.71	0.000414	0.70	8.56	10.01	0.13	0.01888
cl4	1050	PF 1	6.00	21.82	22.69		22.69	0.000399	0.69	8.66	10.01	0.13	0.01841
cl4	1029.18	PF 1	6.00	21.81	22.68	22.03	22.68	0.000393	0.69	8.71	10.04	0.13	0.01818
cl4	1029.17		Inl Struct										
cl4	1000	PF 1	6.00	21.79	22.65		22.66	0.000321	0.63	9.57	11.10	0.12	0.01500
cl4	950	PF 1	6.00	21.76	22.64		22.65	0.000253	0.57	10.59	12.06	0.11	0.01214
cl4	900	PF 1	6.00	21.73	22.63		22.63	0.000237	0.56	10.80	12.06	0.10	0.01159
cl4	850	PF 1	6.00	21.70	22.62		22.62	0.000222	0.54	11.03	12.06	0.10	0.01105
cl4	800	PF 1	7.00	21.67	22.60		22.61	0.000286	0.62	11.22	12.06	0.11	0.01447
cl4	750	PF 1	7.00	21.64	22.59		22.59	0.000271	0.61	11.42	12.06	0.11	0.01390
cl4	700	PF 1	7.00	21.61	22.58		22.58	0.000256	0.60	11.62	12.06	0.11	0.01335
cl4	650	PF 1	7.00	21.58	22.56		22.57	0.000243	0.59	11.82	12.04	0.11	0.01283
cl4	600	PF 1	7.00	21.55	22.55		22.56	0.000228	0.58	12.06	12.06	0.10	0.01228
cl4	550	PF 1	8.00	21.52	22.54		22.54	0.000284	0.65	12.25	12.07	0.11	0.01545
cl4	500	PF 1	8.00	21.49	22.52		22.53	0.000270	0.64	12.45	12.07	0.11	0.01491
cl4	450	PF 1	8.00	21.46	22.51		22.52	0.000257	0.63	12.65	12.07	0.11	0.01436
cl4	400	PF 1	8.00	21.43	22.50		22.50	0.000243	0.62	12.86	12.07	0.11	0.01382
cl4	351.51	PF 1	8.00	21.40	22.49	21.62	22.49	0.000172	0.53	14.96	13.78	0.09	0.01011
cl4	351.50		Inl Struct										
cl4	350	PF 1	8.00	21.40	22.46		22.47	0.000184	0.55	14.66	13.86	0.09	0.01060
cl4	300	PF 1	8.00	21.37	22.45		22.46	0.000167	0.53	15.19	14.08	0.09	0.00981
cl4	250	PF 1	8.00	21.34	22.44		22.45	0.000157	0.52	15.50	14.07	0.09	0.00937
cl4	200	PF 1	9.00	21.31	22.43		22.44	0.000188	0.57	15.78	14.07	0.09	0.01137
cl4	150	PF 1	9.00	21.28	22.43		22.43	0.000177	0.56	16.08	14.08	0.09	0.01090
cl4	100	PF 1	9.00	21.25	22.42		22.42	0.000167	0.55	16.39	14.08	0.09	0.01043
cl4	50	PF 1	9.00	21.22	22.41	21.45	22.42	0.000087	0.40	35.34	35.42	0.07	0.00558

HEC-RAS Plan: Chum_Final_7000c River: PR BACKWATER Reach: cl4 Profile: PF 1

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Shear Chan
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(lb/sq ft)
cl4	1350	PF 1	5.00	22.00	22.94	22.20	22.95	0.000210	0.53	9.46	10.02	0.10	0.01045
cl4	1300	PF 1	5.00	21.97	22.93		22.94	0.000197	0.52	9.66	10.03	0.09	0.00996
cl4	1250	PF 1	5.00	21.94	22.93		22.93	0.000184	0.51	9.87	10.03	0.09	0.00949
cl4	1200	PF 1	5.00	21.91	22.92		22.92	0.000173	0.50	10.08	10.02	0.09	0.00904
cl4	1150	PF 1	5.00	21.88	22.91		22.91	0.000161	0.49	10.30	10.03	0.08	0.00861
cl4	1100	PF 1	6.00	21.85	22.90		22.90	0.000220	0.57	10.48	10.01	0.10	0.01191
cl4	1050	PF 1	6.00	21.82	22.89		22.89	0.000208	0.56	10.67	10.01	0.10	0.01143
cl4	1029.18	PF 1	6.00	21.81	22.88	22.03	22.89	0.000203	0.56	10.77	10.04	0.09	0.01120
cl4	1029.17		Inl Struct										
cl4	1000	PF 1	6.00	21.79	22.86		22.86	0.000164	0.51	11.86	11.11	0.09	0.00920
cl4	950	PF 1	6.00	21.76	22.85		22.86	0.000128	0.46	13.15	12.07	0.08	0.00739
cl4	900	PF 1	6.00	21.73	22.85		22.85	0.000119	0.45	13.44	12.07	0.07	0.00703
cl4	850	PF 1	6.00	21.70	22.84		22.84	0.000112	0.44	13.74	12.08	0.07	0.00670
cl4	800	PF 1	7.00	21.67	22.83		22.84	0.000143	0.50	14.01	12.08	0.08	0.00871
cl4	750	PF 1	7.00	21.64	22.83		22.83	0.000134	0.49	14.29	12.08	0.08	0.00833
cl4	700	PF 1	7.00	21.61	22.82		22.82	0.000126	0.48	14.57	12.08	0.08	0.00797
cl4	650	PF 1	7.00	21.58	22.81		22.82	0.000119	0.47	14.84	12.05	0.07	0.00764
cl4	600	PF 1	7.00	21.55	22.81		22.81	0.000112	0.46	15.15	12.08	0.07	0.00729
cl4	550	PF 1	8.00	21.52	22.80		22.81	0.000138	0.52	15.44	12.09	0.08	0.00912
cl4	500	PF 1	8.00	21.49	22.79		22.80	0.000130	0.51	15.71	12.09	0.08	0.00876
cl4	450	PF 1	8.00	21.46	22.79		22.79	0.000123	0.50	16.00	12.09	0.08	0.00841
cl4	400	PF 1	8.00	21.43	22.78		22.79	0.000117	0.49	16.29	12.09	0.07	0.00807
cl4	351.51	PF 1	8.00	21.40	22.78	21.62	22.78	0.000082	0.42	18.94	13.80	0.06	0.00590
cl4	351.50		Inl Struct										
cl4	350	PF 1	8.00	21.40	22.75		22.76	0.000086	0.43	18.71	13.88	0.06	0.00607
cl4	300	PF 1	8.00	21.37	22.75		22.75	0.000078	0.41	19.36	14.09	0.06	0.00563
cl4	250	PF 1	8.00	21.34	22.74		22.75	0.000074	0.41	19.73	14.09	0.06	0.00540
cl4	200	PF 1	9.00	21.31	22.74		22.74	0.000088	0.45	20.09	14.10	0.07	0.00656
cl4	150	PF 1	9.00	21.28	22.74		22.74	0.000083	0.44	21.93	28.25	0.06	0.00624
cl4	100	PF 1	9.00	21.25	22.73		22.73	0.000078	0.43	23.12	43.76	0.06	0.00597
cl4	50	PF 1	9.00	21.22	22.73	21.45	22.73	0.000039	0.31	46.61	35.64	0.04	0.00304

HEC-RAS Plan: Chum_Final_10000 River: PR BACKWATER Reach: cl4 Profile: PF 1

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Shear Chan
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(lb/sq ft)
cl4	1350	PF 1	5.00	22.00	23.72	22.20	23.72	0.000032	0.29	17.34	10.92	0.04	0.00265
cl4	1300	PF 1	5.00	21.97	23.72		23.72	0.000030	0.29	17.65	11.04	0.04	0.00255
cl4	1250	PF 1	5.00	21.94	23.72		23.72	0.000029	0.28	17.97	11.15	0.04	0.00245
cl4	1200	PF 1	5.00	21.91	23.72		23.72	0.000027	0.28	18.29	11.26	0.04	0.00236
cl4	1150	PF 1	5.00	21.88	23.71		23.72	0.000026	0.27	18.61	11.37	0.04	0.00228
cl4	1100	PF 1	6.00	21.85	23.71		23.71	0.000038	0.32	18.65	10.02	0.04	0.00324
cl4	1050	PF 1	6.00	21.82	23.71		23.71	0.000037	0.32	18.92	10.02	0.04	0.00313
cl4	1029.18	PF 1	6.00	21.81	23.71	22.03	23.71	0.000033	0.31	19.42	11.66	0.04	0.00301
cl4	1029.17		Inl Struct										
cl4	1000	PF 1	6.00	21.79	23.70		23.70	0.000025	0.28	21.61	12.89	0.04	0.00240
cl4	950	PF 1	6.00	21.76	23.70		23.70	0.000020	0.26	23.81	13.86	0.03	0.00195
cl4	900	PF 1	6.00	21.73	23.70		23.70	0.000019	0.25	24.21	13.98	0.03	0.00189
cl4	850	PF 1	6.00	21.70	23.70		23.70	0.000018	0.25	24.62	14.10	0.03	0.00182
cl4	800	PF 1	7.00	21.67	23.70		23.70	0.000022	0.28	29.65	21.96	0.03	0.00225
cl4	750	PF 1	7.00	21.64	23.70		23.70	0.000022	0.28	25.44	14.33	0.03	0.00232
cl4	700	PF 1	7.00	21.61	23.70		23.70	0.000021	0.28	25.85	14.43	0.03	0.00224
cl4	650	PF 1	7.00	21.58	23.70		23.70	0.000021	0.27	26.21	14.51	0.03	0.00218
cl4	600	PF 1	7.00	21.55	23.69		23.70	0.000020	0.27	26.69	14.67	0.03	0.00210
cl4	550	PF 1	8.00	21.52	23.69		23.69	0.000024	0.30	27.13	14.79	0.04	0.00266
cl4	500	PF 1	8.00	21.49	23.69		23.69	0.000023	0.30	28.13	25.32	0.04	0.00257
cl4	450	PF 1	8.00	21.46	23.69		23.69	0.000022	0.30	28.23	22.23	0.03	0.00249
cl4	400	PF 1	8.00	21.43	23.69		23.69	0.000021	0.29	28.42	15.14	0.03	0.00242
cl4	351.51	PF 1	8.00	21.40	23.69	21.62	23.69	0.000015	0.25	32.91	17.37	0.03	0.00179
cl4	351.50		Inl Struct										
cl4	350	PF 1	8.00	21.40	23.68		23.68	0.000015	0.25	33.04	17.49	0.03	0.00177
cl4	300	PF 1	8.00	21.37	23.68		23.68	0.000014	0.24	33.84	17.29	0.03	0.00167
cl4	250	PF 1	8.00	21.34	23.68		23.68	0.000018	0.21	39.68	35.49	0.03	0.00138
cl4	200	PF 1	9.00	21.31	23.68		23.68	0.000016	0.20	46.77	45.47	0.03	0.00127
cl4	150	PF 1	9.00	21.28	23.68		23.68	0.000012	0.17	71.86	61.12	0.03	0.00095
cl4	100	PF 1	9.00	21.25	23.68		23.68	0.000011	0.19	69.10	50.85	0.03	0.00113
cl4	50	PF 1	9.00	21.22	23.68	21.45	23.68	0.000008	0.17	82.47	39.90	0.02	0.00083

ATTACHMENT 2

Engineer's Cost Opinion

Engineer's Cost Opinion for Eagle Island Chum Channel

No.	Description	Unit	Quantity	Unit Cost	Total Cost	Design and Quantity Assumptions
1	Mobilization and demobilization	LS	1	$ 33,000	$ 33,000	Calculated at 5% of construction sub-total. Rounded to the nearest $1,000.
2	Site access measures	LS	1	$ 5,000	$ 5,000	Includes access road improvements, traffic control, and site restoration.
3	Environmental protection measures	LS	1	$ 68,000	$ 68,000	Includes dewatering, sheetpile coffer dam, coordinate with fish relocation, and erosion control BMPs
4	Clearing and grubbing	AC	2.0	$ 8,000	$ 16,000	Includes clearing and grubbing of channel area and staging areas
5	Excavation to subgrade	LS	1	$ 101,788	$ 101,788	Excavation to subgrade. Includes haul to fill area and grading. Measurement by pre and post survey of fill area. Final design criteria and analysis will likely alter these estimates up or down. Assumes disposal to be on-site using off-road trucks.
6	Log toe construction	LS	1	$ 233,200	$ 233,200	Furnish logs in sufficient quantity to construct the length and height of channel shown in the plan. Furnish 2 piles per segment/group of stacked toe logs. Includes on-site movement and cutting to adjust length. Includes furnishing threaded rod, washers, bolts, drilling equipment for log-log connections in log toe construction. Includes pilings placement and fastening of toe logs.
7	Native backfill	CY	1,581	$ 8	$ 12,648	Includes excavation from fill area, haul.
8	Spawning gravel mix & placement	CY	1,205	$ 60	$ 72,300	Furnish specified spawning gravel (as specified in Final Design Plans). Includes hauling and installing spawning gravel mix from stockpile area.
9	Sheetpile control weirs	EA	3	$ 6,000	$ 18,000	Includes materials and labor for 2 sheetpile weirs as shown in Final Design Plans.
10	Flow supplementation	LS	1	$ 41,552	$ 41,552	Includes materials and labor for construction of flow supplementation system, including pipe trench and backfill with native material, light loose riprap, drain rock, pipe and fittings, well screen and fittings, canal gate, trash rack.
11	Riverbank log structure	LS	1	$ 40,196	$ 40,196	Furnish, deliver and install logs with root wads attached and cut logs. Includes excavation, stockpile, hauling, installing and fastening logs, and backfilling log structure. Excess material to be hauled to fill area. Includes cable and hardware for log to log connections.
12	Floodplain wood	LS	1	$ 39,000	$ 39,000	Furnish, deliver, and install. Includes cable and hardware for log to log connections.
13	Revegetation	AC	2	$ 10,000	$ 20,000	Includes materials and labor for planting riparian areas and staging areas (based on revegetation plan in Final Design Plans).
	Construction Total				**$700,684**	

Key LS = Lump Sum CY = Cubic Yard LF = Lineal Foot AC = Acre EA = Each

General Notes:
-Costs assume all materials (wood and rock) are purchased and hauled to the site from a nearby source

ATTACHMENT 3

Specifications

TABLE OF CONTENTS

DIVISION 1 – AMENDMENTS AND SPECIAL CONDITIONS

DIVISION 1 - INTRODUCTION

The following Amendments and Special Provisions shall be used in conjunction with the *Washington State Department of Transportation's Standard Specifications for Road, Bridge and Municipal Construction 2012* (WSDOT Standard Specifications). Additional specifications in the following contract sections are included for items not covered by the WSDOT Standard Specifications.

DIVISION 2 – EARTHWORK

SECTION 2-05 EXCAVATION TO SUBGRADE
This section is added.

2-05.1 Description
The work includes excavating earthen material from the new channel vertical and horizontal alignment to achieve subgrade to the lines and grades shown on the project plans; hauling the excavated material to a designated on-site fill area, and grading the fill site.

2-05.2 Materials
The Contractor shall provide all required materials for the project.

2-05.3 Construction Requirements

2-05.3(1) Site Excavation

1. General Excavation Requirements

The Contractor shall excavate to the lines, grades, slopes, and elevations shown on the Contract Drawings.

Excavation on slopes shall proceed downward, working from top of slope to toe of slope. As the work progresses, it is anticipated that some slope material will slough into the cut area. The Contractor shall remove this material and will make a final pass to clear up the slope with the excavator bucket along the sections' edges when the excavation is completed.

In performing the excavation the Contractor shall pay particular attention to the conditions of issued permits and authorizations requiring the minimization of turbidity and siltation and adherence to water quality requirements.

2. Schedule Constraints and Avoidance of In-Water Work

All work shall be scheduled per the Hydraulic Project Approval issued by WDFW.

3. Management of Excavated Surfaces

The Contractor shall be aware of the potential for erosion, and potential water quality problems. The Contractor shall control the potential for erosion of materials from freshly exposed excavated surfaces and stockpiled materials.

In planning for rain events, the Contractor shall be prepared to install plastic, straw bales or other Best Management Practices (BMPs) with Project Manager approval. It is the Contractor's responsibility to install BMPs as necessary to prevent siltation.

In case an excavated area fills with water during excavation operations, Contractor shall pump the water out and discharge it to an infiltration area, subject to water quality requirements and monitoring.

2-05.3(2) Fill Disposal

An on-site fill area is designated in the Plans. Excavated material shall be hauled to the fill area and graded. Edges of the fill area shall be graded to smoothly transition to adjacent ground surfaces.

2-05.4 Measurement

Measurement will be based on the item from the bid list installed and the work for that portion completed.

2-05.5 Payment

Payment will be made in accordance with Section 1-04.1 for each of the following bid item:

“Excavation to Subgrade” per lump sum

The unit contract prices for Excavation to Subgrade shall be full compensation for all costs incurred for excavating, loading, spoiling and placing, or otherwise disposing of the material.

The unit contract prices for all other items shall be full compensation for all costs incurred for material and labor for installation, placing, and disposing of the excess material.

DIVISION 8 – MISCELLANEOUS CONSTRUCTION

SECTION 8-26 SITE ACCESS MEASURES
This section is added.

8-26.1 Description
The work consists of construction, maintenance, and removal of access road improvements, and temporary traffic control.

8-26.2 Materials
The Contractor shall provide all required materials for the project except as directed by the Project Manager. Materials are described in the project plans.

8-26.3 Construction Requirements

8-26.3(1) Site Access Measures

Temporary traffic control requirements shall include barricades and construction signage at the entrance to the project site and any other measures required by State or local regulations.

8-26.4 Measurement
Measurement will be based on the item from the bid list installed and the work for that portion completed.

"Site Access Measures," will be measured by lump sum.

8-26.5 Payment
Payment will be made in accordance with Section 1-04.1 for the following

bid items: "Site Access Measures" per lump sum

The unit contract prices for "Site Access Measures" shall be full compensation for all costs incurred for equipment, materials and labor for furnishing, installing, securing, maintaining, and removal of access road, temporary traffic control, and general site restoration.

SECTION 8-27 ENVIRONMENTAL PROTECTION MEASURES
This section is added.

8-27.1 Description
The work consists of dewatering, sheetpile cofferdam, coordinating with the Owner for fish salvage relocation activities, and erosion control Best Management Practices (BMPs).

8-27.2 Materials
The Contractor shall provide all required materials for the project except as

directed by the Project Manager. Materials are described in the project plans.

8-27.3 Construction Requirements

8-27.3(1) Environmental Protection Measures

This work consists of furnishing and installing any and all equipment, materials, and labor required for dewatering, installation of sheetpile cofferdams, and erosion control BMPs.

It is anticipated that water will need to be pumped from the excavation area. Water that comes in contact with construction activity should be pumped away from the site and infiltrated into the ground without entering the waterway. If infiltration becomes an ineffective means to control turbidity, additional and alternative methods, such as pumping into a filter bag, shall be employed.

8-27.3(2) Cofferdam
The contractor shall isolate the work area from the waterway by installing cofferdams per the plans. No turbidity from construction activities shall enter the waterway.

8-27.3(3) Pumps
To help prevent turbidity from leaking through the cofferdam, the contractor shall provide and operate pumps to lower the water surface within each isolated area and discharge to an infiltration area. Pumping capacity exceeding 600 gpm shall be required.

8-27.3(4) Coordination with Fish Rescue
The Contractor shall provide minimum 5 days advance notice to the Owner before each cofferdam installation date. The Contractor shall understand that cofferdam installation requires coordination with the Owner and only after the Owner has completed fish rescue can the cofferdams be completed.

8-27.4 Measurement
Measurement will be based on the item from the bid list installed and the work for that portion completed.

“Environmental Protection Measures” will be measured by lump sum.

8-27.5 Payment
Payment will be made in accordance with Section 1-04.1 for the following

bid items: “Environmental Protection Measures” per lump sum

The unit contract prices for “Environmental Protection Measures” shall be full compensation for all costs incurred for equipment, materials and labor for furnishing, installing, securing, maintaining and removal of environmental protection measures as outlined in the plan.

SECTION 8-30 LOG TOE CONSTRUCTION

This section is added.

8-30.1 Description

The work consists of furnishing logs and installing them parallel along the channel to form log walls to create channel banks that armor the toe and sides of the spawning channel as shown on the project plans.

8-30.2 Materials

The Contractor shall provide all required materials for the project except as directed by the Project Manager. Materials are described in the project plans.

8-30.3 Construction Requirements

8-30.3(1) Log Toe Construction

This work consists of furnishing and installing horizontal logs to construct the length and height of stacked-log-channel-bank as shown in the plans. The work also consists of furnishing and installing two vertical timber piles per segment of log toe to secure the horizontal logs as shown on the project plans. Each segment of stacked logs shall be drilled and threaded rods driven in, secured with washers and bolts to secure the horizontal logs to two vertical timber piles.

This work includes installing timber piles.

The work shall occur within the confines of the planned limits of disturbance. To achieve the required depth for installed timber piles, a vibratory pile driver capable of installing timber piles is recommended.

8-30.4 Measurement

Measurement will be based on the item from the bid list installed and the work for that portion completed.

“Log Toe Construction,” will be measured by lump sum.

8-30.5 Payment

Payment will be made in accordance with Section 1-04.1 for the following

bid items: “Log Toe Construction” per lump sum

The unit contract prices for “Log Toe Construction,” shall be full compensation for all costs incurred for equipment, materials, and labor for excavating, building, installing and backfilling. Wood fastening hardware including furnishing and installing threaded rod, washers, bolts, drilling equipment for log to log connections shall be considered incidental to “Log Toe Construction”.

SECTION 8-31 NATIVE BACKFILL
This section is added.

8-31.1 Description
The work consists of hauling approved material from the stockpile site shown on the project plans to the proposed channel to backfill behind (landward of) the log toe sidewalls.

8-31.2 Materials
The Contractor shall utilize coarse material sorted from material excavated from the proposed channel area for the project except as directed by the Project Manager.

8-31.3 Construction Requirements

8-31.3(1) Native Backfill

This works consists of hauling and placing native backfill material from the material removed from the proposed channel location as shown in the plans. The Native Backfill shall be placed per Method A, as defined in 2-03.3(14)C.

8-31.4 Measurement
Measurement will be based on the item from the bid list installed and the work for that portion completed.

“Native Backfill” will be measured by cubic yards.

8-31.5 Payment
Payment will be made in accordance with Section 1-04.1 for the following

bid items: “Native Backfill” per cubic yards

The unit contract prices for “Native Backfill,” shall be full compensation for all costs incurred for equipment and labor for excavating, installing and compacting material.

SECTION 8-32 SPAWNING GRAVEL

This section is added.

8-32.1 Description
The work consists of furnishing and installing Spawning Gravel to form the new channel within the confines of the Toe Logs and to the lines and grades shown on the project plans.

8-32.2 Materials
The Contractor shall provide all required materials for the project except as directed by the Project Manager. Spawning Gravel mix shall meet the requirements of the gradation defined within the plan set.

8-32.3 Construction Requirements

8-32.3(1) Spawning Gravel

The work consists of placing Spawning Gravel to form the new channel within the confines of the Toe Logs and to the lines and grades shown on the project plans.

8-32.4 Measurement
Measurement will be based on the item from the bid list installed and the work for that portion completed.

"Spawning Gravel" will be measured by cubic yards.

8-32.5 Payment
Payment will be made in accordance with Section 1-04.1 for the following

bid items: "Spawning Gravel" per cubic yards

The unit contract prices for "Spawning Gravel," shall be full compensation for all costs incurred for equipment and labor for excavating, installing and compacting material.

SECTION 8-33 CONTROL WEIRS
This section is added.

8-33.1 Description
The work consists of installing control weirs as shown on the project plans. A single installation consists of installing of sheet pile, attaching brackets to sheet pile to facilitate installation of fish screen or flashboards during channel maintenance and operations by the Owner.

8-33.2 Materials
The Contractor shall provide all required materials for the project except as directed by the Project Manager. Materials are described in the project plans.

8-33.3 Construction Requirements

8-33.3(1) Control Weirs

This works consists of installing sheet pile, constructing a fish screen slot, and attaching brackets for fish screens or flashboards. Riprap shall be placed as shown in plan.

Contractor shall submit shop drawings signed and stamped by a Professional Structural Engineer for the sheet pile and pile cap design as well as submit supporting computations for approval.

8-33.4 Measurement
Measurement will be based on the item from the bid list installed and the work for that portion completed.

"Control Weir" will be measured by the number installed.

8-33.5 Payment
Payment will be made in accordance with Section 1-04.1 for the following

bid items: "Control Weir" per each

The unit contract prices for "Control Weirs," shall be full compensation for all costs incurred for design, equipment, materials, labor, excavating, construction, installation, and riprap.

SECTION 8-34 FLOW SUPPLEMENTATION
This section is added.

8-34.1 Description
The work consists of constructing a water intake structure to supply water to the proposed chum spawning channel.

8-34.2 Materials
The Contractor shall provide all required materials for the project except as directed by the Project Manager. Materials include: riprap, drain rock, wells screen pipe and fittings, conveyance pipe and fittings, canal gate, and trash rack Materials are described in the project plans.

8-34.3 Construction Requirements

8-34.3(1) Flow Supplementation

This work consists of furnishing and installing any and all equipment, materials, and labor required for construction of flow supplementation system including: excavating and backfilling pipe trench; riprap, drain rock, wells screen pipe and fittings, conveyance pipe and fittings, canal gate, and trash rack.

8-34.4 Measurement
Measurement will be based on the item from the bid list installed and the work for that portion completed.

“Flow Supplementation” will be measured by lump sum.

8-34.5 Payment
Payment will be made in accordance with Section 1-04.1 for the following

bid items: “Flow Supplementation” per lump sum

The unit contract prices for “Flow Supplementation” shall be full compensation for all costs incurred for equipment, materials and labor for constructing the system per the plan.

SECTION 8-35 RIVERBANK LOG STRUCTURE This section is added.

8-35.1 Description
The work consists of installing wood within and along the edge of the riverbank as shown on the project plans and as directed by Project Manager.

8-35.2 Materials
The Contractor shall provide all required materials for the project except as directed by the Project Manager. Materials are described in the project plans.

8-35.3 Construction Requirements

8-35.3(1) Riverbank Log Structure

This works consists of furnishing and installing riverbank log structure as indicated in the plans. The task includes excavation, stockpile, hauling, installing, and fastening logs, backfilling log structures, and hauling excess fill material to fill areas as indicated on plans.

This work includes installing timber piles.

The work shall occur within the confines of the planned limits of disturbance. To achieve the required depth for installed timber piles, a vibratory pile driver capable of installing timber piles is recommended.

8-35.4 Measurement
Measurement will be based on the item from the bid list installed and the work for that portion completed.

“Riverbank Log Structure” will be measured by lump sum.

8-35.5 Payment
Payment will be made in accordance with Section 1-04.1 for the following

bid items: “Riverbank Log Structure” lump sum.

The unit contract prices for “Riverbank log Structure” shall be full compensation for all costs incurred for equipment, materials and labor for furnishing, securing, and installing wood. Wood fastening hardware including furnishing and installing threaded rod, washers, bolts, drilling equipment for log to log connections shall be considered incidental to “Riverbank log Structure” construction.

SECTION 8-36 FLOODPLAIN WOOD
This section is added.

8-36.1 Description
The work consists of installing wood within the floodplain to increase surface roughness as shown on the project plans and as directed by Project Engineer.

8-36.2 Materials
The Contractor shall provide all required materials for the project except as directed by the Project Manager. Quantities and descriptions of materials are included in the project plans.

8-36.3 Construction Requirements

8-36.3(1) Floodplain wood

This works consists of furnishing and installing floodplain wood as indicated in the plans.

This work includes installing timber piles.

The work shall occur within the confines of the planned limits of disturbance. To achieve the required depth for installed timber piles, a vibratory pile driver capable of installing timber piles is recommended.

8-36.4 Measurement
Measurement will be based on the item from the bid list installed and the work for that portion completed.

"Floodplain Wood" will be measured by lump sum

8-36.5 Payment
Payment will be made in accordance with Section 1-04.1 for the following

bid items: "Floodplain Wood" lump sum.

The unit contract prices for "Floodplain Wood," shall be full compensation for all costs incurred for equipment, materials, and labor for furnishing, securing, and installing wood. Wood fastening hardware including cable and clamps for log to log connections shall be considered incidental to "Floodplain Wood" construction.

SECTION 8-37 REVEGETATION
Section 8-02 Roadside Restoration shall hereby be apply as the controlling specification for Revegation. Section 8-02 is hereby supplemented as follows:

8-37.1 Description
The work consists of furnishing and installing plantings for all disturbed areas per the plan.

8-37.2 Materials
The Contractor shall provide all required materials for the project except as directed by the Project Manager. Materials are described in the project plans.

8-37.4 Measurement
Measurement will be based on the item from the bid list installed and the work for that portion completed.

"Revegetation" will be measured by the acres installed.

8-37.5 Payment
Payment will be made in accordance with Section 1-04.1 for the following

bid items:

"Revegetation" per acre

The unit contract prices for "Revegetation," shall be full compensation for all costs incurred for equipment, materials, labor, excavating,

ATTACHMENT 4

Wetland Report

Preliminary Wetland Assessment
WDFW Chum Channels Project

November 9, 2012

Provided for:
Washington Department of Fish and Wildlife
2108 Grand Boulevard
Vancouver, WA 98661

Preliminary Wetland Assessment
WDFW Chum Channels Project

Provided for

Washington Department of Fish and Wildlife
2108 Grand Boulevard
Vancouver, WA 98661

Prepared by

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November 9, 2012

WDFW Chum Channels Project

Preliminary Wetland Assessment

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INTRODUCTION

The Washington Department of Fish and Wildlife (WDFW) is proposing to complete a salmon habitat enhancement project on the North Fork Lewis River in order to provide spawning and rearing habitat for Chum Salmon. The proposed Chum Channels Project will create valuable side channel habitat in flooplain areas that historically supported these types of features. These side channels will be created through excavation to suitable grades and the installation of strategically placed engineered log jams to ensure the longevity of the project.

Wetlands within the project area were initially identified by project staff during early surveying activities. In order to categorize and determine the approximate boundary of the on-site wetlands, a preliminary wetland assessment was completed. It was determined through the course of the assessment that the project area contains jurisdictional wetlands as defined and regulated by the U.S. Army Corps of Engineers, Washington Department of Ecology, and Clark County. The results of the assessment are detailed below.

METHODS

The wetland predetermination was completed using the methods for wetland identification defined in the wetland delineation was conducted according to the Routine Onsite method described in the 1987 Corps of Engineers Wetlands Delineation Manual (Department of the Army 1987), and the Corps of Engineers Western Mountains, Valleys, and Coast Regional Supplement (Department of the Army, 2008) hereafter, referred to as the manual. According to the manual, jurisdictional wetlands are defined as:

> *Those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas.*

The manual uses three parameters in making wetland determinations: hydrophytic vegetation, hydric soils and wetland hydrology.

Hydrophytic vegetation are plants that due to morphological, physiological, and/or reproductive adaptations, have the ability to grow, effectively compete, reproduce, and/or persist in anaerobic soil conditions. Hydric soils are soils that are saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions that favor the growth and regeneration of hydrophytic vegetation. Wetland hydrology is present when an area is inundated or saturated to the surface for at least 5 percent of the growing season. The growing season is defined as the portion of the year when soil temperature at 19.7 inches below the soil surface is greater than biological zero (5 degrees C). Except in certain situations defined in the manual, evidence of all the three parameters (hydrology, soil, and vegetation) must be found in order to make a positive wetland determination.

Following the background information review, an on-site investigation was completed on November 8, 2012. In order to determine if wetlands were present within the study area, transects were walked throughout the project area. General notes on vegetation and other important characteristics of the site were recorded and photographs from representative locations were taken. In areas where wetlands were suspected, observation points were selected to correspond with terrain features, vegetation, hydrology and any mapped hydric soils identified on the site. At each observation point, the vegetation, soils and hydrology were characterized and this information was then used as the basis for making wetland determinations.

To determine if hydrophytic vegetation was present, the vegetation on the site was compared to the National List of Plant Species that Occur in Wetlands: 1988 - Northwest (Region 9) (Reed 1988) to determine plant wetland indicator status. This list places plants into four categories:

Obligate wetland plants (OBL) -- plants likely to occur in wetlands greater than 99 percent of the time.

Facultative wetland plants (FACW) -- plants likely to occur in wetlands 67 to 99 percent of the time.

Facultative plants (FAC) -- plants equally likely to occur in wetland and non-wetland areas (34-66 percent of the time).

Facultative upland plants (FACU) -- plants that only occur in wetlands 1 to 33 percent of the time.

Hydrophytic vegetation is present when more than 50 percent of the dominant species have an indicator status of OBL, FACW, and/or FAC. The presence or absence of hydric soils was determined by digging soil pits to a depth of 18 inches and examining the soil for hydric soil indicators. Organic soils such as peats and mucks are considered hydric soils. Mineral hydric soils are generally either gleyed or have bright mottles and/or low matrix chroma immediately below the A-horizon or 10 inches (whichever is shallower). Soil colors are determined using the Munsell Soil Color Chart (Kollmorgen Instr. Corp. 1990).

BACKGROUND INFORMATION

The project site is located on a narrow forested floodplain adjacent to a small, river-right side channel of the North Fork Lewis River, at approximately RM 11.5. Prior to the completion of the site visit, existing information concerning the conditions of the site was reviewed. This review included current and historic aerial photographs; NRCS soil maps, national wetland inventory maps, and published topographic maps.

Soils

The Clark County soil Survey shows the entire project area mapped as Riverwash, cobbly (Rc). This soil is located on floodplains with slopes between 0 and 2 percent. The parent material consists of sandy alluvium, cobble, and gravels. This soil is listed as seasonally flooded and not ponded. Organic matter content in the upper soil layers is around 3% or less. This soil is not listed as hydric in the Clark County Soil Survey.

Mapped Wetlands

The National Wetland Inventory (NWI) maps have the following wetland units mapped within the project area:

- PFOA- Palustrine, Forested, Temporarily Flooded

The NWI map indicates that the entire western portion of the project area is mapped as forested wetlands. Although wetlands were identified within the project during the site visit, their actual extent is much less than that shown within the NWI map. It should be noted that NWI maps are produced from aerial photo and topographic map interpretation and are not meant to represent the extent of jurisdictional wetlands. This is especially the case in this instance where the project area is located adjacent to a large river and thereby subject to scouring and deposition patterns during high water events.

SITE VISIT RESULTS

A site visit was completed on November 8 in order to access the conditions of the project area and verify the presence or absence of jurisdictional wetlands within or directly adjacent to the project area. The project area consists of a relatively narrow floodplain bench vegetated with mixed native deciduous trees and shrubs (Figure 1). The topography of the site is best described as gently rolling and highly variable with many small depressions and historic drainage ways located throughout the project area. Through the course of the site visit, a single forested wetland was identified and its boundaries demarcated (Figure 1). The boundaries of the wetland were easily identifiable and corresponded with rapid changes in elevation and dominant vegetation type. Approximate wetland boundaries were recorded using a geoXT GPS receiver. The condition of the uplands and wetlands within the project area are detailed below.

Uplands

Vegetation throughout the majority of the project area is dominated by a canopy of medium-aged black cottonwood *(Populus trichocarpa)* trees and small groups of Oregon ash *(Fraxinus latifolia – FACW),* and big-leaf maple *Acer macrophyllum – FACU)* trees. Shrub layer vegetation is well developed and includes the following species: beaked hazlenut *(Corylus cornuta – FACU)*, salmonberry *(Rubus spectabilis – FAC),* osoberry *(Oemleria cerasiformis – FACU),* snowberry *(Symphoricarpos albus – FACU),* Pacific ninebark *(Physocarpos capitatus – FAC+),* Scotch broom *(Cytisus scoparius – UPL)*, trailing blackberry *(Rubus ursinus – UPL),* and cascara *(Rhamnus purshiana – FAC-*). Emergent vegetation is somewhat sparse and limited to swordfern *(Polystichtum munitum – FACU),* orchardgrass *(Dactylis glomerata - FACU),* perennial ryegrass (*Lolium perenne - FACU*), reed canarygrass (*Phalaris arundinacea - FACW*), and other mixed forbs. Soil samples within these upland areas revealed sandy silt loam 10YR 3/2 soils with no reductions or concretions. No primary indicators of wetland hydrology were observed.

Wetlands

The wetlands within the project area are located within a prominent depression that runs through the entire western portion of the project area (Figure 1). Figure 1 illustrates that three separate wetland polygons were mapped but these three wetland areas are so similar in terms of soil, vegetation, and hydrology that they will be described as one single wetland unit. The total area of wetlands on the site is roughly 1 acre. The palustrine forested wetlands on the site are likely supported by interactions with the seasonally high ground water table, surface runoff from adjacent slopes, and periodic flooding from the North Fork Lewis River. The entire wetland is forested in nature and has a canopy comprised of Oregon ash and black cottonwood trees. Understory vegetation is dominated by red-osier dogwood *(Cornus stolonifera – FACW),* Pacific ninebark, salmonberry, and Douglas spiraea *(Spiraea douglasii – FACW).* Emergent vegetation is mostly comprised of slough sedge *(Carex obnupta - OBL),* stinging nettle *(Urtica dioica – FAC+),* and a few small clumps of reed canarygrass. Photographs of various areas within the wetland are presented in Figure 2. Positive indicators of wetland soils included low chroma color soil matrices (10YR 2/2 and 10YR 3/1) and the presence of soil mottles. Positive indicators of wetland hydrology included soil saturation within the upper 12" of the soil and small areas of inundation.

The Washington Department of Ecology's (Ecology) Western Washington Wetland Rating System was used to qualitatively score wetland functions provided by the wetland and determine its regulatory classification. Based on the rating system, the on-site forested wetland received a score of 8 for water quality functions, 7 for hydrologic functions, and 19 for habitat functions yielding a total score 34 and a Category III rating. Although the wetland is relatively undisturbed and contains a diverse native vegetation community a score of 34 is on the lower end for a Category III wetland. This is likely due to the undisturbed nature of the surrounding area and low opportunity to provide water quality and hydrologic wetland functions.

SUMMARY

A preliminary wetland assessment was conducted on the WDFW Chum Channels project area to determine the presence or absence of jurisdictional wetlands as defined by the U.S. Army Corps of Engineers and other regulatory entities. Through the process of the assessment, a palustrine forested wetland was identified and its approximate boundaries determined. The boundaries of the wetland were easily identifiable in the field through rapid changes in elevation and vegetation. The wetland would be classified as a Category II wetland using Ecology's wetland rating system.

The wetlands on this site are subject to protection under section 404 and 401 of the Federal Clean Water Act in addition to regulation on a local level by Clark County. It is recommended that this report be forwarded to the appropriate regulatory agencies prior to the commencement of activities on the site that may impact jurisdictional wetlands.

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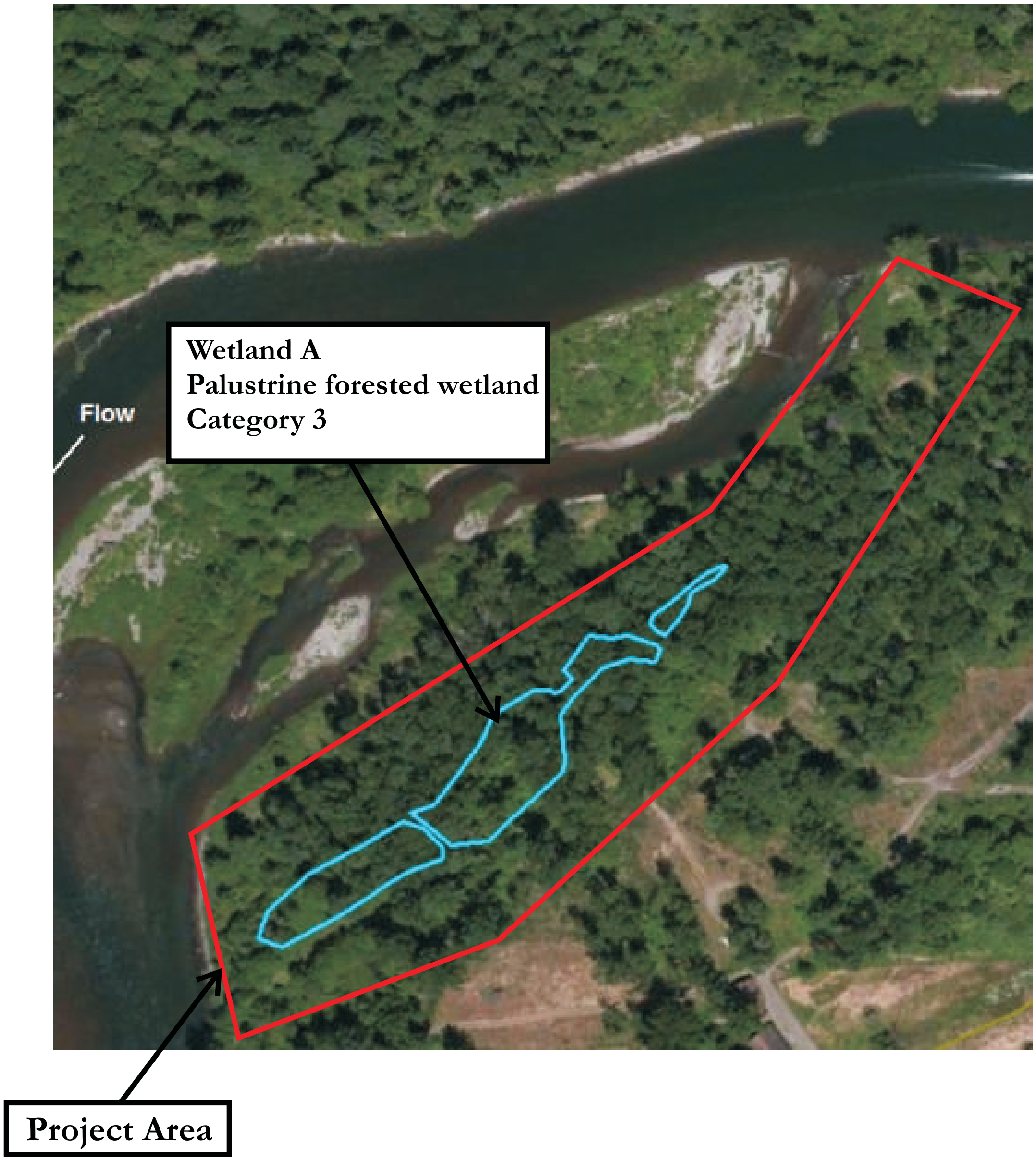

Approx. Scale 1”- 300’

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Aerial Photograph
WDFW Chum Channels Project
Clark County, WA

Project: Chum Channels Project
Client: WDFW
County: Clark County
Purpose: Preliminary Wetland Assess.

Figure 1

Wetland A - Ponded area in eastern section

Wetland A- Typical conditions

Wetland A- Typical conditions

Wetland A- Western portion of wetland

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Site Photographs
WDFW Chum Channels Project
Clark County, WA

Project: Chum Channels Project
Client: WDFW
County: Clark County
Purpose: Preliminary Wetland Assess.

Figure 2

WETLAND RATING FORM – WESTERN WASHINGTON

Version 2 - Updated July 2006 to increase accuracy and reproducibility among users
Updated Oct 2008 with the new WDFW definitions for priority habitats

Name of wetland (if known): Wetland A Date of site visit: 11/7/12

Rated by Brian Bieger Trained by Ecology? Yes_x_No___ Date of training 8/07

SEC: 9 TWNSHP: 5n RNGE: 1E Is S/T/R in Appendix D? Yes ___ No x

Map of wetland unit: Figure 1 **Estimated size** 1 acre

SUMMARY OF RATING

Category based on FUNCTIONS provided by wetland

I___ II___ III x **IV___**

Category I = Score >=70
Category II = Score 51-69
Category III = Score 30-50
Category IV = Score < 30

Score for Water Quality Functions	8
Score for Hydrologic Functions	7
Score for Habitat Functions	19
TOTAL score for Functions	34

Category based on SPECIAL CHARACTERISTICS of wetland

I___ II___ Does not Apply ___

Final Category **(choose the "highest" category from above)** III

Summary of basic information about the wetland unit

Wetland Unit has Special Characteristics		**Wetland HGM Class used for Rating**	
Estuarine		**Depressional**	x
Natural Heritage Wetland		**Riverine**	
Bog		**Lake-fringe**	
Mature Forest		**Slope**	
Old Growth Forest		**Flats**	
Coastal Lagoon		**Freshwater Tidal**	
Interdunal			
None of the above		Check if unit has multiple HGM classes present	

Does the wetland unit being rated meet any of the criteria below?

If you answer YES to any of the questions below you will need to protect the wetland according to the regulations regarding the special characteristics found in the wetland.

Check List for Wetlands That May Need Additional Protection (in addition to the protection recommended for its category)	**YES**	**NO**
SP1. *Has the wetland unit been documented as a habitat for any Federally listed Threatened or Endangered* ***animal or plant*** *species (T/E species)?* For the purposes of this rating system, "documented" means the wetland is on the appropriate state or federal database.		x
SP2. *Has the wetland unit been documented as habitat for any State listed Threatened or Endangered* ***animal*** *species?* For the purposes of this rating system, "documented" means the wetland is on the appropriate state database. Note: Wetlands with State listed plant species are categorized as Category I Natural Heritage Wetlands (see p. 19 of data form).		x
SP3. *Does the wetland unit contain individuals of Priority species listed by the WDFWf or the state?*		x
SP4. *Does the wetland unit have a local significance in addition to its functions*? For example, the wetland has been identified in the Shoreline Master Program, the Critical Areas Ordinance, or in a local management plan as having special significance.		x

To complete the next part of the data sheet you will need to determine the Hydrogeomorphic Class of the wetland being rated.

The hydrogeomorphic classification groups wetlands into those that function in similar ways. This simplifies the questions needed to answer how well the wetland functions. The Hydrogeomorphic Class of a wetland can be determined using the key below. See p. 24 for more detailed instructions on classifying wetlands.

Classification of Wetland Units in Western Washington

If the hydrologic criteria listed in each question do not apply to the entire unit being rated, you probably have a unit with multiple HGM classes. In this case, identify which hydrologic criteria in questions 1-7 apply, and go to Question 8.

1. Are the water levels in the entire unit usually controlled by tides (i.e. except during floods)?
NO – go to 2 **YES** – the wetland class is **Tidal Fringe**

If yes, is the salinity of the water during periods of annual low flow below 0.5 ppt (parts per thousand)? **YES – Freshwater Tidal Fringe NO – Saltwater Tidal Fringe (Estuarine)**

*Ify our wetland can be classified as a Freshwater Tidal Fringe use the forms for **Riverine** wetlands. If it is Saltwater Tidal Fringe it is rated as an **Estuarine** wetland.* Wetlands that were called estuarine in the first and second editions of the rating system are called Salt Water Tidal Fringe in the Hydrogeomorphic Classification. Estuarine wetlands were categorized separately in the earlier editions, and this separation is being kept in this revision. To maintain consistency between editions, the term "Estuarine" wetland is kept. Please note, however, that the characteristics that define Category I and II estuarine wetlands have changed (see p.).

2. The entire wetland unit is flat and precipitation is the only source (>90%) of water to it. Groundwater and surface water runoff are NOT sources of water to the unit.
NO – go to 3 **YES** – The wetland class is **Flats**

If your wetland can be classified as a "Flats" wetland, use the form for **Depressional** wetlands.

3. Does the entire wetland unit **meet both** of the following criteria?
___The vegetated part of the wetland is on the shores of a body of permanent open water (without any vegetation on the surface) at least 20 acres (8 ha) in size;
___At least 30% of the open water area is deeper than 6.6 ft (2 m)?
NO – go to 4 **YES –** The wetland class is **Lake-fringe (Lacustrine Fringe)**

4. Does the entire wetland unit **meet all** of the following criteria?
____The wetland is on a slope (*slope can be very gradual*),
____The water flows through the wetland in one direction (unidirectional) and usually comes from seeps. It may flow subsurface, as sheetflow, or in a swale without distinct banks.
____The water leaves the wetland **without being impounded**?
NOTE: *Surface water does not pond in these type of wetlands except occasionally in very small and shallow depressions or behind hummocks (depressions are usually <3ft diameter and less than 1 foot deep).*
NO - go to 5 **YES –** The wetland class is **Slope**

5. Does the entire wetland unit **meet all** of the following criteria?

____ The unit is in a valley, or stream channel, where it gets inundated by overbank flooding from that stream or river

____ The overbank flooding occurs at least once every two years.

NOTE: The riverine unit can contain depressions that are filled with water when the river is not flooding.

NO - go to 6 **YES** – The wetland class is **Riverine**

6. Is the entire wetland unit in a topographic depression in which water ponds, or is saturated to the surface, at some time during the year. *This means that any outlet, ifp resent, is higher than the interior of the wetland.*

NO – go to 7 **YES – The wetland class is Depressional**

7. Is the entire wetland unit located in a very flat area with no obvious depression and no overbank flooding. The unit does not pond surface water more than a few inches. The unit seems to be maintained by high groundwater in the area. The wetland may be ditched, but has no obvious natural outlet.

NO – go to 8 **YES – The wetland class is Depressional**

8. Your wetland unit seems to be difficult to classify and probably contains several different HGM clases. For example, seeps at the base of a slope may grade into a riverine floodplain, or a small stream within a depressional wetland has a zone of flooding along its sides. GO BACK AND IDENTIFY WHICH OF THE HYDROLOGIC REGIMES DESCRIBED IN QUESTIONS 1-7 APPLY TO DIFFERENT AREAS IN THE UNIT (make a rough sketch to help you decide). Use the following table to identify the appropriate class to use for the rating system if you have several HGM classes present within your wetland. NOTE: Use this table only if the class that is recommended in the second column represents 10% or more of the total area of the wetland unit being rated. If the area of the class listed in column 2 is less than 10% of the unit; classify the wetland using the class that represents more than 90% of the total area.

HGM Classes within the wetland unit being rated	*HGM Class to Use in Rating*
Slope + Riverine	Riverine
Slope + Depressional	Depressional
Slope + Lake-fringe	Lake-fringe
Depressional + Riverine along stream within boundary	Depressional
Depressional + Lake-fringe	Depressional
Salt Water Tidal Fringe and any other class of freshwater wetland	Treat as ESTUARINE under wetlands with special characteristics

If you are unable still to determine which of the above criteria apply to your wetland, or if you have more than 2 HGM classes within a wetland boundary, classify the wetland as **Depressional** for the rating.

D	Depressional and Flats Wetlands **WATER QUALITY FUNCTIONS** - Indicators that the wetland unit functions to improve water quality	**Points** (only 1 score per box)
D	**D 1. Does the wetland unit have the potential to improve water quality?**	*(see p.38)*
D	D 1.1 Characteristics of surface water flows out of the wetland: Unit is a depression with no surface water leaving it (no outlet) points = 3 Unit has an intermittently flowing, OR highly constricted permanently flowing outlet points = 2 Unit has an unconstricted, or slightly constricted, surface outlet (*permanently flowing*) points = 1 Unit is a "flat" depression (Q. 7 on key), or in the Flats class, with permanent surface outflow **and no obvious natural outlet** and/or outlet is a man-made ditch points = 1 (*If ditch is not permanently flowing treat unit as "intermittently flowing"*) Provide photo or drawing	**Figure** 1 3
D	S 1.2 The soil 2 inches below the surface (or duff layer) is clay or organic *(use NRCS definitions)* YES points = 4 NO points = 0	0
D	D 1.3 Characteristics of persistent vegetation (emergent, shrub, and/or forest Cowardin class) Wetland has persistent, ungrazed, vegetation > = 95% of area points = 5 Wetland has persistent, ungrazed, vegetation > = 1/2 of area points = 3 Wetland has persistent, ungrazed vegetation > = 1/10 of area points = 1 Wetland has persistent, ungrazed vegetation <1/10 of area points = 0 Map of Cowardin vegetation classes	**Figure** 1 5
D	D1.4 Characteristics of seasonal ponding or inundation. This is the area of the wetland unit that is ponded for at least 2 months, but dries out sometime during the year. Do not count the area that is permanently ponded. Estimate area as the average condition 5 out of 10 yrs. Area seasonally ponded is > 1/2 total area of wetland Area seasonally ponded is > 1/4 total area of wetland Area seasonally ponded is < 1/4 total area of wetland points = 4 points = 2 points = 0 Map of Hydroperiods	**Figure** 1 **0**
D	**Total for D 1** *Add the points in the boxes above*	**8**
D	**D 2. Does the wetland unit have the opportunity to improve water quality?** Answer YES if you know or believe there are pollutants in groundwater or surface water coming into the wetland that would otherwise reduce water quality in streams, lakes or groundwater downgradient from the wetland. *Note which of the following conditions provide the sources ofp ollutants. A unit may have pollutants coming from several sources, but any single source would qualify as opportunity.* — Grazing in the wetland or within 150 ft — Untreated stormwater discharges to wetland — Tilled fields or orchards within 150 ft of wetland — A stream or culvert discharges into wetland that drains developed areas, residential areas, farmed fields, roads, or clear-cut logging — Residential, urban areas, golf courses are within 150 ft of wetland — Wetland is fed by groundwater high in phosphorus or nitrogen — Other ______________________ **YES** multiplier is **2** **NO** multiplier is **1**	*(see p. 44)* multiplier 1
D	**TOTAL - Water Quality Functions** Multiply the score from D1 by D2 ***Add score to table on p. 1***	8

D	**Depressional and Flats Wetlands** HYDROLOGIC FUNCTIONS - Indicators that the wetland unit functions to reduce flooding and stream degradation	**Points** (only 1 score per box)
	D 3. Does the wetland unit have the <u>potential</u> to reduce flooding and erosion?	***(see p.46)***
D	D 3.1 Characteristics of surface water flows out of the wetland unit Unit is a depression with no surface water leaving it (no outlet) points = 4 Unit has an intermittently flowing, OR highly constricted permanently flowing outlet points = 2 Unit is a "flat" depression (Q. 7 on key), or in the Flats class, with permanent surface outflow **and no obvious natural outlet** and/or outlet is a man-made ditch points = 1 (*If ditch is not permanently flowing treat unit as "intermittently flowing"*) Unit has an unconstricted, or slightly constricted, surface outlet (*permanently flowing*) points = 0	4
D	D 3.2 Depth of storage during wet periods *Estimate the height of ponding above the bottom of the outlet. For units with no outlet measure from the surface of permanent water or deepest part (if dry).* Marks of ponding are 3 ft or more above the surface or bottom of outlet points = 7 The wetland is a "headwater" wetland" points = 5 Marks of ponding between 2 ft to < 3 ft from surface or bottom of outlet points = 5 Marks are at least 0.5 ft to < 2 ft from surface or bottom of outlet points = 3 Unit is flat (yes to Q. 2 or Q. 7 on key) but has small depressions on the surface that trap water points = 1 Marks of ponding less than 0.5 ft points = 0	3
D	D 3.3 Contribution of wetland unit to storage in the watershed *Estimate the ratio of the area of upstream basin contributing surface water to the wetland to the area of the wetland unit itself.* The area of the basin is less than 10 times the area of unit The points = 5 area of the basin is 10 to 100 times the area of the unit The area points = 3 of the basin is more than 100 times the area of the unit Entire points = 0 unit is in the FLATS class points = 5	0
D	**Total for D 3** *Add the points in the boxes above*	7
D	**D 4. Does the wetland unit have the <u>opportunity</u> to reduce flooding and erosion?** Answer YES if the unit is in a location in the watershed where the flood storage, or reduction in water velocity, it provides helps protect downstream property and aquatic resources from flooding or excessive and/or erosive flows. Answer NO if the water coming into the wetland is controlled by a structure such as flood gate, tide gate, flap valve, reservoir etc. OR you estimate that more than 90% of the water in the wetland is from groundwater in areas where damaging groundwater flooding does not occur. *Note which of the following indicators of opportunity apply.* — Wetland is in a headwater of a river or stream that has flooding problems — Wetland drains to a river or stream that has flooding problems — Wetland has no outlet and impounds surface runoff water that might otherwise flow into a river or stream that has flooding problems — Other ______________________________ **YES** multiplier is **2** **NO** multiplier is **1**	***(see p. 49)*** multiplier 1
D	**TOTAL - Hydrologic Functions** Multiply the score from D 3 by D 4 ***Add score to table on p. 1***	7

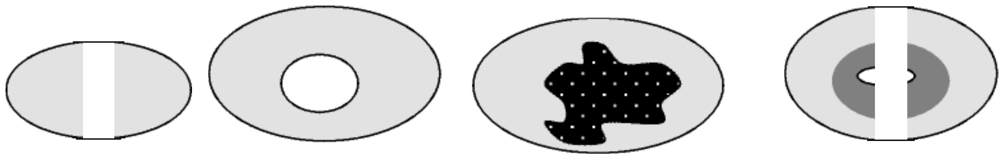
These questions apply to wetlands of all HGM classes. HABITAT FUNCTIONS - Indicators that unit functions to provide important habitat	**Points** (only 1 score per box)
H 1. Does the wetland unit have the <u>potential</u> to provide habitat for many species?	
H 1.1 <u>Vegetation structure</u> ***(see p. 72)*** *Check the types of vegetation classes present (as defined by Cowardin)- Size threshold for each class is 1/4 acre or more than 10% of the area if unit is smaller than 2.5 acres.* ____Aquatic bed x___Emergent plants Scrub/shrub (areas where shrubs have >30% cover) x___Forested (areas where trees have >30% cover) *If the unit has a forested class check if:* ____The forested class has 3 out of 5 strata (canopy, sub-canopy, shrubs, herbaceous, moss/ground-cover) that each cover 20% within the forested polygon *Add the number of vegetation structures that qualify. Ify ou have:* 4 structures or more points = 4 Map of Cowardin vegetation classes 3 structures points = 2 2 structures points = 1 1 structure points = 0	**Figure** ___ 1
H 1.2. <u>Hydroperiods</u> ***(see p. 73)*** *Check the types of water regimes (hydroperiods) present within the wetland. The water regime has to cover more than 10% of the wetland or 1/4 acre to count. (see text for descriptions of hydroperiods)* ____Permanently flooded or inundated 4 or more types present points = 3 ____Seasonally flooded or inundated 3 types present points = 2 x___Occasionally flooded or inundated 2 types present point = 1 x___Saturated only 1 type present points = 0 ____ Permanently flowing stream or river in, or adjacent to, the wetland ____ Seasonally flowing stream in, or adjacent to, the wetland ***Lake-*** ____ ***fringe wetland* = 2 points** ____***Freshwater tidal wetland* = 2 points** Map of hydroperiods	**Figure** ___ 1
H 1.3. <u>Richness of Plant Species</u> ***(see p. 75)*** Count the number of plant species in the wetland that cover at least 10 ft^2. (*different patches of the same species can be combined to meet the size threshold)* *You do not have to name the species.* *Do not include Eurasian Milfoil, reed canarygrass, purple loosestrife, Canadian Thistle* If you counted: > 19 species points = 2 *List species below ify ou want to:* 5 - 19 species points = 1 < 5 species points = 0	1

Total for page __3__

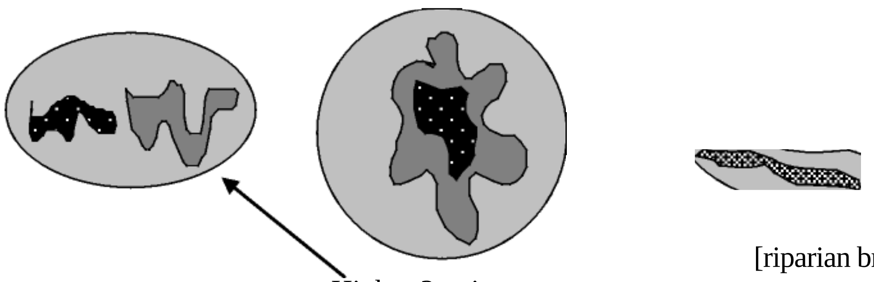
H 1.4. Interspersion of habitats *(see p. 76)* | Figure ___

Decide from the diagrams below whether interspersion between Cowardin vegetation classes (described in H 1.1), or the classes and unvegetated areas (can include open water or mudflats) is high, medium, low, or none.

2



None = 0 points　　Low = 1 point　　Moderate = 2 points



[riparian braided channels]

High = 3 points

NOTE: If you have four or more classes or three vegetation classes and open water the rating is always "high". Use map of Cowardin vegetation classes

H 1.5. Special Habitat Features: *(see p. 77)*

3

Check the habitat features that are present in the wetland. The number of checks is the number ofp oints you put into the next column.

x___Large, downed, woody debris within the wetland (>4in. diameter and 6 ft long).

____Standing snags (diameter at the bottom > 4 inches) in the wetland

____ Undercut banks are present for at least 6.6 ft (2m) and/or overhanging vegetation extends at least 3.3 ft (1m) over a stream (or ditch) in, or contiguous with the unit, for at least 33 ft (10m)

____ Stable steep banks of fine material that might be used by beaver or muskrat for denning (>30degree slope) OR signs of recent beaver activity are present *(cut shrubs or trees that have not yet turned grey/brown)*

x___ At least 1/4 acre of thin-stemmed persistent vegetation or woody branches are present in areas that are permanently or seasonally inundated.*(structures for egg-laying by amphibians)*

x___ Invasive plants cover less than 25% of the wetland area in each stratum of plants

NOTE: The 20% stated in early printings of the manual on page 78 is an error.

H 1. TOTAL Score - potential for providing habitat
Add the scores from H1.1, H1.2, H1.3, H1.4, H1.5

8

Comments

H 2. Does the wetland unit have the opportunity to provide habitat for many species?	
H 2.1 Buffers ***(see p. 80)*** *Choose the description that best represents condition of buffer of wetland unit. The highest scoring criterion that applies to the wetland is to be used in the rating. See text for definition of "undisturbed."* — 100 m (330ft) of relatively undisturbed vegetated areas, rocky areas, or open water >95% of circumference. No structures are within the undisturbed part of buffer**.** (relatively undisturbed also means no-grazing, no landscaping, no daily human use) **Points = 5** x — 100 m (330 ft) of relatively undisturbed vegetated areas, rocky areas, or open water > 50% circumference. **Points = 4** — 50 m (170ft) of relatively undisturbed vegetated areas, rocky areas, or open water >95% circumference. **Points = 4** — 100 m (330ft) of relatively undisturbed vegetated areas, rocky areas, or open water > 25% circumference, **Points = 3** — 50 m (170ft) of relatively undisturbed vegetated areas, rocky areas, or open water for > 50% circumference. **Points = 3** **If buffer does not meet any of the criteria above** — No paved areas (except paved trails) or buildings within 25 m (80ft) of wetland > 95% circumference. Light to moderate grazing, or lawns are OK. **Points = 2** — No paved areas or buildings within 50m of wetland for >50% circumference. Light to moderate grazing, or lawns are OK. **Points = 2** — Heavy grazing in buffer. **Points = 1** — Vegetated buffers are <2m wide (6.6ft) for more than 95% of the circumference (e.g. tilled fields, paving, basalt bedrock extend to edge of wetland **Points = 0**. — Buffer does not meet any of the criteria above. **Points = 1** Aerial photo showing buffers	Figure 3___ 4
H 2.2 Corridors and Connections ***(see p. 81)*** H 2.2.1 Is the wetland part of a relatively undisturbed and unbroken vegetated corridor (either riparian or upland) that is at least 150 ft wide, has at least 30% cover of shrubs, forest or native undisturbed prairie, that connects to estuaries, other wetlands or undisturbed uplands that are at least 250 acres in size? (*dams in riparian corridors, heavily used gravel roads, paved roads, are considered breaks in the corridor*). YES = **4 points** (*go to H 2.3*) NO = go to H 2.2.2 H 2.2.2 Is the wetland part of a relatively undisturbed and unbroken vegetated corridor (either riparian or upland) that is at least 50ft wide, has at least 30% cover of shrubs or forest, and connects to estuaries, other wetlands or undisturbed uplands that are at least 25 acres in size? **OR** a **Lake-fringe** wetland, if it does not have an undisturbed corridor as in the question above? YES = **2 points** (*go to H 2.3*) NO = H 2.2.3 H 2.2.3 Is the wetland: within 5 mi (8km) of a brackish or salt water estuary OR within 3 mi of a large field or pasture (>40 acres) OR within 1 mi of a lake greater than 20 acres? YES = **1 point** NO = **0 points**	2

Total for page __6__

H 2.3 Near or adjacent to other priority habitats listed by WDFW ***(see new and complete descriptions of WDFWp riority habitats, and the counties in which they can be found, in the PHS report http://wdfw.wa.gov/hab/phslist.htm)***	3
Which of the following priority habitats are within 330ft (100m) of the wetland unit? *NOTE: the connections do not have to be relatively undisturbed.* ____**Aspen Stands:** Pure or mixed stands of aspen greater than 0.4 ha (1 acre). ____**Biodiversity Areas and Corridors**: Areas of habitat that are relatively important to various species of native fish and wildlife (*full descriptions in WDFW PHS report p. 152*). ____**Herbaceous Balds:** Variable size patches of grass and forbs on shallow soils over bedrock. ____**Old-growth/Mature forests:** (Old-growth west of Cascade crest) Stands of at least 2 tree species, forming a multi-layered canopy with occasional small openings; with at least 20 trees/ha (8 trees/acre) > 81 cm (32 in) dbh or > 200 years of age. **(**Mature forests) Stands with average diameters exceeding 53 cm (21 in) dbh; crown cover may be less that 100%; crown cover may be less that 100%; decay, decadence, numbers of snags, and quantity of large downed material is generally less than that found in old-growth; 80 - 200 years old west of the Cascade crest. _____**Oregon white Oak:** Woodlands Stands of pure oak or oak/conifer associations where canopy coverage of the oak component is important (*full descriptions in WDFW PHS report p. 158*). x___**Riparian**: The area adjacent to aquatic systems with flowing water that contains elements of both aquatic and terrestrial ecosystems which mutually influence each other. ____**Westside Prairies:** Herbaceous, non-forested plant communities that can either take the form of a dry prairie or a wet prairie (*full descriptions in WDFW PHS report p. 161*). ____**Instream:** The combination of physical, biological, and chemical processes and conditions that interact to provide functional life history requirements for instream fish and wildlife resources. ____ **Nearshore**: Relatively undisturbed nearshore habitats. These include Coastal Nearshore, Open Coast Nearshore, and Puget Sound Nearshore. (*full descriptions of habitats and the definition of relatively undisturbed are in WDFW report: pp. 167-169 and glossary in Appendix A*). ____**Caves:** A naturally occurring cavity, recess, void, or system of interconnected passages under the earth in soils, rock, ice, or other geological formations and is large enough to contain a human. ____**Cliffs:** Greater than 7.6 m (25 ft) high and occurring below 5000 ft. ____**Talus:** Homogenous areas of rock rubble ranging in average size 0.15 - 2.0 m (0.5 - 6.5 ft), composed of basalt, andesite, and/or sedimentary rock, including riprap slides and mine tailings. May be associated with cliffs. x___**Snags and Logs:** Trees are considered snags if they are dead or dying and exhibit sufficient decay characteristics to enable cavity excavation/use by wildlife. Priority snags have a diameter at breast height of > 51 cm (20 in) in western Washington and are > 2 m (6.5 ft) in height. Priority logs are > 30 cm (12 in) in diameter at the largest end, and > 6 m (20 ft) long. If wetland has **3 or more** priority habitats **= 4 points** If wetland has **2** priority habitats = **3 points** If wetland has **1** priority habitat **= 1 point** No habitats = 0 points *Note: All vegetated wetlands are by definition a priority habitat but are not included in this list. Nearby wetlands are addressed in question H 2.4)*	

H 2.4 Wetland Landscape *(choose the **one** description of the landscape around the wetland that best fits)* ***(see p. 84)*** There are at least 3 other wetlands within 1/2 mile, and the connections between them are relatively undisturbed (light grazing between wetlands OK, as is lake shore with some boating, but connections should NOT be bisected by paved roads, fill, fields, or other development. points = 5 The wetland is Lake-fringe on a lake with little disturbance and there are 3 other lake-fringe wetlands within 1/2 mile points = 5 There are at least 3 other wetlands within 1/2 mile, BUT the connections between them are disturbed points = 3 The wetland is Lake-fringe on a lake **with** disturbance and there are 3 other lake-fringe wetland within 1/2 mile points = 3 There is at least 1 wetland within 1/2 mile. points = 2 There are no wetlands within 1/2 mile. points = 0	2
H 2. TOTAL Score - opportunity for providing habitat *Add the scores from H2.1,H2.2, H2.3, H2.4*	11
TOTAL for H 1 from page 14	8
Total Score for Habitat Functions – add the points for H 1, H 2 and record the result on p. 1	19

CATEGORIZATION BASED ON SPECIAL CHARACTERISTICS

Please determine if the wetland meets the attributes described below and circle the appropriate answers and Category.

Wetland Type *Check off any criteria that apply to the wetland. Circle the Category when the appropriate criteria are met.*	**Category**
SC 1.0 Estuarine wetlands *(see p. 86)* Does the wetland unit meet the following criteria for Estuarine wetlands? — The dominant water regime is tidal, — Vegetated, and — With a salinity greater than 0.5 ppt. YES = Go to SC 1.1 NO x__	
SC 1.1 Is the wetland unit within a National Wildlife Refuge, National Park, National Estuary Reserve, Natural Area Preserve, State Park or Educational, Environmental, or Scientific Reserve designated under WAC 332-30-151? YES = Category I NO go to SC 1.2	**Cat. I**
SC 1.2 Is the wetland unit at least 1 acre in size and meets at least two of the following three conditions? YES = Category I NO = Category II — The wetland is relatively undisturbed (has no diking, ditching, filling, cultivation, grazing, and has less than 10% cover of non-native plant species. If the non-native *Spartina* spp. are the only species that cover more than 10% of the wetland, then the wetland should be given a dual rating (I/II). The area of Spartina would be rated a Category II while the relatively undisturbed upper marsh with native species would be a Category I. Do not, however, exclude the area of Spartina in determining the size threshold of 1 acre. — At least 3/4 of the landward edge of the wetland has a 100 ft buffer of shrub, forest, or un-grazed or un-mowed grassland. — The wetland has at least 2 of the following features: tidal channels, depressions with open water, or contiguous freshwater wetlands.	**Cat. I** **Cat. II** **Dual rating I/II**

<table>
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SC 2.0 Natural Heritage Wetlands ***(see p. 87)***
Natural Heritage wetlands have been identified by the Washington Natural Heritage Program/DNR as either high quality undisturbed wetlands or wetlands that support state Threatened, Endangered, or Sensitive plant species.
SC 2.1 Is the wetland unit being rated in a Section/Township/Range that contains a Natural Heritage wetland? *(this question is used to screen out most sites before you need to contact WNHP/DNR)*
S/T/R information from Appendix D ___ or accessed from WNHP/DNR web site ___
YES ____ – contact WNHP/DNR (see p. 79) and go to SC 2.2 NO _x_
SC 2.2 Has DNR identified the wetland as a high quality undisturbed wetland or as or as a site with state threatened or endangered plant species?
YES = Category I NO _x_ not a Heritage Wetland

</td><td>**Cat. I**</td></tr>
<tr><td>

SC 3.0 Bogs ***(see p. 87)***
Does the wetland unit (**or any part of the unit**) meet both the criteria for soils and vegetation in bogs? *Use the key below to identify if the wetland is a bog.* ***Ify ou answer yes you will still need to rate the wetland based on its functions.***
1. Does the unit have organic soil horizons (i.e. layers of organic soil), either peats or mucks, that compose 16 inches or more of the first 32 inches of the soil profile? (See Appendix B for a field key to identify organic soils)? Yes - go to Q. 3 No - go to Q. 2
2. Does the unit have organic soils, either peats or mucks that are less than 16 inches deep over bedrock, or an impermeable hardpan such as clay or volcanic ash, or that are floating on a lake or pond?
Yes - go to Q. 3 No - Is not a bog for purpose of rating
3. Does the unit have more than 70% cover of mosses at ground level, AND other plants, if present, consist of the "bog" species listed in Table 3 as a significant component of the vegetation (more than 30% of the total shrub and herbaceous cover consists of species in Table 3)?
Yes – Is a bog for purpose of rating No - go to Q. 4
NOTE: If you are uncertain about the extent of mosses in the understory you may substitute that criterion by measuring the pH of the water that seeps into a hole dug at least 16" deep. If the pH is less than 5.0 and the "bog" plant species in Table 3 are present, the wetland is a bog.
1. Is the unit forested (> 30% cover) with sitka spruce, subalpine fir, western red cedar, western hemlock, lodgepole pine, quaking aspen, Englemann's spruce, or western white pine, WITH any of the species (or combination of species) on the bog species plant list in Table 3 as a significant component of the ground cover *(> 30% coverage of the total shrub/herbaceous cover)?*
2. YES = Category I No ___ Is not a bog for purpose of rating

</td><td>**Cat. I**</td></tr>
</table>

SC 4.0 Forested Wetlands ***(see p. 90)*** Does the wetland unit have at least 1 acre of forest that meet one of these criteria for the Department of Fish and Wildlife's forests as priority habitats? *Ify ou answer yes you will still need to rate the wetland based on its functions.* — **Old-growth forests**: (west of Cascade crest) Stands of at least two tree species, forming a multi-layered canopy with occasional small openings; with at least 8 trees/acre (20 trees/hectare) that are at least 200 years of age OR have a diameter at breast height (dbh) of 32 inches (81 cm) or more. NOTE: The criterion for dbh is based on measurements for upland forests. Two-hundred year old trees in wetlands will often have a smaller dbh because their growth rates are often slower. The DFW criterion is and "OR" so old-growth forests do not necessarily have to have trees of this diameter. — **Mature forests**: (west of the Cascade Crest) Stands where the largest trees are 80 – 200 years old OR have average diameters (dbh) exceeding 21 inches (53cm); crown cover may be less that 100%; decay, decadence, numbers of snags, and quantity of large downed material is generally less than that found in old-growth. YES = Category I NO _x_ not a forested wetland with special characteristics	**Cat. I**
SC 5.0 Wetlands in Coastal Lagoons ***(see p. 91)*** Does the wetland meet all of the following criteria of a wetland in a coastal lagoon? — The wetland lies in a depression adjacent to marine waters that is wholly or partially separated from marine waters by sandbanks, gravel banks, shingle, or, less frequently, rocks — The lagoon in which the wetland is located contains surface water that is saline or brackish (> 0.5 ppt) during most of the year in at least a portion of the lagoon *(needs to be measured near the bottom)* YES = Go to SC 5.1 NO _x_ not a wetland in a coastal lagoon SC 5.1 Does the wetland meets all of the following three conditions? — The wetland is relatively undisturbed (has no diking, ditching, filling, cultivation, grazing), and has less than 20% cover of invasive plant species (see list of invasive species on p. 74). — At least 3/4 of the landward edge of the wetland has a 100 ft buffer of shrub, forest, or un-grazed or un-mowed grassland. — The wetland is larger than 1/10 acre (4350 square feet) YES = Category I NO = Category II	**Cat. I** **Cat. II**

SC 6.0 Interdunal Wetlands ***(see p. 93)*** Is the wetland unit west of the 1889 line (also called the Western Boundary of Upland Ownership or WBUO)? YES - go to SC 6.1 NO __x not an interdunal wetland for ***Ify ou answer yes you will still need to rate the wetland based on its functions.*** In practical terms that means the following geographic areas: Long Beach Peninsula- lands west of SR 103 Grayland-Westport- lands west of SR 105 Ocean Shores-Copalis- lands west of SR 115 and SR 109 SC 6.1 Is the wetland one acre or larger, or is it in a mosaic of wetlands that is once acre or larger? YES = Category II NO – go to SC 6.2 SC 6.2 Is the unit between 0.1 and 1 acre, or is it in a mosaic of wetlands that is between 0.1 and 1 acre? YES = Category III	 **Cat. II** **Cat. III**
Category of wetland based on Special Characteristics *Choose the "highest" rating if wetland falls into several categories, and record on p. 1.* If you answered NO for all types enter "Not Applicable" on p.1	N/A