Winter Lake Phase III Project
Hydrologic Assessment

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EXECUTIVE SUMMARY

The “Winter Lake” land area is a distinct river adjacent floodplain west of Coquille Oregon. The portion that is east and south of North Bank Lane and south of Hwy 42 bordered by the Coquille River is ~1,873 acres in size. Historically the acres of this unique valley floodplain that lie below elevation 8.0ft NAVDD88 were subjected to regular tidal inflow and outflow. In 1906-1907 the Beaver Slough Drainage District (BSDD) was formed and the Coaledo Drainage District (CDD) some years thereafter. These drainage districts provided social and financial framework facilitating construction of canal networks and installation of large tidegate systems for the properties to be drained. The BSDD installed canals and tidegates in 1908-1909 allowed for drainage of 1,700 acres and the CDD installed the Beaver Creek tidegate that allowed for drainage of the remainder in the early 1900s. The lands prior to conversion to pastureland were forested with wetland tree species with a highly dendritic tidal channel network. As part of the land alterations, interior berms were constructed along pasture and property boundaries with elevation crests of ~5.5ft in order to allow for individual pasture management when water was below that elevation. The land area ownership was originally comprised of multiple individuals and entities and in the early years and land use varied with cultivation of some crops and extensive hay production on higher pastures. Currently the primary use is pastureland grazing and ownership has been greatly consolidated.

In 2017 a largescale restoration project developed by the BSDD, Oregon Department of Fish and Wildlife (ODFW), and The Nature Conservancy (TNC) was implemented in the BSDD, where the four legacy 8.0ft corrugated metal culverts with associated top-hinged wooden tidegates connecting BSDD lands to the Coquille River were replaced with the C3P project (Phase I). The C3P project consisted of construction of seven 10.0x8.0ft concrete box culverts and associated vertical slide-gates and side-hinged aluminum tidegates. In addition, an access road was rebuilt from Hwy 42 and from North Bank Lane, with associated bridges to provide access across existing legacy canals to serve this infrastructure. In 2018 restoration actions (Phase II) installed 31,000ft of sinuous channel on properties upstream of the C3P tidegate referred to as “Unit 2” lands and hydrology was returned to more historical condition within Unit 2 using the Muted Tidal Regulator (MTR) effects that were possible with the new C3P vertical slide-gates.

Upstream of the new C3P tidegate, in Units 1 and 3 and pastures along Beaver Creek in the BSDD and CDD are 42 undersized culverts with a high prevalence in the 2.0-3.0 diameter range. These culverts greatly underserve the tidal inflow/outflow capacity of the new C3P tidegate and the water management strategies outlined under the BSDD Water Management Plan (DWMP). Additionally, the tidal channels that were present historically were largely cut-off when linear field drainage channels were originally laid out. These linear channels were installed with little attention to microtopography, often on property and or pasture boundaries resulting in a number of hydrologic discontinuity issues. The Winter Lake Phase III project is proposing to replace the remaining 42 interior culverts and old style top-hinged tidegates in Units 1, 3, and pastures along Beaver Creek with 38 appropriately sized culverts. Upstream of the new culverts within pastures the project will construct on-grade channels that meet the precipitation hydrology as well as the tidal hydrology of the landscape and the BSDD DWMP. Existing engineering tools (USGS Streamstats) and engineering culvert capacity information were utilized to develop culvert and channel sizing that meets or exceeds the site hydrology and fish passage guidelines for both Federal and State jurisdictions.

I. INTRODUCTION

The Winter Lake floodplain area, at over 1,873 acres, represents one of the largest contiguous land areas in the lower Coquille River Basin with both high potential for providing Oregon Coast (OC) coho overwintering habitat and high-quality pasture grazing. Approximately 1,295 acres within the Beaver Slough Drainage District (BSDD) are below elevation 8.0ft NAVDD 88 and thus below the highest measured tides. The project area is upstream of saline influence at River Mile (RM) 21.5 in the Coquille estuary (*Figure 1*). The current proposed Phase III actions seek to address hydrologic connectivity within BSDD Units 1 and 3 and two pastures, which are 62 and 44 acres respectively in the Coaledo Drainage District (CDD) (*Figures 1 and 2*). Prior to installation of the linear canals and tidegates which eliminated tidal influence in 1908-1909; the lands were forested and contained a dense tidal channel network (Benner 1992). Native salmonids, specifically coho salmon *(Oncorhynchus kisutch)* juveniles, used these habitats heavily during fall/winter/spring months to feed and rear prior to smoltification. The habitats were also highly important for fall Chinook salmon *(O tshawytscha),* winter steelhead *(O. mykiss)* coastal cutthroat trout *(O. clarki clarki),* and tidal outflow from the dendritic tidal network of channels likely provided large quantities of macroinvertebrate food items to in-river native fish.

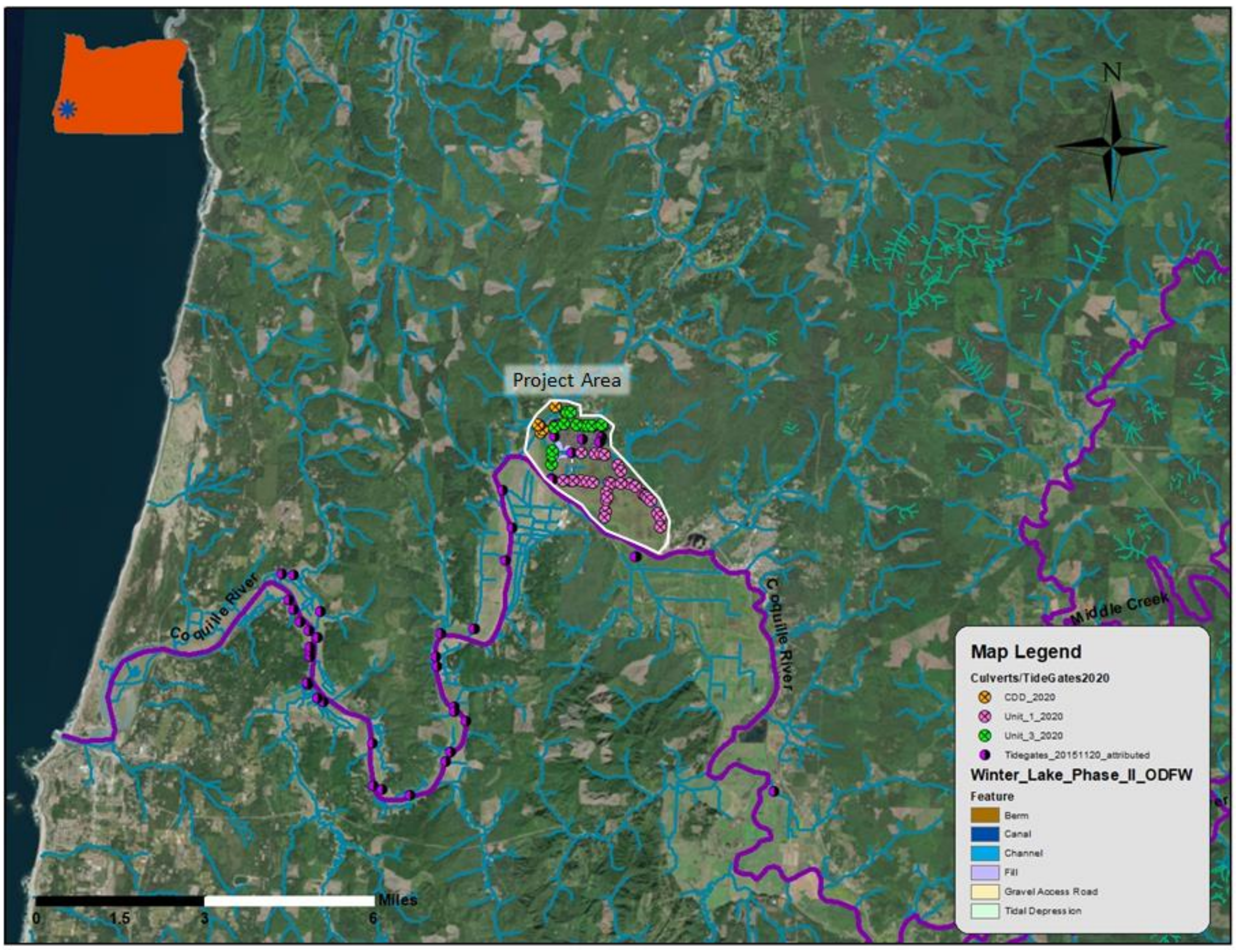

Figure 1. Coquille River estuary with demarcation of the Phase III project area at River Mile 21. 5.

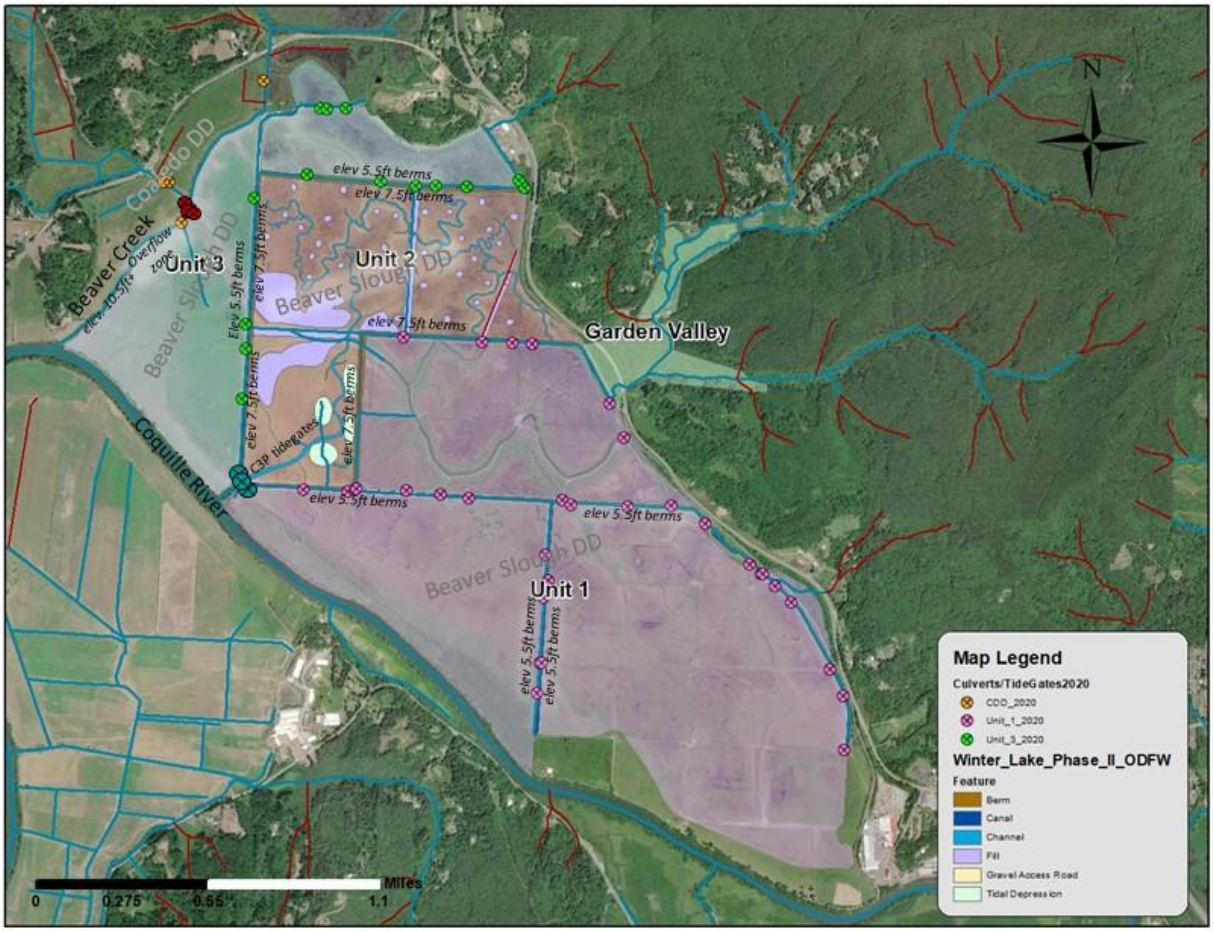

Figure 2. Winter Lake Phase I, II, and III project area and the land management Units within the Beaver Slough Drainage District. Note the two small parcels in the Coaledo Drainage District are immediately to west/northwest of Unit 3 label and are also in the Phase III project area.

II. WINTER LAKE PROJECT BACKGROUND

The "Winter Lake Phase I," project installed seven new tidegates to replace the four previously existing undersized culverts and top-hinged gates that were failing. The four 8.0ft corrugated metal culverts (CMP's) were originally installed in the early 1960's on the stem channel that provides interface of the BSDD floodplain with the Coquille River. These were replaced in 2017 with seven 10.0x8.0ft concrete box culverts. New Vertical Slide Frame Tide Gates (VSFTG) were then installed on the seven concrete box culverts. On three of the VSFTG gates feeding into the BSDD (Units 1, 2, and 3), secondary side-hinged aluminum tidegates (*Figure 3*) were installed to provide a dual water management power-off backup capacity. The slide-gate water control system is currently configured with both manual and remote access control. The seven new culverts with associated tidegates are collectively referred to as the "C3P Tidegate" project. The new tidegates also have the capacity to be operated with Muted Tidal Regulator (MTR) technology, whereby they can be opened to allow for tidal inflow to a set desired level, and controlled by a computer program, which is linked to river/tidal level feedback. The seven new slide-gate tidegates have increased the capacity for water movement into and out of the 1,700acre BSDD by 300%.

The Phase I C3P tidegate construction resolved the problem of hydrologic restriction of tidal inflow/outflow from the Coquille River BSDD main canals that had existed prior to the project. The Winter Lake Phase I project resulted in potential for delivery of large volumes of tidal inflow/outflow. However, while the two main BSDD canals were sufficient in size to carry flow volumes from the new C3P tidegates into the floodplain landscape; water entry from these canals into the interior pasture channel networks within Units 1, 2, and 3 (*Figures 1 and 2*) remained unchanged following completion of Phase I.

Unit 2 lands are owned by the China Camp Gun Club and Oregon Department of Fish and Wildlife (ODFW). The China Camp Gun Club lands are managed for summer pasture grazing and recreational duck hunting during winter months. The ODFW-owned lands comprise 286 acres (northern portion of Unit 2- see *Figure 2*) with the Gun Club accounting for the remaining 121 acres that extend south to the C3P tidegates in Unit 2. In 2018, the Unit 2 restoration project or "Winter Lake Phase II" was implemented and a total of 31,000ft of tidal channel were excavated as designed by ODFW, BSDD, The Nature Conservancy (TNC), and Tetratech Engineering staff, in the 407 acre Unit 2 (*Figure 2*).
The main tidal channel upstream of the C3P tidegates (*Figure 3*) in Unit 2 was designed to have volume capacity that exceeds that of the four concrete box culverts and tidegates which feed into Unit 2. The design was based on the Hydraulic Analysis completed by Northwest Hydrology Consultants (NHC), (see Appendix A). This large channel has facilitated ability to serve water from the C3P tidegates to Unit 2 lands, provide juvenile coho and other native fish passage into the site, as well as provide for pasture irrigation on the China Camp Gun Club property. Hydrologic connectivity provided by the new Phase I and II projects in 2017-2018 is considered fully adequate to provide tidal inflow/outflow into Unit 2. The proposed Phase III project does not include any proposed actions within Unit 2.

The proposed "Winter Lake Phase III" project has been developed by a team of partners including the BSDD, the Coos Soil and Water Conservation District (Coos SWCD), and ODFW. This project is designed to complement the BSDD C3P tidegate replacement project which was completed in 2017. Phase III actions proposed within BSDD Units 1 and 3 include replacement of 42 existing undersized culverts and their associated old-style top-hinged tidegates with 38 new culverts; installation of upgraded water control structures; and redesign of the interior pasture channel network. These project actions are anticipated to maximize hydrologic connectivity, with the goal of achieving a more sustainable balance of fish/wildlife and forage production. We are incorporating designs that meet the ODFW Habitat Mitigation Policy guidelines (OAR 635-415) and National Marine Fisheries Service (NMFS) Tidal Area Restoration Project (TARP) and Standard Local Operating Procedures for Endangered Species (SLOPES V) restoration guidelines.

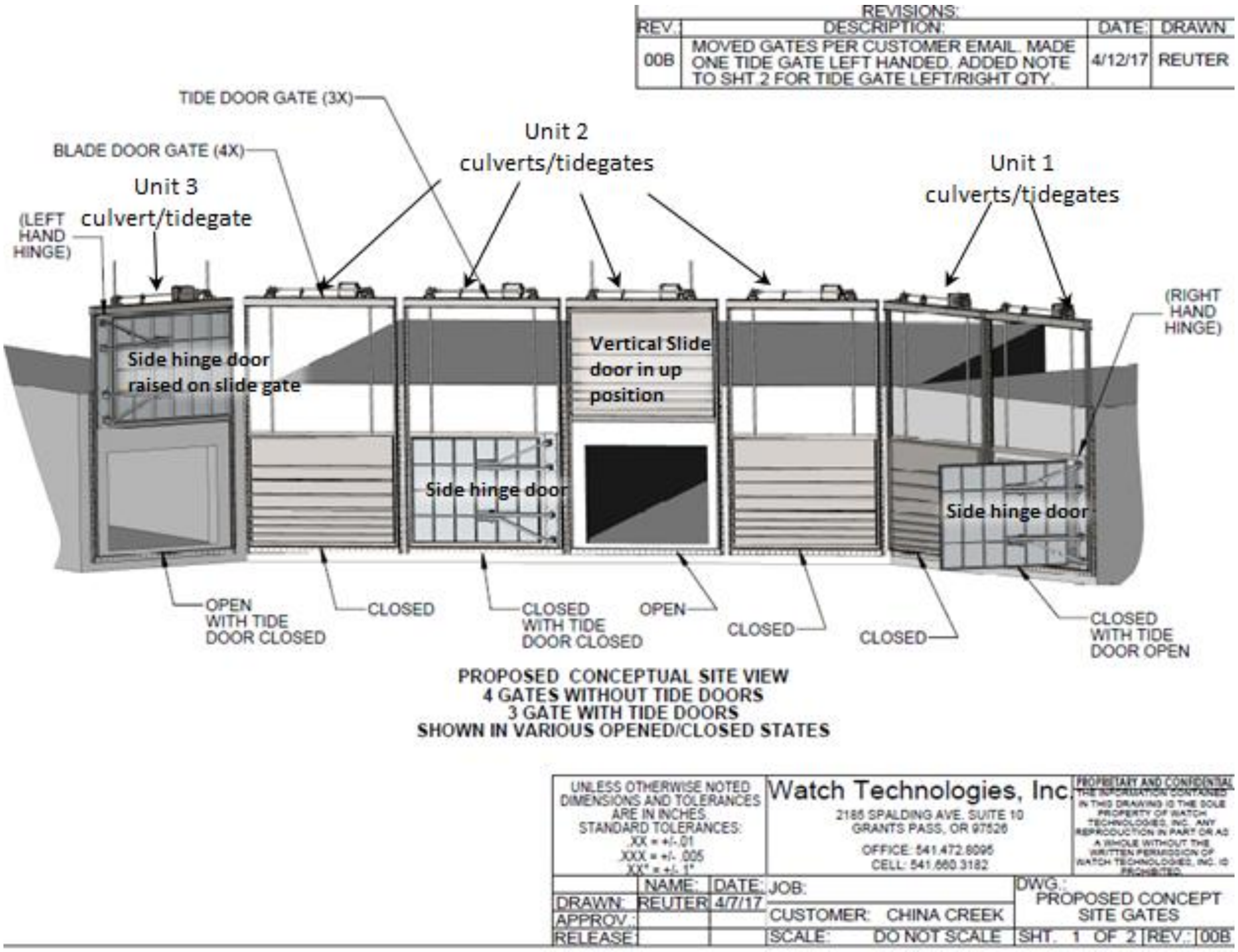

Figure 3. C3P tidegates and 10.0x8.0ft concrete box culverts configuration.

The proposed Phase III project is designed to address current insufficient hydrologic capacity and channel layout issues in both Units 1 and 3 of Winter Lake, and two parcels in the CDD (*Figure 2*). The lands within Units 1 and 3 are actively managed for agricultural production (grazed pasture) during the spring, summer, and early fall months. These lands are, however, considered to have largely unrealized capacity for rearing of juvenile coho during the late fall, winter, and early spring. Water management to date within Units 1 and 3 has relied primarily on linear channel networks that were installed in the early 1900's, with subsequent modifications implemented over time, and maintenance dredging occurring at roughly 15yr intervals to clean sediments that had accumulated in "ditches" or canals.

It is important to note that the individual landowner pastures within Units 1 and 3 are isolated up to elevation 5.5ft NAVDD88 by legacy earthen berms that run along the sides of the major canals (*Figure 2*). Culverts installed through the berms provide for hydrologic connectivity from low water elevations up to elevation 5.5ft, at which point sheet flow begins to overtop the berms. Secondary tidegate water control structures have been installed on these interior culverts to allow landowners the ability to manage water on their individual parcels, up to water elevation 5.5ft. These berms have had little or no maintenance for a number of years, and currently have substantive need for reconstruction and repair. There are five key locations where 100-200ft segments of the berms have been eroded down to heights below elevation 3.5ft. These damaged segments of berm are breached sooner by rising water, disrupting the functionality of individual pasture irrigation inflow management.

The forty-two culverts currently installed within the berms also present a major need for improvement as most are equipped with outdated, top-hinge style wooden tidegates for water control. These interior tidegates present hydrologic discontinuity issues due to being undersized, installed at incorrect elevations, and many are located in sub-optimal areas of topography. These culverts with their associated hydrologic issues impact the pasture channel network's overall capacity to move water efficiently and evenly across the landscape, thereby negatively impacting fish and wildlife values; wetland ecological function; pasture drainage for forage production; and irrigation.

III. KEY HYDROLOGY AND HABITAT CONCERNS

The Winter Lake Phase I C3P Tidegate project completed in 2017 alleviated hydrologic connectivity issues at the connection point between the BSDD overall land area and the mainstem Coquille River. In 2018, the Phase III/Unit 2 "Restoration" project installed over 31,000ft of channel, fully connecting 407 acres of land in Unit 2. The Phase II restoration actions addressed hydrologic discontinuity, limited access for fish, stranding potential, and mosquito production risk.

However, most of the land within Winter Lake Units 1 and 3 upstream of the C3P tidegate in the BSDD, and two parcels in the CDD, were not included in restoration plans for either Phase I or Phase III. These approximately 1,873 acres retain numerous dysfunctional hydrological and habitat attributes for floodplain connectivity, wetland function, and access for a native fish. There are a number of salmonid species including Oregon Coast (OC) coho juveniles; fall Chinook juveniles; winter steelhead outmigrants; and coastal cutthroat trout that would otherwise use these locations during fall, winter, and spring as temperature regimes are within preferable range. In addition, the limited hydrologic capacity/connectivity leads to poor functionality in regard to water management capability for irrigation.

A. Subsidence:

It is important to visit the issue of subsidence through time. Removal of water in 1908-1909 through tidegate installation and canal construction effectively reduced the average summer water table by around 5.0ft. Through millennia prior to 1908, soils on the floodplain forested tidal wetland developed with deposition of sediments during flood events that flowed to the extent of a highly dendritic channel networks. Not all sediment was deposited through tidal channels. A large overflow channel directly entering the Winter Lake floodplain from the Coquille River was also diked in the mid-1900s, which has prevented heavy influx of turbid waters.

No less important to subsidence has been the oxygenation of the highly organic soils, which has allowed bacterial digestion similar to a compost pile. When the wetlands were drained in 1909 thousands of years of carbon rich leaf litter from trees, layers of detritus, such as slough sedge, rushes, and other wetland plants that had reached maturity in the late summer each year, and then fallen into water directly or on the forest floor were incorporated into soils. This resulted in a very carbon rich soil profile and the constant tidal inundation resulted in limited levels of oxygen in the soil to support bacterial decomposition. Soil layers in the top 5-8ft may have been 60%+ carbon prior to dewatering. Accordingly, once dewatering allowed for oxygenation bacteria would have been able to use this carbon for energy. This condition is very prevalent in the farmlands around San Francisco Bay, where some locations have subsided over 20ft. The current condition at the Phase III project area is that the soils have likely subsided in some locations greater than 3.0ft. Subsidence has not been uniform across the floodplain and thus there are locations where water currently struggles to drain as shallow depressions are now present. Subsidence has complicated fish ingress/egress and pasture management.

B. Hydrological Issues:

1. Channel Discontinuity:

Discontinuity of channel networks due to the original historic construction of linear "ditches" in 1908-1909, which redirected flows from the sinuous native/natural channel flow paths. This results in the inability for tidal inflow/outflow to move into and out of the floodplain pastures properly.

2. Insufficient Fish Access:

Insufficient interior channel network density/acre and average channel depths in Units 1 and 3 to provide access routes for juvenile fish to feed and find sufficient depth refugia. This condition results in limited utilization of large portions of the floodplain by juvenile OC coho, except when water levels exceed roughly 3.0ft above pasture elevations.

3. Fish Stranding*:*

Low-lying land areas within individual pasture ownership that are disconnected from channel networks, which results in water retention or "ponding" when flood levels decline and resulting in high stranding risk for juvenile coho on the floodplain.

4. Restriction of Tidal Flow:

Undersized culverts connecting to the main canals within Units 1 and 3 and the CDD pastures that restrict proper tidal/flood-flow and underserve hydrologic connectivity/irrigation needs in the period when salmonid fish would use the habitats and pasture production months.

5. High Invert:

Culverts were in many locations installed with an invert elevation inappropriately high, which results in a condition where pasture channel networks at early winter water elevation levels are disconnected from main canals resulting in delayed ability for fish to enter the floodplain and resultant increased potential for stranding and predation.

6. Top-Hinged Tidegates:

Top-hinged tidegates on the existing interior culverts upstream of the C3P tidegates that are difficult to manage in the open position (Figure 4). This results in restriction of fish movements from the canals into pasture floodplain channels where food availability is higher and competition with non-native fish lower.

7. Channel Grades:

Channel networks that were not constructed on-grade and thus do not allow for sediments to be transported properly, resulting in premature accumulation, limited connectivity for fish movement, and poor drainage for landowners. Limited excavation/maintenance through time to compensate for the poor sediment transport capacity of these historical designs has led to sediment accumulation restricting inflow/outflow of these interior channels. Reconstruction or new construction is now needed to achieve the desired capacity and functionality.

8. Underserved Acres:

Poorly located linear channel networks that do not follow land elevation hydrologic paths and undersized segments, with both insufficient volume capacity, length, and or routes to provide connectivity to hundreds of acres of agricultural pastures within the BSDD resulting in highly limited ability to utilize the capacity of the new C3P tidegate for irrigation.

9. Nonnative Fish:

The main large canals are sufficiently large to serve C3P inflow/outflow capacity, however, Units 1 and 3 currently do not have ample channel lengths and volumetric capacity of interior pasture channel networks. This condition results in extremely limited ability to exchange volume when tidal influence is induced at the C3P tidegate. Resultantly, non-native fish including bullhead catfish, yellow perch, black crappie, bluegill, and mosquitofish are accommodated by the relatively slack water conditions within the canals that serve Units 1 and 3. This project will allow much greater exchange of volume in those canals reducing ecological dominance of species that are not native and move conditions towards native fish.

10. Water Quality:

The pastureland channel networks are insufficient in density and network layout to properly move water with the tidal inflow/outflow from the main C3P tidegates to manage water quality. Currently water will enter a channel and stagnate for long periods until a high flow event (Fall/Winter) or an irrigation event. Resultantly, dissolved oxygen levels deteriorate, and aquatic production reflects this poor habitat condition in affected areas. Water quality in late spring/summer/fall is largely a function of water movement into the canals and pasture channel network on incoming tide through water delivered from C3P tidegates and then outflow following high tide. Reconstructed/new channels will eliminate this issue as it will provide for direct connectivity to regular tidal inflow/outflow management at the C3P tidegates and much greater volumetric exchange of water.

11. Subsidence*:*

Two factors have contributed to subsidence of the floodplain pastures on the BSDD and CDD: 1). The historical input of sediments annually through floodflow delivery was essentially eliminated in 1909 with installation of tidegates that were not able to be opened during winter; and 2) Drying of the landscape through tidegate installation that allowed for bacterial digestion of the organic (carbon) components that comprised what were relatively peaty soils prior to 1909. Currently the C3P tidegate has restored a notable ability to deliver sediment laden floodwaters to the main canal networks. However, pastureland interior channel networks are greatly undersized, without divergences into large sections of pastures, and interior channels are linked to main canals with insufficiently sized culverts. Resultantly, the network is unable to provide for inflow of sediment rich waters to pastures reducing further subsidence and restoring this natural process.

12. Pasture Residual Water:

Channel networks that do not connect to low-lying areas properly resulting in long periods of standing water reducing pasture grass production during spring drain-out and early summer.

13. Improper Location:

Channel networks that are not located properly for individual pasture drainage/irrigation, resulting in over/under-watering of individual landowner pastures.

14. C3P Duration of Door-Open Condition:

The current interior pasture channels capacities are insufficient by several magnitudes to provide inflow volume capacity that allows a substantive timer period for inflow filling of the network prior to water reaching pasture elevation. With the C3P tidegates adjusted to allow for tidal inflow, the amount of water and the quantity of time from low tide to field height elevation is linked to the volumetric capacity of the canals and interior pasture channel networks. Increased channel capacity will allow for opportunity to keep the tidegates open a greater amount of time prior to water entering the pastures and impacting other land management needs. This duration when channel networks are able to absorb inflow is important within the DWMP for increasing the duration the slide-gates are open and fish can ingress on the incoming tide.

Figure 4. Typical top hinged flapper tidegate style currently used within Units 1 and 3.

C. Water Management:

NOTE: *The historically installed infrastructure (main tidegates and interior culverts and channels) have been used to provide both drainage and irrigation function since installation in 1909. Irrigation function has been used by ranchers within the BSDD consistently over the past 100+ years through opening of tidegates and allowing tidal inflow into pastures on high tide cycles. The new C3P tidegates installed in 2017, greatly enhanced irrigation inflow potential at the main tidegate network. Native fish have adapted to both tidal and floodwater inflow regimes. BSDD irrigation tactics utilize tidal inflow, which is a natural hydrologic pattern within native fish adaptive behavioral capacity. Native fish have used inherent adaptive genetic traits to react to tidal/floodwater cues that allow movement into floodplain habitats and retreat to channels following relatively short (6hr tidal cycles) inundation periods. Irrigation is implemented from mid-June to mid-September for the individual pastures over one to three days monthly. Coho juveniles are smolted and entering the ocean prior to the summer irrigation period. Salmonids are essentially absent from the BSDD canals and the mainstem Coquille River during summer months due to canal and river temperatures that have been measured as high as 80°F and 76° respectively. Irrigation utilizing tidal inflow during summer, is therefore considered to be companionable with the natural life-history of native fish that are present; and native salmonids are unlikely to be present during the months when irrigation is implemented within the project area.*

The Coquille River has a natural levee that developed over thousands of years as higher sediment deposition occurred in the first 100-350ft adjacent to the river channel with decreasing unloading as the floodplain extends to the north. The natural levee runs from the toe of a large point just west of Coquille on the north side of the river to the Beaver Creek natural levee ~13,600ft downstream. There are two channels that currently enter the main Coquille River through the natural levee that hydrologically connect the Winter Lake floodplain: the BSDD channel at the C3P tidegates and Beaver Creek. This levee has facilitated the ability to manage tidal water elevation within the Winter Lake floodplain up to elevation 10.5ft NAVDD88 through use of the C3P tidegate and CDD tidegate on Beaver Creek. At elevation 10.5 river waters overtop the Beaver Creek dike *(Figure 2*) and flows overland into the Winter Lake floodplain.

Tidal elevations observed in the mainstem Coquille River are softened by the riverbank friction in the length from the ocean to RM 21.5 where the C3P tidegate channel enters the main Coquille River. Despite this effect the tidal signal is substantial and generally ranges from a low of around +1.5ft on the lowest tides to highs at the C3P channel of 8.5+ft (See Northwest Hydrology Consultants “Hydraulic Analysis” in the BSDD Water Management Plan (DWMP) Appendix A)). Tidal signal is highly related to river flow and when precipitation events raise river flows the tidal signal is also dampened. River levels are able to exceed elevation 16ft NAVDD88 when major flooding events occur.

Up to elevation 10.5ft the C3P tidegates are able to resist inflow and provide water management of BSDD floodplain pastures of which ~1,295 acres are <8.0ft in elevation *(Figure 5)*. The C3P tidegate operations and water management goals within the District are based on the needs of both the upstream landowners and fish and wildlife goals, which are defined in the BSDD DWMP. The lands upstream of the C3P tidegates and the 39 BSDD culverts addressed in this **Hydrologic Assessment** are <u>subservient</u> to water management at the C3P tidegates and the BSDD DWMP, which has been reviewed and approved by the National Marine Fisheries Service (NMFS) and ODFW Fish Passage staff during the Winter Lake Phase I and II permitting process. The BSDD DWMP strategies for Units 1 and 3 are structured around seasonal agriculture pasture grazing and fish/wildlife needs with the following operational goals (*see Table 1*):

- *Winter Habitat Elevation Level:* November to March; transition in April-May
- *Spring Drain-out:* April to May
- *Summer Low Elevation:* June to October; transition in October-November

NOTE: *Individual landowners have plasticity under the District Water Management Plan to operate internal water control structures in transition periods for pasture management needs. The three culverts that will be addressed in the CDD are not under a Water Management Plan and are upstream and subservient to the Beaver Creek tidegate.*

Table 1. Beaver Slough Drainage District Water Management Plan (DWMP).

BEAVER SLOUGH DRAINAGE DISTRICT - OPERATING PROTOCOLS					
SEASON	**UNIT**	**WATER LEVEL**	**TARGET ELEVATION RANGE**		
WINTER - Oct to Mar:					
	Units 1&3				
		Basic Flush Level until first flood event or cattle are pulled	3.0	to	3.5
		After first flood event transition to Over Winter Habitat Level	4.5	to	5.5
	Unit 2				
		Complete transition to Over Winter Habitat Level	4.5	to	5.5
SPRING DRAIN OUT – Apr to May:					
	Units 1&3				
		Maximum Dry Out – maximum elevation	2.0	to	4.0
		Transition to Basic Flush Level as conditions allow	3.0	to	3.5
	Unit 2				
		Transition back to Basic Flush Level	3.5	to	4.0
SUMMER – Jun to Sep:					
	Units 1&3				
		Complete Transition from Maximum Dry Out to Basic Flush Level	3.0	to	3.5
		Irrigation Level – Every 10 to 14 days as per coordinated request from landowners	4.0	to	4.5
	Unit 2				
		Basic Flush Level	3.5	to	4.0
		Sept to October begin transition to Over Winter Habitat Level	4.5	to	5.5

1. Water Elevation Management:

***NOTE**: there currently are locations where the interior berms in Units 1 and 3 are below elevation 5.5ft NAVDD88 and in need of repair. This section discusses the water management goals with berms reconstructed to the goal height of elevation 5.5ft. The CDD tidegate (Figure 3) on Beaver Creek consists of three 6.0ft CMP's with top-hinged tidegates. There is no MTR capability at that site thus water is managed for Drain-out only. At the BSDD C3P tidegates water is able to be managed for Drain-out and inflow. At C3P VSFTG's are able to be opened to allow for inflow or outflow and secondary side-hinged aluminum tidegates allow for outflow only.*

a) When floodwaters are above elevation 10.5ft NAVDD88 water moves up Beaver Creek and subsequently flows over the low portions of the Beaver Creek levee just downstream of the CDD tidegate then moving across the pastures. At this elevation

Units 1, 2, 3, and the CDD are hydrologically connected in a lake like condition *(Figure 2)*. *(Berms that isolate Unit 2 were reconstructed to elevation 7.0ft in 2018; and berms around individual water management pastures in Units 1 and 3 are elevation 5.5ft or lower).*

b) As floodwaters recede below elevation 10.5ft the natural river levee along the Coquille serves as hydrologic control. The C3P concrete box culverts/tidegate outflow control point is through this levee and when river levels are below 10.5ft C3P is at an elevation sufficient to allow for management of water in the BSDD. From elevation 10.5ft and lower the BSDD is separated from the CDD by the natural levee along the west side along Beaver Creek (Figure 2). From 10.5ft as water recedes to elevation 7.0ft (Unit 2 berm height), Units 1, 2, and 3 are remain connected within BSDD, however, BSDD is disconnected from CDD at 10.5ft.

c) With water levels from elevation 7.0ft to 5.5ft Unit 2 is isolated from Units 1 and 3. As Unit 2 is located between Units 1 and 3 there is thus no longer connection of Units 1, 2, or 3 hydrologically below elevation 7.0ft *(Figure 2)*.

d) Below elevation 5.5ft the interior berms in Units 1 and 3 allow for individual water management on the various pastures using the interior pasture culvert water control structures and channel networks *(Figure 2)*.

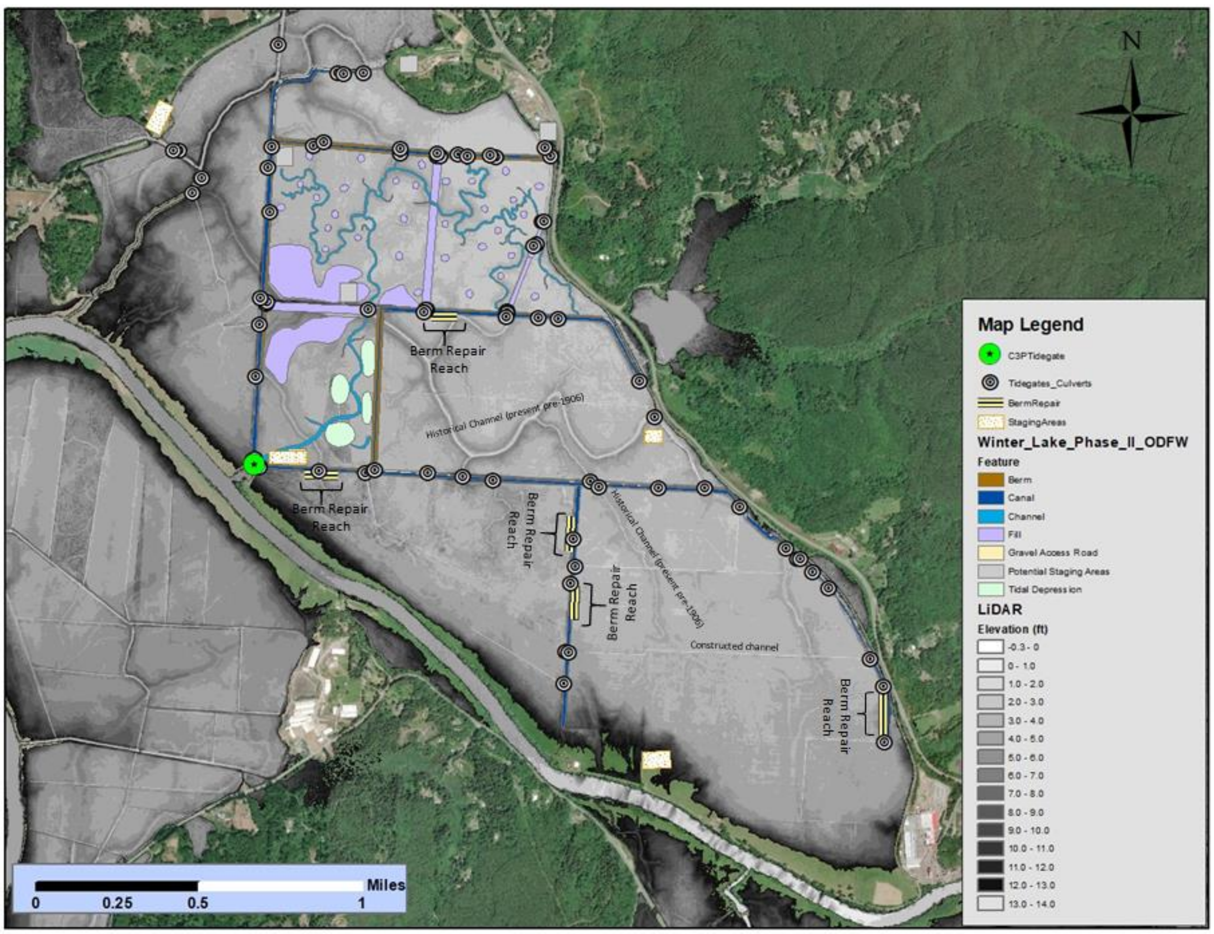

Figure 5. LiDAR elevational map and locations where berm reconstruction is needed. Grayscale depiction allows for historically installed linear pasture drainage channels to be visible.

D. Pasture Drainage Management:

NOTE: *In regards to Interior Pasture Culvert capacity it is important to keep in mind that above elevation 5.5ft water is able to move laterally over berms within the various pastures and into canals in Units 1 and 3 without dependence on or control through culverts and associated water control structures. This allows for large flood inflow/outflow volume movement independent of the culvert infrastructure when water is above elevation 5.5ft. The sizing of culverts and channels is: 1) In order to provide for fully adequate connectivity of pastures and canals below elevation 5.5ft; 2) To provide fully functional fish passage that meets State and Federal criteria in periods when water is restricted to movement through the Unit 1 and 3 culvert network below elevation 5.5ft.*

Water that is moved into the interior landscape from the C3P tidegate enters pasture floodplains through the existing undersized culverts that penetrate through earthen berms up to elevation 5.5ft whereas water is then able to sheetflow over berms. Currently the channel networks and undersized culverts connecting these channels do not provide capacity and connectivity that serves fish/wildlife and landowner needs. We have sized the new culvert infrastructure to respond to the inflow/outflow stimulus as river levels or tide levels are managed at the C3P tidegate. In the spring period when there is a strong need to provide pasture Drain-out for forage production, the proposed project will reduce the length of time needed to accommodate dewatering of pastures, which will be line with agricultural production goals.

E. Irrigation Management:

Irrigation for individual landowner pastures within Units 1 and 3 is incorporated in the period of June through September. Higher tide cycles associated with the moon phase are used to push water into the main canal networks, which is delivered to pastures through manipulation of individual water control structures on culverts through the interior pasture berms. Irrigation is able to be delivered when tides are generally above 4.0ft in elevation, through the peak of the tide. As tides subside water moves from pastures through sheetflow and the insufficient channel networks to the main canals and then back to the Coquille River through the C3P tidegate box culverts. Irrigation is generally for very short periods, e.g. three high tides over a three day period once a month. This equilibrates to roughly 6.0hrs of water delivery on a high tide cycle for three high tides over three days or a total of 18.0hrs of irrigation water delivery per month. When evaluated for the percent of hours per month that irrigation occurs, roughly 2.5% of the hours would be associated with inflow with another 6.0hrs for outflow/Drain-out or roughly 5.0% of the total hours per month. On an annual basis irrigation delivery including both inflow and outflow would account for 18hrs per month x 4 months or a total of ~72hrs per summer out of 8,760 hours per year or 0.8% of the period that fish would need to enter or emigrate from pasture channels. Flow velocities through interior culverts during irrigation events will potentially exceed 5.0ft/sec. However, due to the very limited duration annually that irrigation would be implanted and the period of year irrigation would occur, which is not a period when native migratory fish are present, we propose that the Phase III culvert sizing will meet Federal and State criteria in regards to irrigation management.

F. Culverts and Tidegates:

Historically, culverts on the project area were installed with undersized capacity for various reasons, however, often due to lower cost. There have been negative legacy effects during winter flooding for fish passage and subsequent extended drain-out in spring due to undersizing, which impacts pasture grass production. The Phase III project is designed to address the hydrologic capacity limitation associated with the culverts that are currently in place. Of the numerous channels proposed, four will also be realigned to reduce the overall culvert number needed from the current 42 to 38 through channel network consolidation. Old-style flapper tidegates predominate currently *(Figure 4)*. These will be replaced with either slide style vertical knife gate water control devices or side-hinged aluminum tidegates with a device to maintain the door open as desired. The BSDD DWMP dictates the water management strategies (Appendix A). This DWMP provides for a high degree of access for water and fish from the mainstem Coquille River during winter months. Landowners are on board with managing interior pasture channel culvert water control structures from November 1 to March 30th in alignment with the BSDD DWMP and needs for fish access and floodflow hydrology.

Note: *The BSDD DWMP provides for individual landowners to have individual water control structure management flexibility during April-May Drain-out and the pre-winter October transition period.*

G. Channels:

The existing channels in Units 1 and 3 were installed in the 1908-1990s without: a). Design that was based on microelevation topography on the landscape from interior pasture locations to delivery points with main canals; b). The drainage channels are linear along pasture or landowner boundaries; c). Channels were not constructed on grade, which promoted sediment accumulation rather than transport from deposition location downstream to main canals and to the mainstem Coquille River. *Historically, natural channels formed with on-grade morphology and transported sediments prior to installation of tidegates*; d). Channels were constructed with vertical side-wall form that accelerated natural sloughing and cattle hoof action soil deposition into the channels reducing their capacity to transport water.

These above noted factors, which are highly prevalent for existing channels in Units 1 and 3 have resulted in widespread hydrologic discontinuity, poor access for juvenile native fish to enter and leave pasture habitats, and poor drainage for production of pasture grass. There is high inherent potential for fish production within Winter Lake Units 1 and 3; however, their current hydrologic disconnection yields the issues noted in the previous ***Key Hydrology/Habitat*** section. Difficulty with obtaining permits has contributed to inability to conduct excavation maintenance in the past twenty years. Thus, for channels that were not on-grade and without proper hydrologic inflow/outflow to transport sediments (nearly the entire network) there is currently a condition where interior channel networks are clogged with sediment and vegetation and in need of reconstruction.

H. Interior Berms:

From 1908 until the mid-1990's interior berms were constructed utilizing the spoils from channel cleaning. These berms were built upstream of the C3P tidegate along the banks of the main north-south and east-west canals *(Figure 2)*. Berms have generally been elevated to 5.5ft NAVDD88, however, vary somewhat depending on the landowner/location with some short segments a bit higher. The berms in Units 1 and 3 historically provided secondary interior protection from tidegate leakage that occurred through the main CMP culverts and top hinged wooden tidegates draining Units 1, 2, and 3 into the mainstem Coquille River. Since the C3P tidegate Phase I project was installed there has been little or no leakage at the main tidegates. Culverts through interior berms predominantly have top hinged flapper style water control structures in use for providing secondary tidal inflow management. Despite the new functionality of the C3P tidegates in controlling water, the interior berms continue to have strong utility for providing water management during the late spring and early summer during Drain-out. In summer months these berms provide the ability to provide individual pasture irrigation management using the culvert and tidegate networks that enter pastures to deliver water where needed and prevent water entry into locations where livestock are grazing.

IV. WINTER LAKE PHASE III: PROPOSED PROJECT ACTIONS

A. Culvert Replacement*:*

Replacement of 38 of the existing 42 undersized pasture channel culverts and elimination of 4 on the BSDD and CDD project area. At one location, where the Messerle pasture road accesses the Winter Lake floodplain from Hwy 42, a culvert will be replaced with a bridge *(Figure 5)*. The remaining four culverts and their associated tidegates will be removed and consolidated within the remaining reconstructed 38 channel networks. The location of entry for six of these pasture channels and associated culverts to main canals will be moved in order to better configure the interior channel network to landscape topography and ground elevations. Culverts will be primarily HDPE.

B. Hydrologic Connectivity/Drainage Management:

Interior culverts and channel networks are critical for both providing adequate hydrologic connectivity to serve fish/wildlife and landowner pasture production needs. The 38 proposed new culverts have been sized to serve both water inflow and drain-out on the floodplain in order to meet both these goals. Fish access and pasture management are currently in a "poor" functional condition as ingress/egress for fish is limited and ranching operations are hurt by long durations of residual water in pasture areas that prevents proper grass growth. Water movement response time due to interior culvert and channel constrictions fails to properly reflect inflow/outflow from the C3P tidegate operations.

C. Pasture Irrigation:

There will be 12-15 irrigation management and cattle crossing culverts installed in addition to the main 38 pasture channel culverts. These will be interior to the 38 pasture channel culverts and will be sized according to equal or exceed the flow volumes at the points of the crossings. They will not restrict volume that is delivered to these deep pasture locations from the 38 downstream main pasture channel/main canal connecting culverts. As these deep interior cattle crossing culvert will meet or exceed water delivery volumes at the installation point they were not relevant for the Hydrologic Assessment calculations in relation to the C3P tidegates. These will be installed at pasture-to-channel junction points in order to provide for the ability to manipulate water into desired pastures during summer irrigation. These pipes will have associated slide/knife gate water control structures. They will be sized according to the location in the channel network based on the same methods as the main 38 channel culverts (described in Methods section). Exact locations will be finalized upon channel layout prior to construction. The water control structures will be managed to default of open, except when irrigating during high tides in summer months.

D. Water Control Structures:

The project is planning on replacement of tidegates on the 38 interior culverts with either: a). Side-hinged aluminum tidegates (Appendix B); with door brace for managing in the door open position b). Water control slide/knife gates operated manually through screw drive and wheel (Appendix B); or c). Other water control structures such as baffles or louvered gates. The individual water control types will be operated similarly and open as prescribed under the BSDD DWMP.

Note: *The team recognizes that ODFW and NMFS will have a requirement to review design drawings of non-traditional water control structures prior to approval and perhaps inspect function of a scaled down prototype model. Non-traditional water control structures will not be installed on the project until that threshold has been met in order to ensure agency staff approve that they can meet or exceed both State and Federal fish* *passage guidelines. Until that threshold has been met only traditional water control structures will be installed on the project area.*

E. Channel Reconstruction:

The Phase III project proposes reconfigure/reconstructing ~29,981ft or 5.7 miles of existing tidal channel *(Figures 6, 7, and 8)*. The majority of interior pasture channel networks are linear as is visible in Figures 5 and 6 that show the LiDAR elevations. These historically constructed channels were installed without attention to grade and inhibit the ability for fish to move successfully to and from the river without becoming vulnerable to stranding in low-lying pasture locations. This issue currently limits the use the pasture channel network by OC coho juveniles during the important fall/winter/spring rearing period.

F. New Channel Creation:

The project is planning creation of 74,670 ft or 14.1 miles of new tidal and tidal swale channels in Units 1 and 3 *(Figures 6, 7, and 8)*. These channels will encompass lessons learned from Ni-Les'tun and Unit 2 restorations including using on-grade design and bank sloping that maximizes edge habitats in order to:

- provide depth refugia for native salmonids in winter and native resident fish in summer months,
- contribute to greater utilization of the project area by juvenile coho, through increasing channel distribution on the landscape and capacity for fish penetration into the floodplain.
- provide adequate volume capacity for: **a).** A hydrologic connectivity relationship that more closely mimics water inflow/outflow management at the main C3P tidegate; **b).** Capacity that adequately provides for rain and floodwater outflow/drainage below elevation 5.5ft; and **c).** Capacity that provides for delivery of summer irrigation flows.

G. Interior Berms:

Interior pasture berms will be reconstructed to elevation 5.5ft NAVDD88 in locations where they have degraded *(Figure 5)*. Spoils from channel construction will be used to bring these locations into functional condition in order to allow for individual pasture/landowner water management up to elevation 5.5ft.

H. Habitat Uplift:

The Phase III project will incorporate a number of additional habitat uplift benefits. While these are not related to hydrology it is important to note that they will increase ecological functionality of the floodplain and reduce the potential that channels will reaccumulate sediments. These actions are more fully addressed in the Phase III project DSL/USACE 404 fill and removal permit. Proposed Phase III project actions that are designed to greatly enhance ecologic uplift include: Fencing, skip planting of trees, more appropriate channel construction bank sloping, installation of channels into current areas where fish are stranded, and other measures are noted in *Appendix D, Table 1*. The Phase III project goals include:

- Restoration of more natural fish passage from canal networks into secondary channel networks and pasture floodplain habitats.
- Increasing the quantity of water exchange as the new volume capacity of the interior pasture channel networks will provide for more inflow/outflow with main canals and the Coquille River, thus improving oxygenation.
- Improving the processing of livestock nutrients. New channels are designed with 1:1 (main channels), 2:1 (medium channels), and 4:1 (pasture swale channels). This side-sloping will

provide for greatly reduced bank erosion over traditional channels. The bottom and side slopes will be planted with a pasture seed mix. Roughly 60-70% of the channel surface in the upper 2/3 distance of these channels will be at an elevation where grasses will grow providing filtering of livestock nutrients during outflow from pasture floodplains.
- Improving the irrigation capability of the interior channel network as appropriately sized culverts feeding interior pasture channels will allow for greater volumetric delivery of water to irrigate pastures during single high tide events.

V. METHODOLOGY-Background

For any culvert or bridge replacement there is the need to determine the capacity of the new structure to accommodate the upstream flow volume that will be produced through precipitation or groundwater input. Many project sites feature naturally-formed channels that have developed morphology reflecting the hydraulic forces of the flow volume, slope, geology, and vegetative potencies. Channel size for a given watershed directly reflects the volume of water and the above noted factors. Tidal hydraulics, where the land area is well below the higher tide amplitude, result in a condition where tidal forces tend to dominate the hydraulic forces that contribute to channel evolution.

Prior to human manipulation, the Phase III project area had a dense network of channels that formed from both upland precipitation and geology, with tidal forces dominating in the lower elevations of the project area. Before the land was cleared of forest and developed into pasture, the tidal channels that were present ran largely north-northwest into Beaver Creek, where water was then transported southwest to the Coquille River. Through a combination of human intervention, hydrologic modification, and the installation of tidegates, these tidal regime forces were eliminated.

The original native channels were excavated through hand, horse, and steam powered equipment in 1908-1909. In 1908-1909 the drainage networks were circumvented for the BSDD portion of Winter Lake and converted into linear networks. The main exit point for the BSDD 1,700 acres was realigned and a new outlet was excavated through the relatively high river levee of the Coquille River at RM 21.5, where the C3P tidegate now currently exists. Channels on site currently reflect these excavated networks.

The large canals of Unit 1 and 3 were dredged with steam driven shovel methods. The canals size and capacity were more than adequate to transport rain and floodwater delivered from the pastures downstream. However, until Phase I was initiated in 2017, there was a large restriction of flow through both the original 1909 concrete culvert and its associated tidegates, and the four CMP's that were installed in the 1960's at the main Coquille River juncture. Interior pasture culverts have continuously been undersized since 1909. The 42 interior pasture culverts (39 in BSDD and 3 in CDD) that will be addressed through Phase III were essentially the best infrastructure affordable and available historically for the goals of ***a)*** agricultural production of pasture grass; and ***b)*** removing water in the late spring and early summer from the pastures to allow access for livestock grazing.

The installation of the new C3P tidegates in 2017 further illuminated the insufficiency of the interior network. The upgraded capacity and control to allow for inflow/outflow of tidal and floodflow to the main canals and interior pasture channels increased by 300% over the original 8.0ft CMPs that were replaced. The main north-south and east-west canals have been tested since the installation of the C3P tidegate and are considered fully sufficient in size to transport flows that are able to be delivered from the new slide-gate style tidegates. However, there remains a substantive bottleneck for volume delivery to the interior floodplain due to the 42 undersized culverts that currently connect pastures to the main canals.

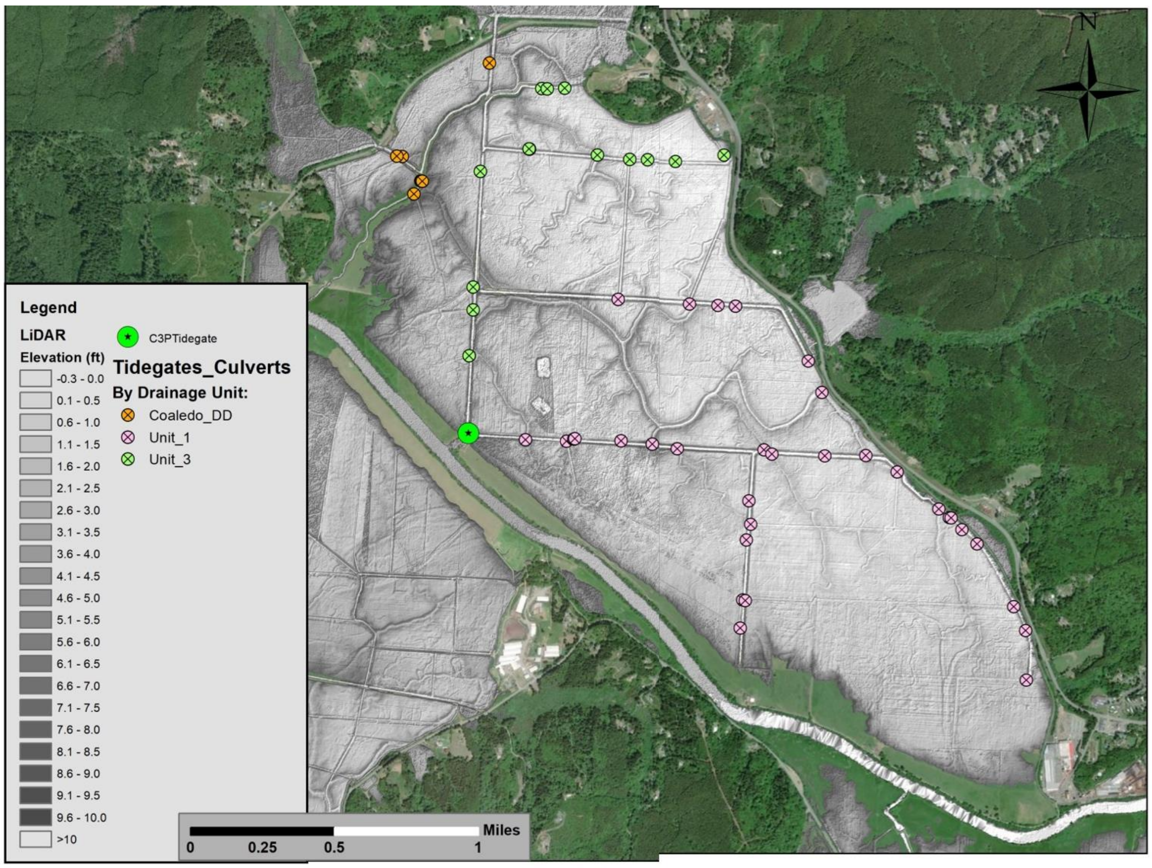

Figure 6. Grayscale Hillshade LiDAR imagery

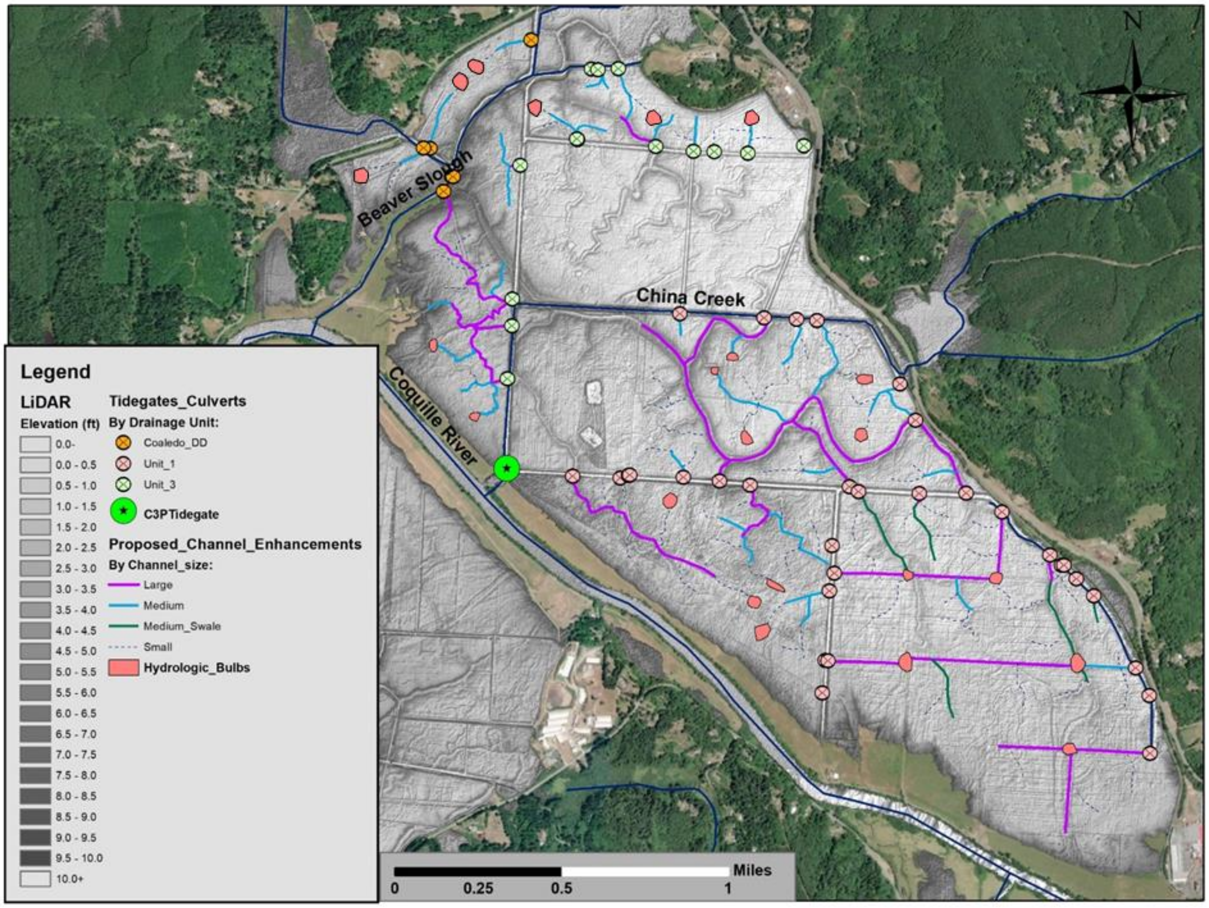

Figure 7. Grayscale Hillshade LiDAR imagery with proposed reconstructed channel network overlaid

The current floodplain pasture channels present are primarily linear shallow ditches that were constructed from 1908-current. The main tidegates downstream have for over 100yrs eliminated most of the hydraulic inflow/outflow forces due to constricted capacity where the land area water volume enters the river. Accordingly, pasture channel morphology has not been retained through time, or been further developed over time due to limited hydraulic forces; and/or does not reflect natural hydrological forces. This is an important feature for consideration in regard to the lack of ability to accurately measure Active Channel Widths (ACWs). In order to assess the proper size of culverts and associated channels that would accommodate a given inflow/outflow for the "microwatersheds" on the project area, we incorporated methodology based on a "Hydrology Logic Train" including the following Technical Tools:

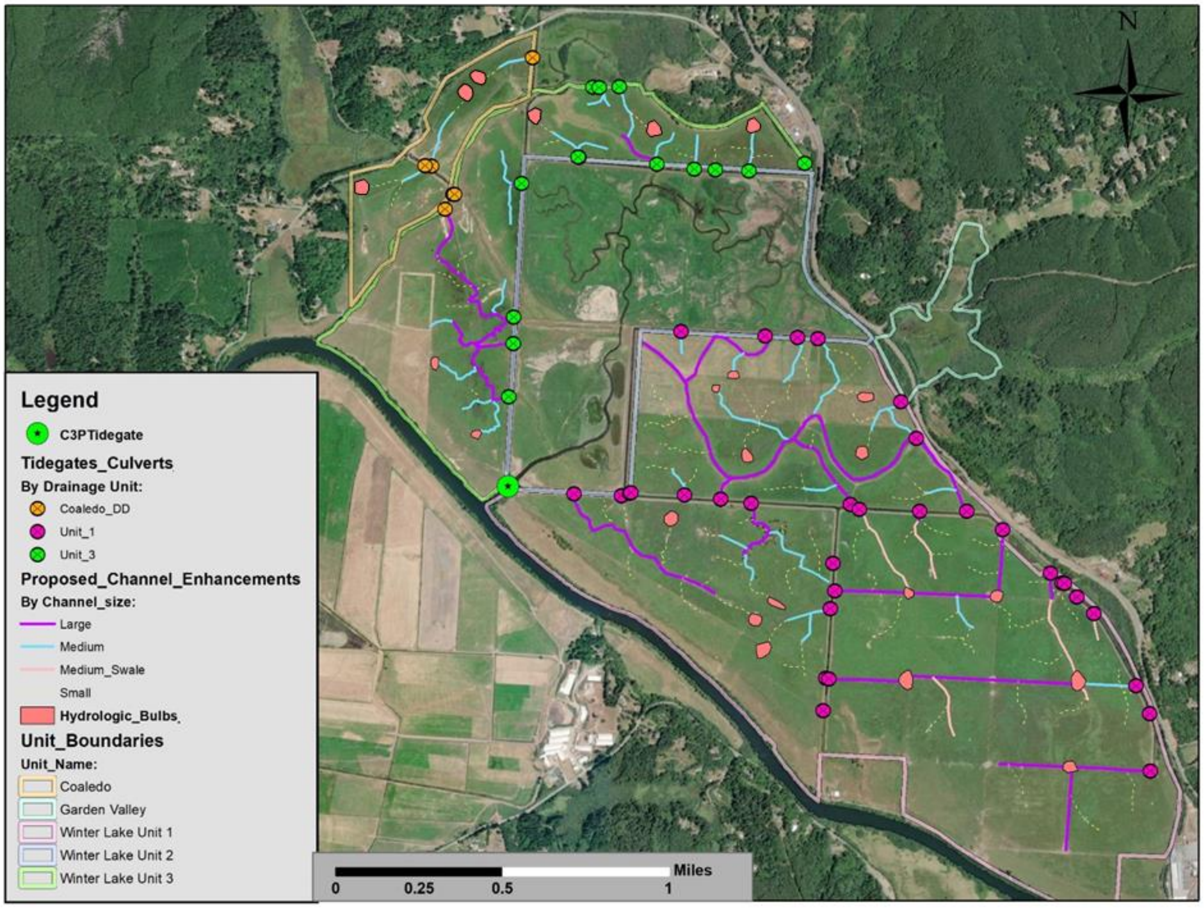

Figure 8. Winter Lake Phase III Proposed Channel Enhancements (hydrologic bulbs are not shown here)

A. Culvert Capacity per Land Area Served:

We determined the size of "microwatersheds" that would be served by the individual culverts proposed to be replaced, through use of the LiDAR, topographic drainage divides, and current culvert locations *(Figure 9)*. This was done as a technical assessment in order to better understand culvert capacity in regard to land areas.

Note: *It is important to note that these land area "microwatersheds" were for technical analysis and are not divided by substantial elevation divides and thus are either hydrologically connected continuously or with minor water elevation increases. This results in a condition whereas numerous culverts are continuously connected to a common water volume on a given pasture area.*

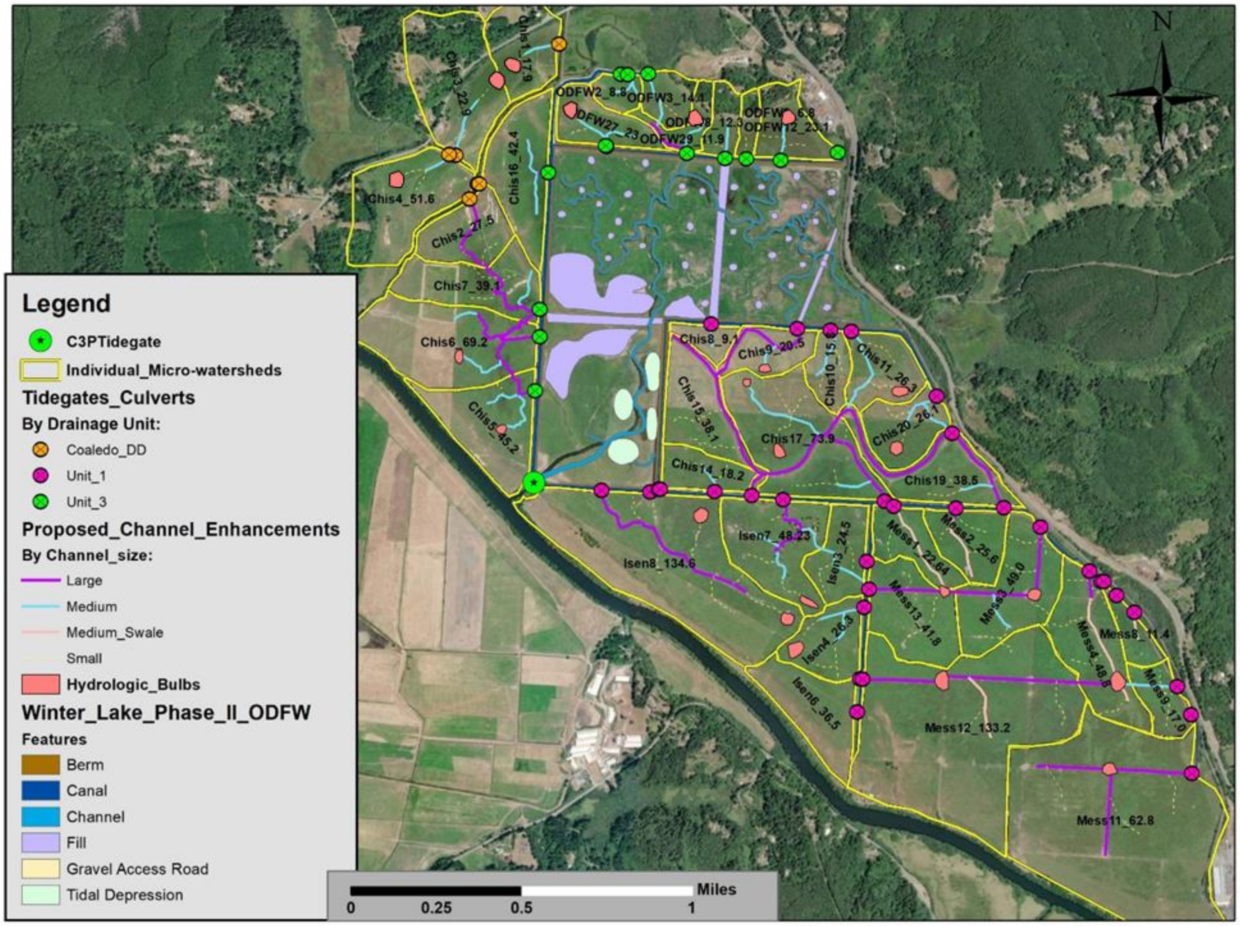

Figure 9. Phase III "microwatersheds" as delineated by LiDAR, culvert location, and main canal entry points.

B. Precipitation and Outflow Analysis:

In order to determine the volume of water that would be produced from precipitation events within the project area individual "microwatersheds" we used the local China Camp Creek watershed (Figure 10) as a surrogate. Through use of USGS streamstats (USGS 2020) regression analysis engine we determined an outflow per acre relationship. This was then applied to the individual "microwatersheds" to determine the cubic feet per second (cfs) outflow that would be expected from a precipitation event of 100yr floodflow magnitude. The 100yr precipitation event volume outflow for individual "microwatersheds" was then analyzed in regards to engineering culvert hydraulics tables in section *C. "Hydraulics Culvert Capacities."* below.

C. Hydraulic Culvert Capacities:

We used the flow volume precipitation regression to determine the cfs that would be produced for a given pastureland area for the 50yr and 100yr floodflows and then evaluated the volume/culvert relationships that would accommodate these flowing using volume tables that had been developed for fish passage (Foltz et al. 2009 and Robison et al. 1999).

D. Hydraulic Evaluation:

We used the combined Technical Tool information noted above (A-C) in our Hydraulic Evaluation to assess the volume capacity (sizing) of the 38 individual pasture culverts (35 in BSDD and 3 in CDD) that would be needed to meet flow dynamics that meet or exceed State and

Federal fish passage guidelines based on <u>an Individual Assessment and Synthesis of three methodologies:</u>

The C3P tidegate box culvert structures have been previously evaluated and approved by Federal and State Fish Passage staff to acceptably meet fish passage standards. We have designed the interior culvert and associated channel networks with capacity by Unit for Units 1, and 3 that meets or exceeds the volume capacity of the previously approved C3P 10x8ft concrete box culvert capacity (*Appendix A and Table 2*). As the interior culvert network is subservient to capacity of the C3P tidegate network and the proposed Phase III project actions result in an upgrade of capacity for interior pasture culverts and channels that exceeds C3P ability for inflow/outflow there was an assumption of fish passage compliance by default.

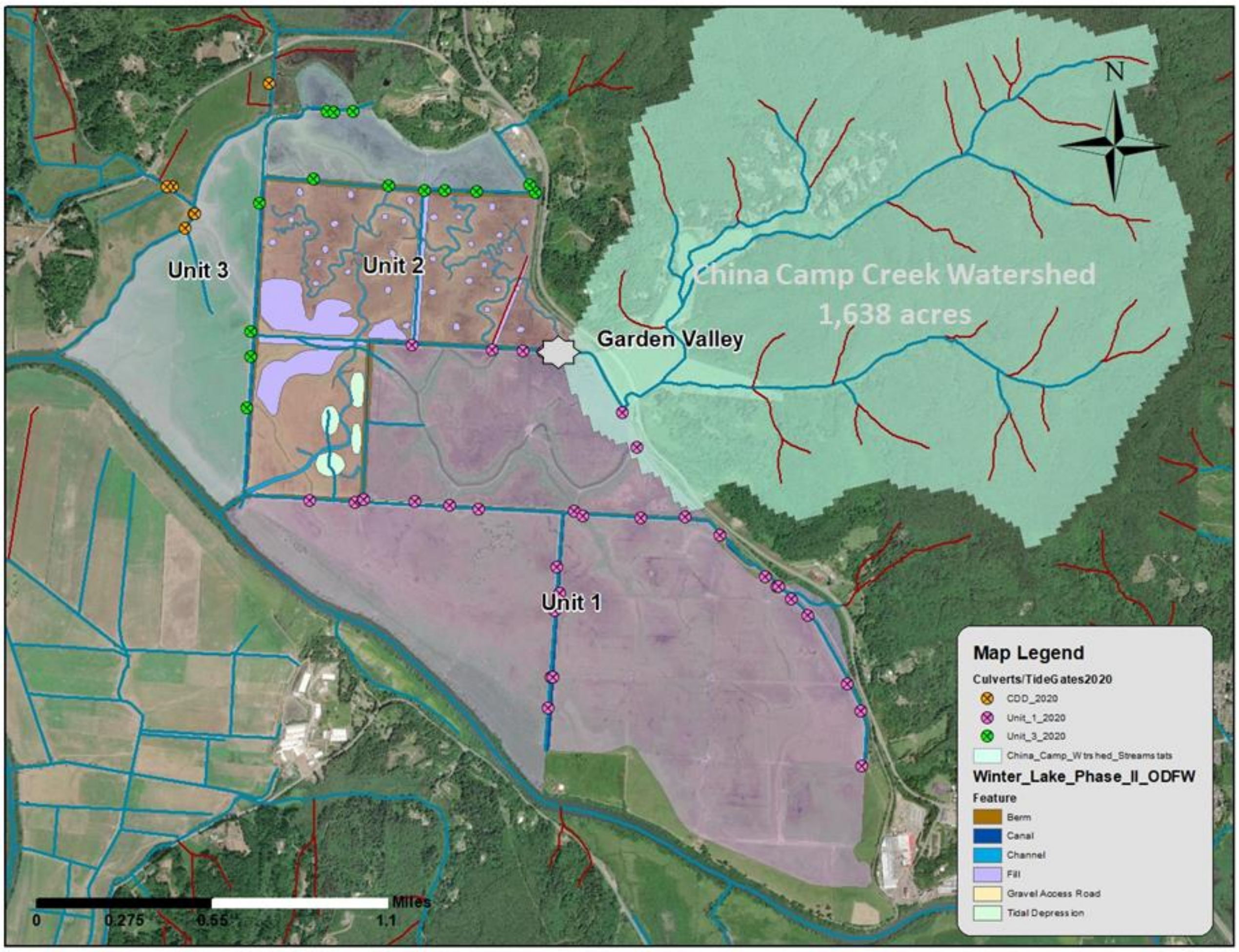

Figure 10. China Camp Creek watershed used as a surrogate for developing peakflow cfs/acre correlations.

Note: *For the CDD culverts this method was not applicable as* a) *the Beaver Creek CDD tidegate serves a large land area in addition to the two pastures within the project area; b) the Beaver Creek CDD tidegate culverts do not have MTR capability; and c) the CDD culverts were not evaluated for fish passage compliance through the Phase I project as they were outside the BSDD project area.*

We assessed the proposed interior culverts hydraulic capacity in regards to:

- Current culvert capacity in relation to proposed culvert capacity;
- Capacity of culverts to accommodate 100yr precipitation events and;
- Proposed culverts to accommodate C3P capacity.

Engineering literature was obtained pertaining to hydraulic capacity of culverts and fish passage. This information served as reference materials for evaluation including: a) Washington Department of Transportation (Barber, M. E. and R. C. Downs 1996); b) Oregon Department of Transportation (ODOT) 1990; c) Federal Highways Administration (Normann, M.N. et al. 1985), and the Oregon Department of Forestry Robison et al. 1999 (Appendix C).

ODFW Coos-Coquille Fish Passage permit information data from eight local sites in the Coos and Coquille River basins was evaluated in regard to the Active Channel Width (ACW) of streams at the location where a culvert or bridge crossing plan had been developed and the ACW had been measured. The upstream watershed size was then evaluated using USGS Streamstats and the regression analysis for a given land area was used to determine the ACW channel the watershed had naturally developed correlated with a given 100yr floodflow volume for the location in the watershed. Active Channel Widths that were naturally occurring for a given watershed size in local watersheds were then compared to the acreage areas for the Phase III "microwatersheds." The outflow volumes produced by the 100yr floodflows were in turn assessed in regards to the ACW, which would represent the size of culvert needed for a given "microwatershed."

VI. HYDROLOGIC ASSESSMENT

It is important to note for both inflow and outflow at the C3P tidegate there are very few occasions when all three vertical slide tidegate doors in Units 1 and 3 are open during water management. Thus, there is a predominant condition that interior culverts and channels upstream are subjected to flow volumes well below full capacity of the 10x8ft box culverts at the C3P tidegate. In the period from 2018-2020 the three slide-gates that serve Units 1 and 3 have only been open to their fully capacity position during short periods of very high flood flows as a measure equalize water elevations in Units 1, 2, and 3 in order to prevent overflow berm infrastructure damage in Unit 2. Water management on a daily basis predominantly involves partial opening of a single slide-gate door resulting in measured flow delivery well below full capacity. That said, we evaluated the proposed interior culvert sizing based on the methodology that C3P gates can at times be managed with full open gate door capacity. We recognize that this level of inflow/outflow assessment is several magnitudes above the standard DWMP prescriptions.

A. Culvert and Channel Size

Note: *It is worthwhile to keep in mind that substantive flood flows most often result in water elevations that are above elevation 5.5ft. Water during those events overtops the interior pasture berms nullifying culvert capacity relationships and concerns with culvert sizing until water has subsided to elevation 5.5ft. The 38 interior pasture channel culverts are <u>subservient</u> to the capacity of the C3P tidegate 10.0x8.0ft concrete box culverts and the BSDD DWMP.*

B. INFLOW Evaluation

The inflow of water to Units 1 and 3 is controlled by the C3P tidegate DWMP and day to day operations of the VSFTG slide-gates. Thus, the volume is limited by the capacity of the number of slide-gates that are open, the height of the slide-gate opening, and the head pressure of the tides. Landowners within the BSDD and CDD that within the Phase III project have agreed to an interior pasture culvert DWMP that provides for the following:

- *Pasture Grazing Season*:
  April through October; where interior pasture channel culvert water control structures will be managed open other than irrigation events. Transition period October-November.

- *Fall/Winter/Spring Flood Season:*
  November through March; interior pasture channel culvert water control structures will be managed fully open continuously. Transition period April-May.

Note: *It is important to keep in mind that individual landowners have plasticity under the DWMP to operate internal water control structures on a needed basis to provide for livestock pasture management goals during spring and fall transition periods. There is a strong need for this flexibility with varying weather and water conditions that affect operations in Units 1 and 3.*

Interior tidegates or knife/slide water control structures will be adjusted to the open position for the Fall/Winter/Spring season and operated in either closed or open during April to September as is needed for irrigation and individual pasture management of water. The core months where there is need for native fish access is during November through March. From May through September the water temperatures in interior pasture channels are generally above the tolerable range of salmonid fishes and they are no longer present inherently.

Northwest Hydrology Consultants (NHC) developed hydraulic analysis (*Appendix A*) of the capacity of the C3P tidegates during project design in order to provide information for the ODFW and NMFS review of the fish passage needs at the site. We evaluated the 23 Unit 1 interior culverts in regards to the capacity of the two 8.0x10ft concrete box C3P box culverts serving Unit 1 and the capacity of the current and proposed interior culvert sizes. The cfs capacity of the two C3P 8.0x10ft box culverts feeding into the east canal feeding Unit 1 is 600cfs x 2 or 1,200 cfs (*Table 2; reproduced from the Winter Lake DSL/USACE permit application Tetratech 2016*) with the tidegate and slide water control structures open to an elevation of 5.5ft.

The side-hinged aluminum tidegate doors at the C3P tidegates open to ~80° from when there is sufficient head pressure upstream and outflow. This angle, which is less than 90° undoubtedly produces some minimal water friction and turbulence associated with water moving past the door. We considered this headloss to be minimal, and thus assumed that the outflow with side-hinged aluminum gates will accommodate the full 600cfs capacity. However, the capacity is likely slightly less due to headloss. The estimated capacity of 600cfs per tidegate box culvert is likely slightly lower with flow through Unit 1 A and Unit 3 C3P culverts when the slide-gates are down and Drain-out reliance is on the side-hinged tidegate door. Our methodology, however, assumed full capacity of the C3P box culverts without tidegate door friction headloss.

In Unit 1 the project is proposing installation of 23 new properly sized culverts. Above elevation 5.5ft elevation water will run over the interior earthen berms and culvert capacity is no longer a limiting factor for inflow. In Unit 3 of the BSDD there are 12 culverts that will be replaced with larger culverts. In Unit 3 water is able to move over berms on the northern side of the Wheeler canal at elevation 5.0ft and culvert capacity no longer controls water flow. We assessed sizing/capacity for these culvert replacement combinations in relation to the capacity of the single 8.0x10.0ft concrete box culvert at the C3P tidegate that feeds into the north canal. The three undersized culverts will be replaced in the CDD with sizing based on relationship of the precipitation 100yr floodflow capacity, ACW and floodflow relationships, and hydraulics. Our assessment resulted in the following conclusions regarding culvert capacity by Unit, as compared to the C3P Tidegate:

1. Unit 1:

The current capacity of the two C3P 8.0x10.0ft box culverts with slide-gate tidegates serving Unit 1 with both doors open to 8.0ft in height at a water elevation of 5.5ft is 600cfs per door or 1,200cfs (Table 2). Above elevation 5.5ft water is able to move over interior berms and interior pasture culvert capacity is not a limiting factor. The capacity of the interior 23 culverts once replaced will be 1,781cfs (Table 3) at elevation 5.5ft with all of the slide/knife and side-hinged water control structures open from November through March.

2. Unit 3:

The current capacity of the single C3P 8.0x 10.0ft with the slide-gate door open to 8.0ft in height serving Unit 3 is 600cfs with water at elevation 5.5ft. Above elevation 5.0ft water moves over berms in Unit 3 and culvert capacity is not a limiting factor. The capacity of the interior 12 culverts upstream of the single tidegate of Unit 3 once replaced has been evaluated to be 654cfs (*Table 3*) at elevation 5.0ft with all the slide and side-hinged water control structures open from November through March.

Note: *Two of the interior pasture culverts in the analysis of Unit 3 were already replaced in 2018 on ODFW properties.*

3. CDD Pastures:

The two pastures where work will occur in the CDD in Phase III are served by 3 interior pasture culverts upstream of the CDD tidegate on Beaver Creek. There is not an ability to open the CDD tidegates without chaining them open and there is rarely a need presently for irrigation in the pastures they serve. Thus, there is not currently demand for inflow through the interior pasture culverts. However, an upcoming project to replace the CDD Beaver Creek tidegate is expected to be implemented prior to 2025. This new tidegate would have MTR capability and thus we considered this in our culvert and channel sizing as well for these lands. The Phase III project is proposing to increase the capacity of these three existing culverts by 200%, 160%, and 178% respectively and these were sized based on “microwatershed” size, precipitation 100yr floodflow capacity, ACW/floodflow relationships, and hydraulic culvert capacity methods.

Table 2. C3P tidegate box culvert flow volume assessment reconstructed from C3P project and Winter Lake Restoration USACE/DSL permit application; Tetratech Engineering 2016

Culvert Area (Square Feet)						
Water Surface Elevation	8-ft CMP (Invert at -4.0 feet)	10-ft x 8-ft Rectangle (Invert at -2 feet)	Difference in Area from Existing to Proposed	Four 8-ft CMP's (invert at -4.0 feet	Seven 10-ft x 8-ft Rectangles (invert at -2 feet)	Difference in Area from Existing to Proposed
6.0		80	+80		560	+560
5.0		70	+70		490	+490
4.0	50.2	60	+9.8	201	420	+219
3.0	46.8	50	+3.2	187.1	350	+162
2.0	40.4	40	-0.4	161.7	280	+118.3
1.0	33.0	30	-3.0	131.9	210	+78.1
0.0	25.1	20	-5.1	100.5	140	+39.5
-1.0	17.3	10	-7.3	69.1	70	+0.9
-2.0	9.8	0	-9.8	39.3	0	-39.3
-3.0	3.5	0	-3.5	13.9	0	-3.9
-4.0	0.0	0	0.0	0	0	0.0
Maximum Flow Volume (cfs) Conveyed by Culvert	*351*	*640*	*+289 (+82%)*	*1,407*	*4,480*	*3,073 (+218%)*

Table 3. Capacity of interior culverts proposed for Units 1 and 3 compared to C3P tidegate culverts.

Unit #		# of Culverts	Total Capacity Unit cfs	C3P Tidegate Capacity cfs	% diff Unit Clvrts to C3P
Unit 1		23	1,781	1,200	+148%
Unit 3		11 C3P/1Coaledo	654	600	+109%
	Totals	**33**	**2,435**	**1,800**	

4. Hydraulic Evaluation:

We also evaluated culvert sizing based on hydraulic assessment of the outflow volume that would be produced from the individual "microwatershed" zones with 100yr floodflow levels of precipitation. We compared eight watersheds in the Coos and Coquille River basins (*Figure 11*) where a stream location ACW had been previously measured, and then used a USGS Streamstats regression of the 100yr peakflow volume for the watershed at the location where the ACW was located (Table 4). This assessment indicated that for the majority (6 out of 8) of locations the recommendations from fish passage engineering literature for a given culvert sizing based on 100yr peakflow was larger than or similar to the ACW as measured for the individual sites (Table 4) and the two that were less than 100% were only slightly under. Using this relationship and design strategies for culvert capacity to exceed 100% capacity relationships (Table 5), we reaffirmed that the proposed culvert and channel designs were within standards for Federal and State fish passage guidelines.

Table 4. Measured Active Channel assessment in relation to hydraulically engineered fish passage culvert sizing recommendations from WashDOT, ODOT, and ODF.

Location/ Stream	SubBasin	Year Meas.	Map I.D.	Watrshed Size (Acres)	Streamstats 100yr flw (cfs	ACW Meas. (ft)	Clvrt Size (ft) for 100yr flw Hyd Tables[1]	Difference in Size (ft) Hyd vs ACW	Percent Diff
Catching Crk	Coos R	2019	**CatchC-1**	781	278	6.8	7.3	0.5	7%
Middle Creek_Trib	NF Coquille R	2016	**Lone_Pine-1**	365	190	5.6	6.3	0.7	12%
Cunningham Crk	Mnstem Coq R	2016	**CunningC-1**	6,912	2,560	14.0	30.7	16.8	120%
Salmon Gulch	MF Coquille R	2017	**SalmonG-1**	1,203	416	5.3	8.5	3.2	60%
Four Bit Gulch	SF Coquille R	2019	**FourBitG-1**	294	154	4.1	5.8	1.7	40%
S. Twomile Creek	Floras Crk/New R	2019	**S_TwomileC-1**	826	440	8.7	8.8	0.1	1%
Fall Creek	Big Crk/MF CoqR	2019	**BigC-1**	1,453	500	9.7	9.3	-0.4	-5%
"Huff Creek"	Big Crk/MF CoqR	2019	**HuffC-1**	198	80	5.1	4.5	-0.6	-12%

1). Based on values from Table 6 Robison, George E., A. Mirati, and M. Allen 1999, also in Foltz et al. 2009

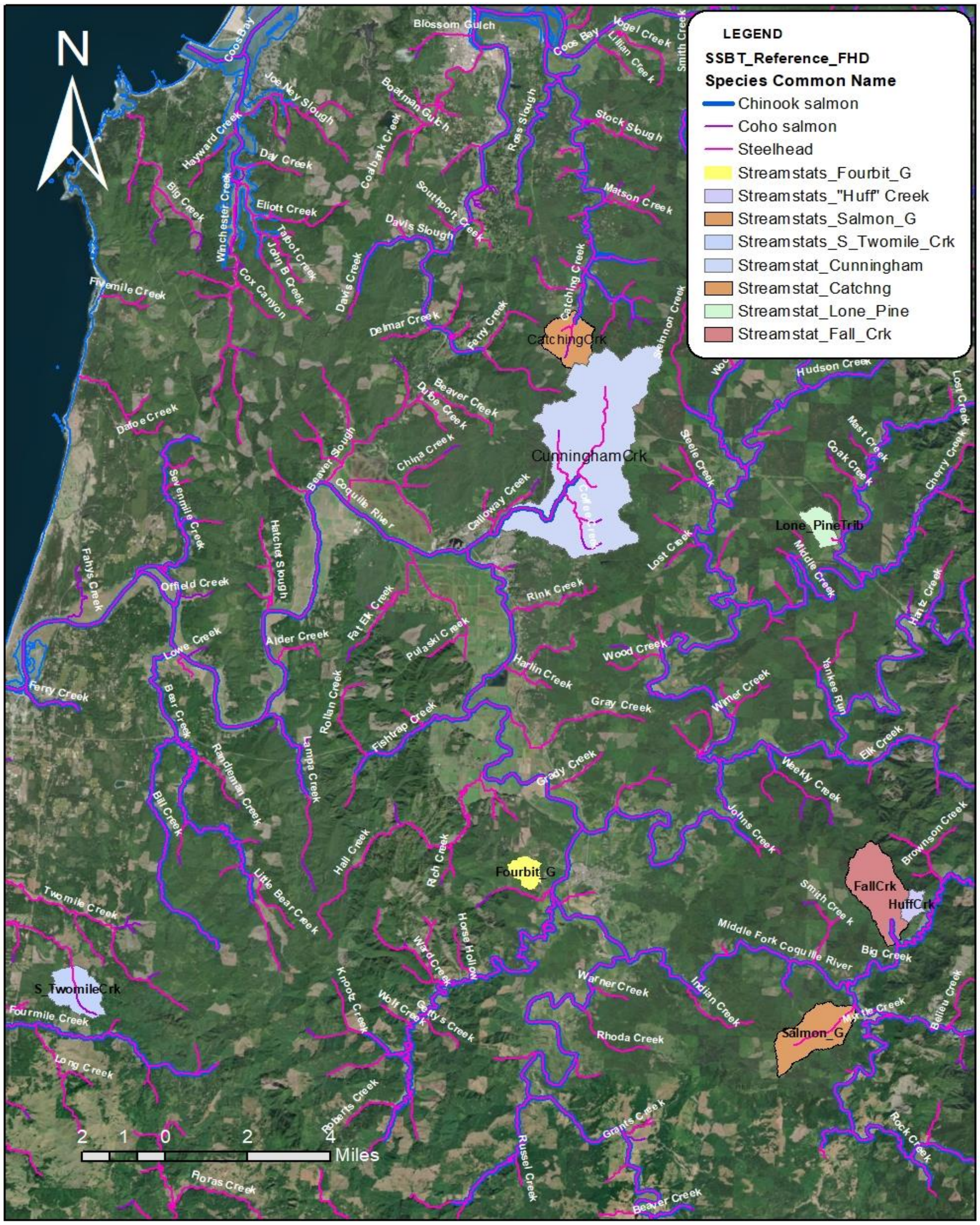

Figure 11. Stream basins where Active Channel Width to 100 Year Peakflow correlations were evaluated.

C. INFLOW Summary

It is important to keep in mind that the Phase III project is designed to provide capacity that will respond to inflow inputs from C3P in a manner that reflects appropriate capacity to mimic muted historical tidal regimes. The new and reconstructed channels will essentially repair the floodplain hydrology network that was broken in 1908-1909 when linear canals were installed that transverse the historical natural channel system, which drained to the northwest rather than the human constructed direction to the west and then south. Low elevation ponding will be connected reducing stranding potential for juvenile fish and providing hydrology regimes that increase wetland function.

We have determined that the inflow capacity of the interior 23 and 12 culverts in Units 1 and 3 once replaced exceed the delivery volume capability of the C3P tidegates in Unit 1 by 148% and 109% in Unit 3. Overall, there will be a total volume inflow capacity at elevation 5.5ft for interior culverts in Units 1 and 3 of 2,435 cfs as compared to 1,800 for the C3P three VGSTG gates that serve Units 1 and 3 respectively (Tables 2 and 3). The C3P tidegate network volume and DWMP plan have been approved by ODFW and NMFS. Accordingly, as the volume capacity for inflow of the interior culverts following Phase III will exceed the C3P box culverts capacity we are suggesting that the interior water conveyance sizing meets Federal and State fish passage guidelines. The culverts proposed for the three CDD locations were sized 200%, 160%, and 178% greater than the 100yr floodflow volume based on hydraulic methods developed from "microwatershed" and ACW relationships.

The reconstructed and new interior pasture/floodplain channels proposed for the project will have a bottom width that equals or exceeds the culvert that they are aligned with. The side-sloping of these channels will range from 1:1 for the first 200-500ft depending on the location and then will be 2:1. This side-sloping will result in channel form with *at least a minimum of 30% greater capacity than the culverts that serve them.*

D. OUTFLOW evaluation

Note: *It is important to keep in mind that individual landowners have plasticity under the DWMP to operate internal water control structures on an as-needed basis to provide for livestock management goals during spring and fall transition periods. There is a strong need for this flexibility with varying weather and water conditions that affect operations in Units 1 and 3.*

The type of water control structure on the interior 38 culverts will be determined by the project team (SWCD, BSDD, ODFW) and the individual landowners. From November through March all water control structures will be set to remain fully open. In the typically warmer/dryer months of April through September it is exceedingly rare for 100yr peak flow events to occur. Outflow capacity calculations assumed full open movement of water through the water control structures for the 38 culverts in Units 1, 3, and for the two pastures sites in the CDD. We then incorporated the volumetric and ACW/100yr floodflow relationship as a second and third methodology, respectively, in addition to the overall capacity relationship already evaluated for the C3P tidegate and interior channel culverts (previously discussed under **INFLOW Evaluation)**.

- We used the information from Barber, M. E. and R. C. Downs 1996; ODOT 1990; and Robison et al. 1999 to determine the recommended culvert sizing for the outflow associated with the 38 "microwatersheds" in the project area (Table 5) using acreage and the 100yr precipitation floodflow data. We then analyzed our proposed culverts in regards to their ability to meet or exceed the recommendations and calculations.
- We used the assessment of information from the eight ODFW fish passage sites and USGS Streamstats regression of the 100yr floodflow in those watersheds to establish the relationship of 100yr peakflow culvert size/capacity relationships to the ACW of a stream. This was then utilized to determine the ACW that would have been present for a given "microwatershed" had there not been human alterations on the Phase III project area. We then used this relationship to assess if our culvert recommendations would reflect the ACW that would be present under typical precipitation and flood regimes within the project area. We determined that the 100yr peakflow for a given acre was 0.29cfs/acre in the China Camp Creek local representative watershed.

E. OUTFLOW Summary

We determined that the 100yr floodflow capacity for the 38 culverts as recommended in the BSDD and CDD Phase III project area following replacement ranged from 159.5 to 4,274.2% larger and averaged 969.9% larger (*Table 5*) than needed to accommodate the 100yr floodflow generated from the “microwatershed” acreage. Similarly, our evaluation indicated that the culvert sizing recommendations for the project ranged from 111.1% to 320.0% larger and averaged 215.2% larger (*Table 5*) than needed using the ODFW fish passage and 100yr floodflow/ACW site relationship.

Table 5. Phase III culverts proposed size assessment in relation to hydrologic flow volume that would be associated with 100yr outflow capacity for the individual "microwatersheds." ***Note:*** *Chis2, although connected to C3P, receives inflow from Beaver Creek, thus is not included in culvert/C3P calculations.*

Unit Number	CIS_ID	Chan Size	Acres	Acres_blw 10ft_elev	Current CulvrtSize_ft	Culvert Prop. (ft)	100yr Flow Clvrt [1]	Culvert_Cap% ± Prop Ovr 100yr[1]	Culvert_Size% ± Prop Ovr 100yr
Unit-3	Chis16	M	42.4	42.4	3.0	4.0	24	+598.8%	200.0%
Unit-3	ODFW27	M	23.0	23.0	4.0	4.0	24	+957.8%	200.0%
Unit-3	ODFW2	M	8.8	8.8	1.0	3.0	15	+1212.5%	240.0%
Unit-3	ODFW3	M	14.1	13.1	1.0	3.0	18	+756.8%	200.0%
Unit-3	ODFW29	L	11.9	9.56	None Present	4.0	15	+1851.2%	320.0%
Unit-3	ODFW8	M	12.3	7.6	2.0	4.0	18	+1791%	266.7%
Unit-3	ODFW9	M	6.8	4.0	1.0	3.0	12	+1569.2%	300.0%
Unit-3	Chis2	L	27.5	25.2	4.0	4.0	21	+801.1%	228.6%
CDD	Chis1	M	31.3	17.9	3.0	4.0	24	+703.8%	200.0%
CDD	Chis3	M	60.5	22.9	4.0	4.0	30	+364.1%	160.0%
CDD	Chis4	M	51.6	41.9	3.0	4.0	27	+426.9%	177.8%
Unit-3	Chis7	L	39.1	35.3	3.0	4.0	24	+563.4%	200.0%
Unit-3	Chis6	L	69.2	47.4	4.0	4.0	30	+318.3%	160.0%
Unit-3	Chis5	L	45.2	31.4	3.0	5.0	27	+860.5%	222.2%
Unit-1	Isen8	L	134.6	112.1	None Present	5.0	42	+289.0%	142.9%
Unit-1	Isen7	L	48.23	48.23	1.0	5.0	27	+806.4%	222.2%
Unit-1	Isen3	M	24.5	24.5	1.0	4.0	21	+899.1%	228.6%
Unit-1	Isen4	M	26.3	26.3	1.0	4.0	21	+837.6%	228.6%
Unit-1	Isen6	S	36.5	23.8	1.5	3.0	24	+292.3%	150.0%
Unit-1	Mess2	M	25.6	25.6	1.0	3.0	21	416.8%	171.4%
Unit-1	Mess3	M	49.0	49.0	1.5	4.0	27	449.2%	177.8%
Unit-1	Mess4	L	48.8	48.8	1.5	4.0	27	451.0%	177.8%
Unit-1	Mess8	M	11.4	11.4	1.5	4.0	15	2078.2%	320.0%
Unit-1	Mess9	M	17.0	17.0	2.0	4.0	18	1293.9%	266.7%
Unit-1	Mess11	M	199.3	162.0	2.0	5.0	48	195.1%	125.0%
Unit-1	Mess13	M	41.8	41.8	2.0	4.0	27	527.2%	177.8%
Unit-1	Mess12	M	177.2	137.6	2.0	5.0	42	219.5%	142.9%
Unit-1	Mess1	L	22.6	22.6	2.0	4.0	21	973.0%	228.6%
Unit-3	ODFW12	M	23.1	18.9	4.0	4.0	21	+1683.8%	228.6%
Unit-1	Chis8	M	9.1	9.1	2.0	4.0	15	+4274.2%	320.0%
Unit-1	Chis14	L	18.2	18.2	2.0	4.0	18	586.3%	266.7%
Unit-1	Chis15	L	38.1	38.1	2.0	4.0	24	+578.2%	200.0%
Unit-1	Chis9	L	20.5	20.5	2.0	5.0	21	+1897.3%	285.7%
Unit-1	Chis17	L	73.9	73.9	2.0	5.0	33	+526.3%	181.8%
Unit-1	Chis10	M	15.3	15.3	2.0	4.0	18	+1439.8%	266.7%
Unit-1	Chis11	M	26.3	26.3	2.0	4.0	21	+837.6%	228.6%
Unit-1	Chis20	M	26.1	26.1	2.0	3.0	21	+408.8%	171.4%
Unit-1	Chis19	L	38.5	38.5	4.0	6.0	24	+1591.4%	300.0%

1) Based on values from Table 6 Robison, George E., A. Mirati, and M. Allen 1999, also in Foltz et al. 2009

F. Microtopography, Differential Velocities, and Fish Passage

Note: *It is important to note that while vertical slide style tidegates provide ability to manage tidal inflow at Winter Lake C3P tidegates, fish passage for juvenile fish entering the land area from the river is accomplished by a combination of traditional side-hinged aluminum mechanical tidegates on slide-gates Unit 1A, 2C, and 3A and opening slide-gates to varying elevation heights.*

The pasture areas within the Winter Lake Phase III Units 1 and 3 overall have very low microtopographic instantaneous relief (*Figure 11*). There are some historic tidal channel ridges denoted in Unit 1 Chisholm East, and a strong ridge in Chisholm West. However, within individual parcels, the majority of the pasture areas are primarily uniform steady gradient land areas where water will move between the multiple channel networks as proposed (Figure 11; new and reconstructed channels are shown). This leads to a hydrologic condition whereas the individual culverts upstream of C3P function relatively as a single "culvert" connecting to the water volume on the landscape during inflow/outflow to the pasture areas when water levels are below elevation 5.5ft. Accordingly, the project has assessed the inflow volume capacity of Phase III interior pasture culverts proposed in relation to the C3P tidegate as a single Unit with the following knowledge:

1. Microtopographic Relief

Microtopography acreage differences vary less within Unit 1 than the lands in Unit 3 (*Table 6*), however, there is a larger quantity of low-lying <3.0ft elevation pasture in the Chisholm and Messerle parcels than Isenhart/Smith (Table 6). In Unit 3 there is substantively more low-lying elevation lands in the ODFW parcel than in the Chisholm West parcel (Table 1). However, in the Winter Water management period of November 15th through March 31st, the Coquille River minimum levels predominantly do not ebb sufficiently to allow low lying area pastures below elevation 2.5-3.0ft to drain (Figures 14 and 17). This results in a pasture hydrologic connectivity of the pasture culverts and a condition where inflow/outflow hydrologic forces are largely pushing on a common mass of water within individual landowner parcel sub-units. Water is then able to move across the landscape freely due to very limited 'microtopographic' relief, which will result in a condition where individual pasture culverts feed water into landscape with similar velocities due to hydrologic elevational equilibrium.

2. Tidegate Management

Although the Winter Lake Phase III project has sized interior pasture culverts based on the capacity of the C3P tidegate the DWMP goals and need to protect infrastructure result in a condition where the C3P Unit 1A, 1B, and Unit 3A vertical slide tidegates are rarely open more than 3.0ft from the closed position, which would be elevation +1.0ft as the bottom of the box culverts are at -2.0ft. For the majority of the period during the fall/winter/spring DWMP period a single slide-gate in Units 1 and in Unit 3 is open from 0.2ft to 2.5ft. We calculated the days during the fall and overwinter DWMP from October 1 to March 31st that the Unit 1A, 1B, and Unit 3A vertical slide tidegates were open 3.0ft or more. From October 1, 2018 to March 31st, 2019 Gate 1A was open a total of 2 days more than 3.0ft in the 172 day period or 1.1% of the time.

An openness of 3.0ft for a single slide-gate door equals a C3P inflow capacity of roughly 240cfs or (13.1%) of the 1,830cfs capacity of the 23 culverts in Unit 1 and 29% of the capacity of the low-lying culverts with elevation 2.0ft pasture area upstream. In Unit 1 the culverts that would be installed into low-lying pastures with elevation 2.0-3.0ft lands in Chisholm (6 clvrts) and Messerle (4 clvrts) have a volume capacity of 770cfs or 320.8% greater capacity than C3P will deliver with a single tidegate door open to 3.0ft in height. Singly for the Chisholm parcel the low-lying culverts proposed in Phase III have a capacity that is 449cfs, which is 187.1% of the C3P capacity with a single slide-gate open to 3.0ft. On an individual basis the low-lying culverts proposed for the Phase III project serving elevation 2.0-3.0ft lands in the Messerle parcel of Unit 1 have capacity of 321cfs or 133.8% of the capacity of a single slide-gate open to 3.0ft in Unit 1. In 2019-2020 the 1A tidegate was not operational for the period and was not opened. The 1B tidegate was open 3.0ft in height or greater (+1.0ft of elevation) for a total of 7 days or 4.1% of the duration from October 1 to March 31st in 2018-2019. Days when Unit 1A or 1B tidegates were open more than 3.0ft did not coincide. Data for 2019-2020 for slide-gate 2B was not able to be sorted due to errors from computer communications.

The vertical slide-gates for Unit3A were analyzed for time of openness for the condition where the tidegate door was open more than 3.0ft in height for the October 1 to March 31st 2018-2019 period. Gate 3A was open for a total of 2 days >3.0ft in height in 2018-2019 for an openness percentage of 1.1% during the period. This equilibrates to a time of 1.1% when the settings at C3P would be at 240cfs or greater inflow capacity. Upstream culvert capacity for the sum of Unit 3 culverts proposed is 654cfs. The capacity of C3P in Unit 3 with the gate door at 3.0ft is 240cfs or 36.7% of the Unit 3 overall capacity. The capacity of the C3P tidegate water delivery in regards to those low-lying culverts in Unit 3 is 84.2% of the capacity of the 6 culverts that would serve the lowest pastures on ODFW or rather these proposed low-lying culverts have capacity that is 118.8% greater capacity than the Unit 3 slide-gate open 3.0ft. Due to an error in the mod-bus and the computer control the data for 2019-2020 for the period was not available.

We anticipate more active management of the C3P tidegates during the Winter period in future years, however, this activity will be in relation to the number of days the slide-gates are open to any level rather than greater quantity of openness >3.0ft. It is important to note that vertical slide-gates are operated most of the time with door openness of <3.0ft in height over large periods of the winter to provide fish passage, while managing for berm stability, recreational public access, and livestock safety. The WMP provides the framework for this style of management in perpetuity. Operation of the slide-gates open to the 5.5ft elevation in a non-flood condition with interior water levels <5.5ft of elevation, below interior berms, where the interior culvert capacity is needing to accommodate C3P will be very rare.

3. Precipitation and Water Elevation

Water inflow into Winter Lake canals is monitored at the C3P tidegate computer network (*Figure 12-13*). The culvert capacity at C3P and DWMP strategies as served through control at the C3P tidegate have a strong dampening effect on inflow (*Figures 12 and 13*) and do not reach Coquille River tidal and flow magnitude or elevation levels on the same time curve (*Figure 13*). Inflow filling of interior pastures is over days generally rather than hours and includes precipitation accumulation in pastures as well as inflow during the Winter Water Management Plan period (*Figures 14-19*). The precipitation accumulation from streams/springs/groundwater within pastures and upstream of C3P in addition to inflow results in a decreased volume of inflow through C3P in order for pastures to reach a particular elevation during a rainfall or flooding event. The peakflow of China Camp Creek upstream of C3P at the 2yr event is 141cfs and at the 100yr precipitation event is 476cfs. Winter Lake lands are often filling upstream of C3P from “In Watershed” generated water at a similar rate as the Coquille river due to water within the BSDD and thus there is often limited movement of water through interior pasture culverts.

4. Sheet Flow

Above elevation 5.5ft the water will sheetflow over canal/landowner parcel berms and individual pipe hydraulic capacity above that elevation will not serve as a hydrologic control.

5. Inflow and Fish Passage

Fish will be able to move through culverts into channels with the inflow of tide/flooding events as well as on outflow rather than a state where they would need to fight culvert outflow velocities to enter a pasture area. This will accommodate fish passage on inflow over the inflow velocity range and with the differences that may occur with individual culvert/channel network locations.

6. Channel Network Connectivity

The interior new/reconstructed channels will be connected with channels from other pasture zones within hydrologically connected landowner parcels at a number of junctions in the networks allowing for hydrologic equilibrium between channels and pastures where elevations are low (Figure 11). This eliminates the "microwatersheds" from being separated in regards to hydrologic elevational equilibrium.

7. Tidal Wave Form and Fish Passage

Although fish are able to fully enter the individual Units pasture channels through movement on incoming tidal inflow, the culvert sizing and tidal hydrologic waveform allows for long periods where there is a range of velocities that serve to accommodate fish passage (*Figures 12 and 13*) during outflow as well.

G. Land Elevations within Unit and Parcel

We have calculated the individual landowner acreages for elevation 2.0-3.0ft, 3.0-4.0ft and 4.0-5.0ft using GIS LiDAR elevation mapping methods. The methods used, although more coarse than individual raster evaluation, provide reasonable land area elevation relationships (Table 6). At very low (elevation 2.0-3.0ft there is a greater quantity of land area in Unit 1 comparing Messerle, Chisholm, and Isenhart/Smith. Isenhart/Smith properties have very few acres that are elevation 2.0-3.0ft, however, from 2.0-4.0ft elevation the acreages for individual landowner parcels are more similar. The Chisholm cells within Unit 3 have no 2.0-3.0ft elevation area, while ODFW lands have 26 acres. However, from elevation 2.0-4.0ft these two parcels in Unit 3 have similar quantity of acres (Table 6).

Table 6: Estimates of Winter Lake Phase III project area lands by Unit/Landowner.

Unit	Parcel	Elevation 2.0-3.0ft Acres	Elevation 3.0-4.0 ft Acres	*Tot Acres Elev 2.0-4.0ft*	Elevation 4.0-5.0ft Acres	*Tot Acres Elev 2.0-5.0ft*	Culverts/C3P Nmbr in Parcel	Culvert Capcty Proposed cfs
1	Messerle	10	266	276	167	443	9	641
1	Chisholm East	43	136	179	43	222	9	755
1	Smith/Isenhart	1	70	71	170	241	5	385
3	Chisholm West	0	7	7	46	54	4	305
3	ODFW	26	39	65	9	74	7	349
	Unit 1 Totals	54	472	526	380	906	23	1781
	Unit 3 Totals	26	46	72	56	128	11	654
	Totals	**81**	**517**	**598**	**436**	**1,034**	**34**	**2,435**

Unit	Parcel	Culverts/C3P Nmbr in Parcel	Culvert Capcty Proposed cfs	C3P Capcty 1 Door 3ft (cfs)	Clvrts Prop cfs % to C3P @ 3ft
1	**Messerle tot**	9	641	240	+267.1%
	Mess_Low_Elev[1]	4	321	240	+133.8%
1	**Chisholm East**	9	755	240	+314.6%
	Chis_E_Low_Elev[1]		449	240	+187.1%
1	**Smith/Isenhart**	5	385	240	+160.4%
	Smth_Isen_Low_Elev[1]	*N/A*	*N/A*	*N/A*	
3	**Chisholm West**	4	305	240	+127.1%
	Chis_W_Low_Elev[1]	*N/A*	*N/A*	*N/A*	
3	**ODFW**	7	349	240	+145.4%
	ODFW_Low_Elev1	6	285	240	+118.8%

1) Low-lying denotes areas served by culverts that have acreage w. elevation 2.0-3.0ft

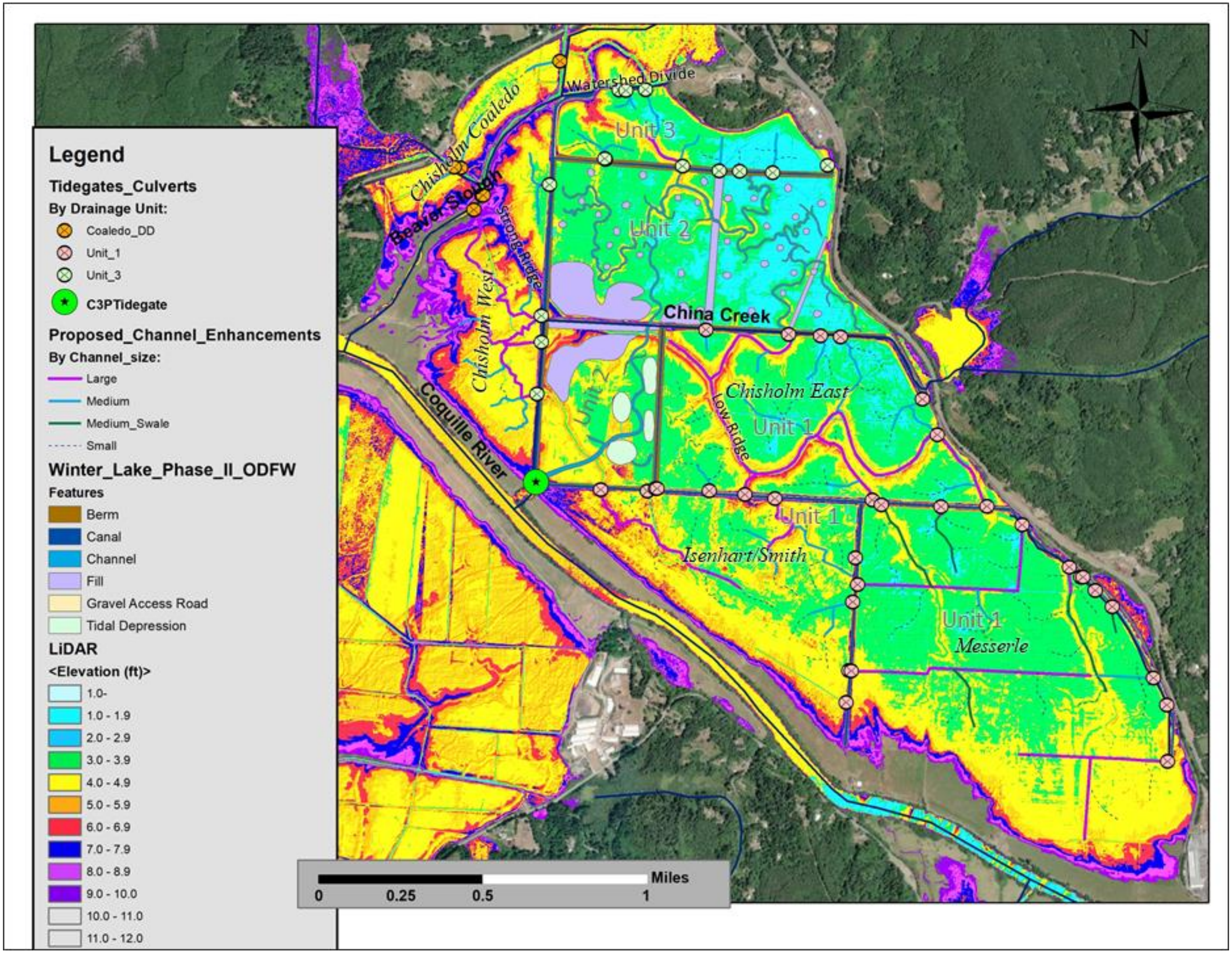

Figure 12. Winter Lake Phase III project area LiDAR depicted elevational relief with new proposed channels shown.

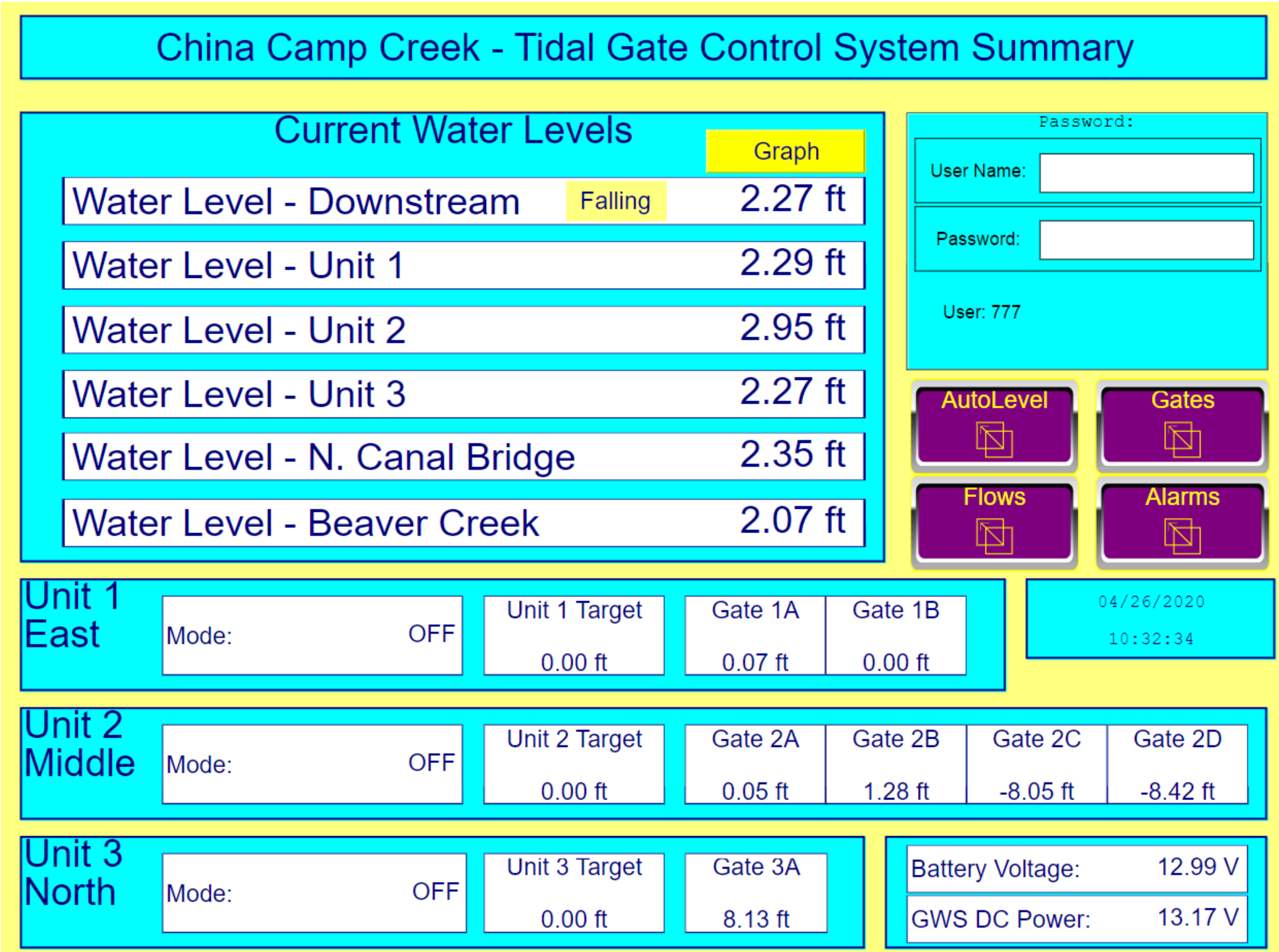

Figure 13. C3P tidegate control network readout as viewed on 04/26/20, outgoing tide 10:32hrs.

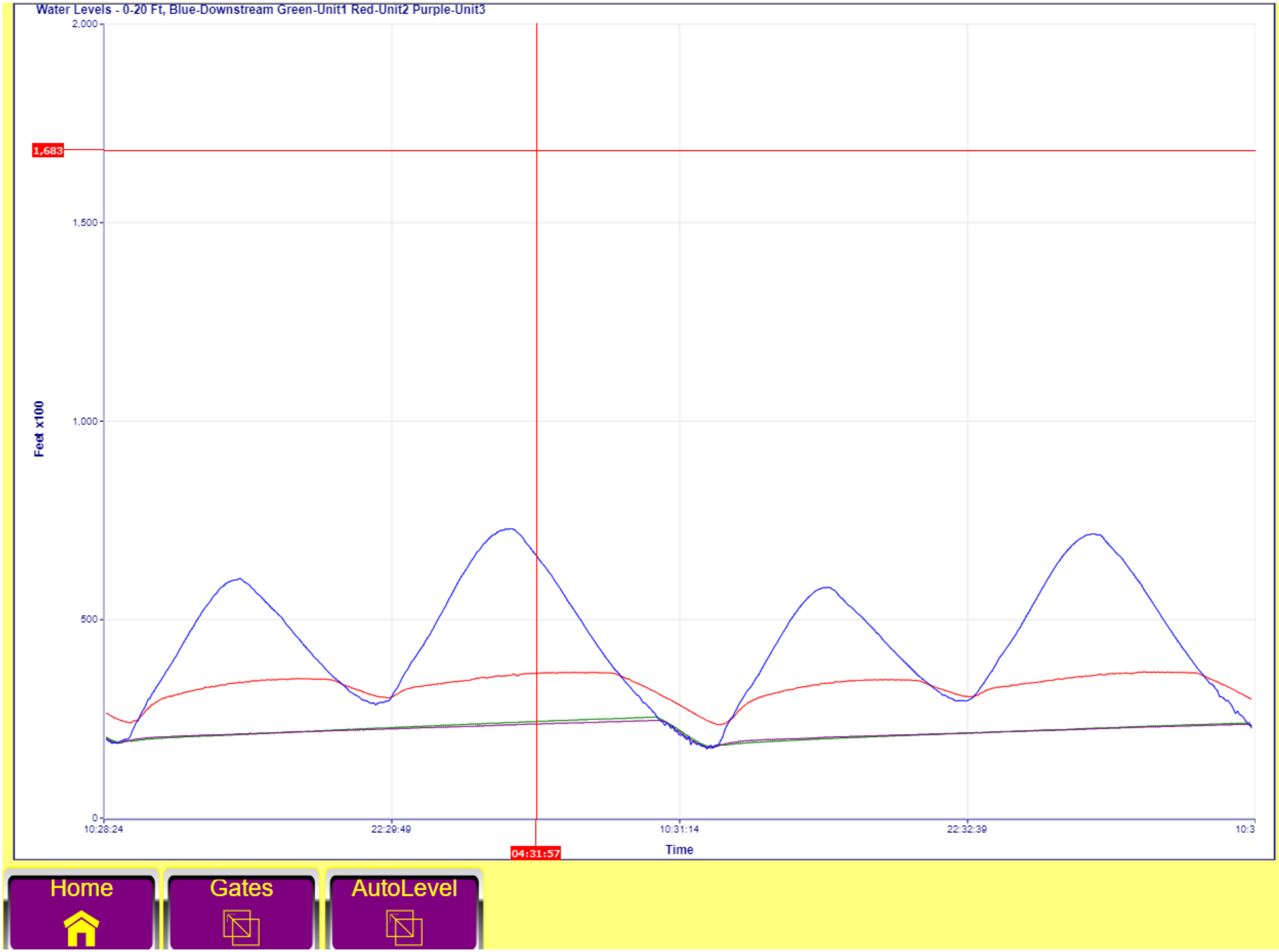

Figure 14. Water level waveforms as measured for the mainstem Coquille River and Units 1, 2, and 3 at the C3P tidegate; 04/26/20: 10:32hrs.

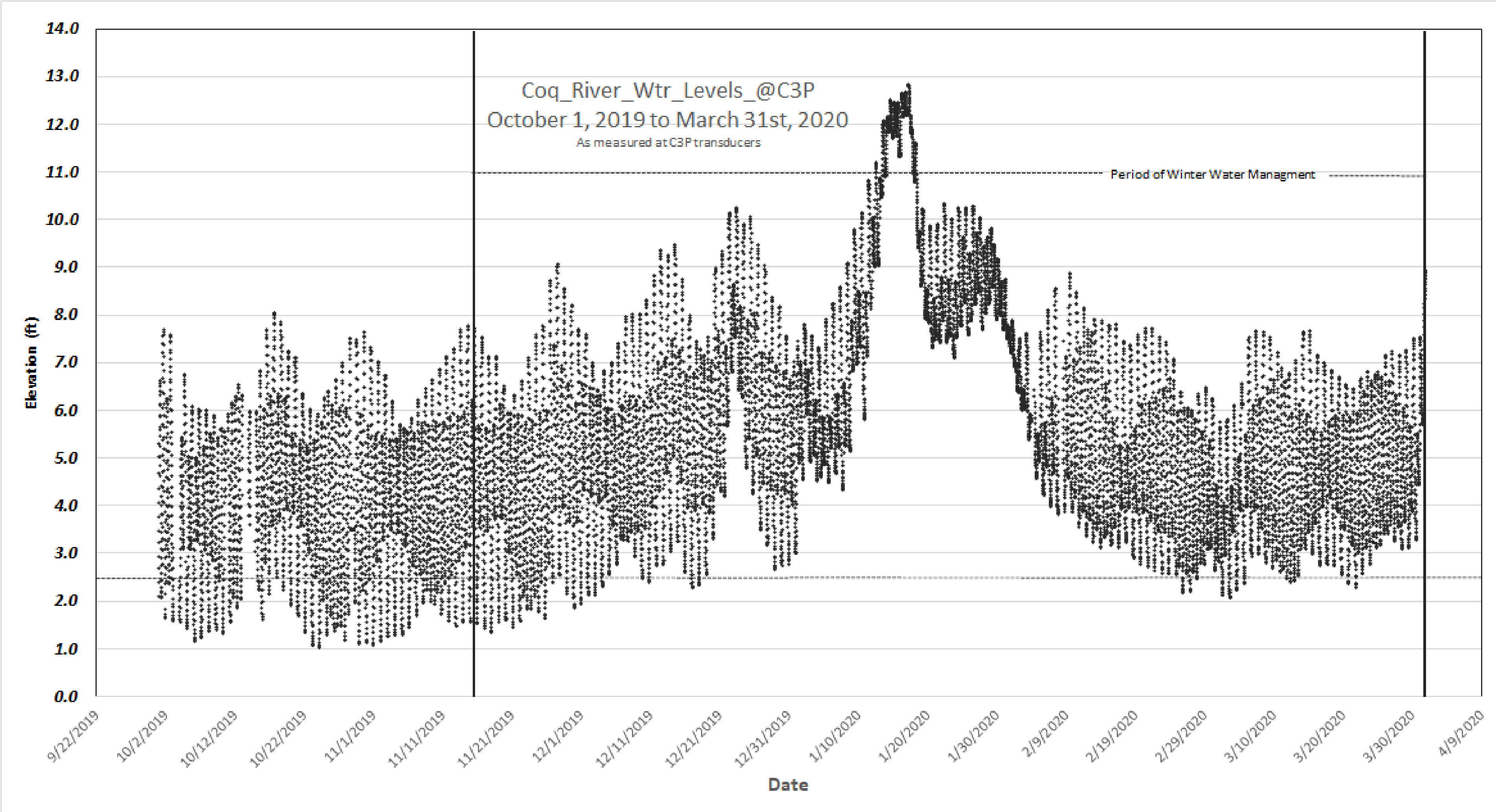

Figure 15. Coquille River Water levels as measured at the C3P tidegate from October 1, 2019 to March 31st, 2020.

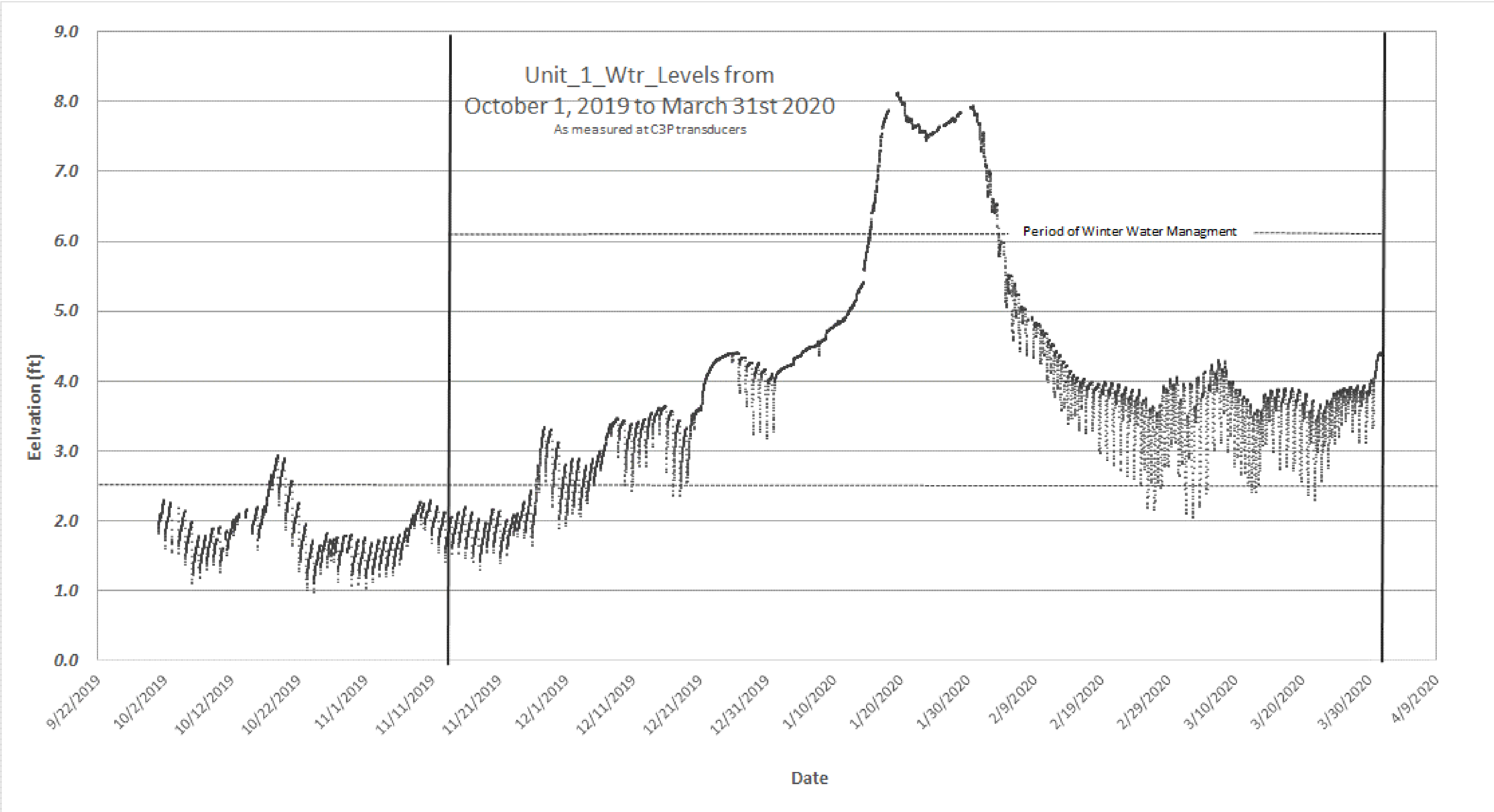

Figure 16. Unit 1 water levels from October 1, 2019 to March 31st, 2020 as measured at upstream of the C3P tidegates in Unit 1 canal.

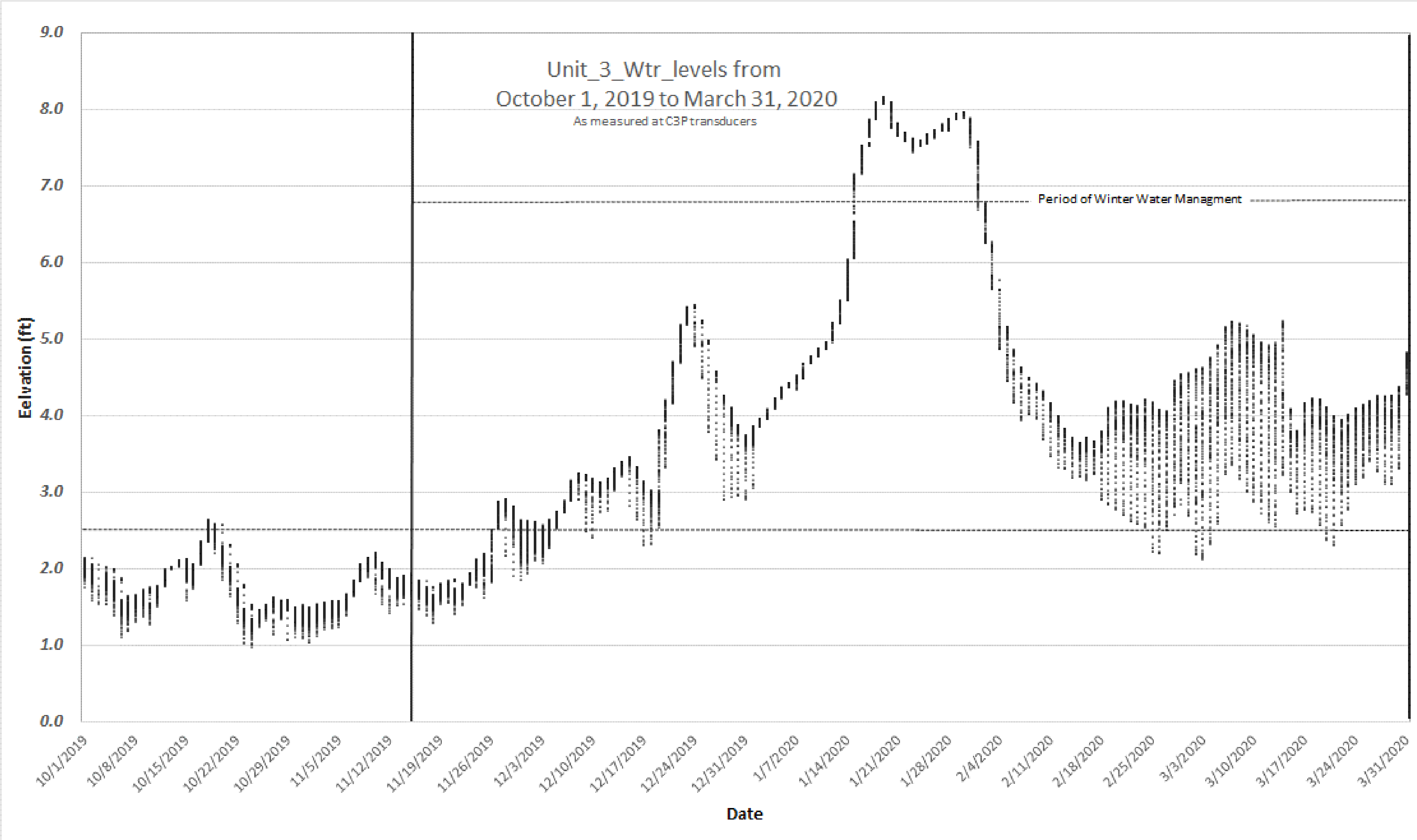

Figure 17. Unit 3 water levels from October 1, 2019 to March 31st, 2020 as measured at upstream of the C3P tidegates in Unit 3 canal.

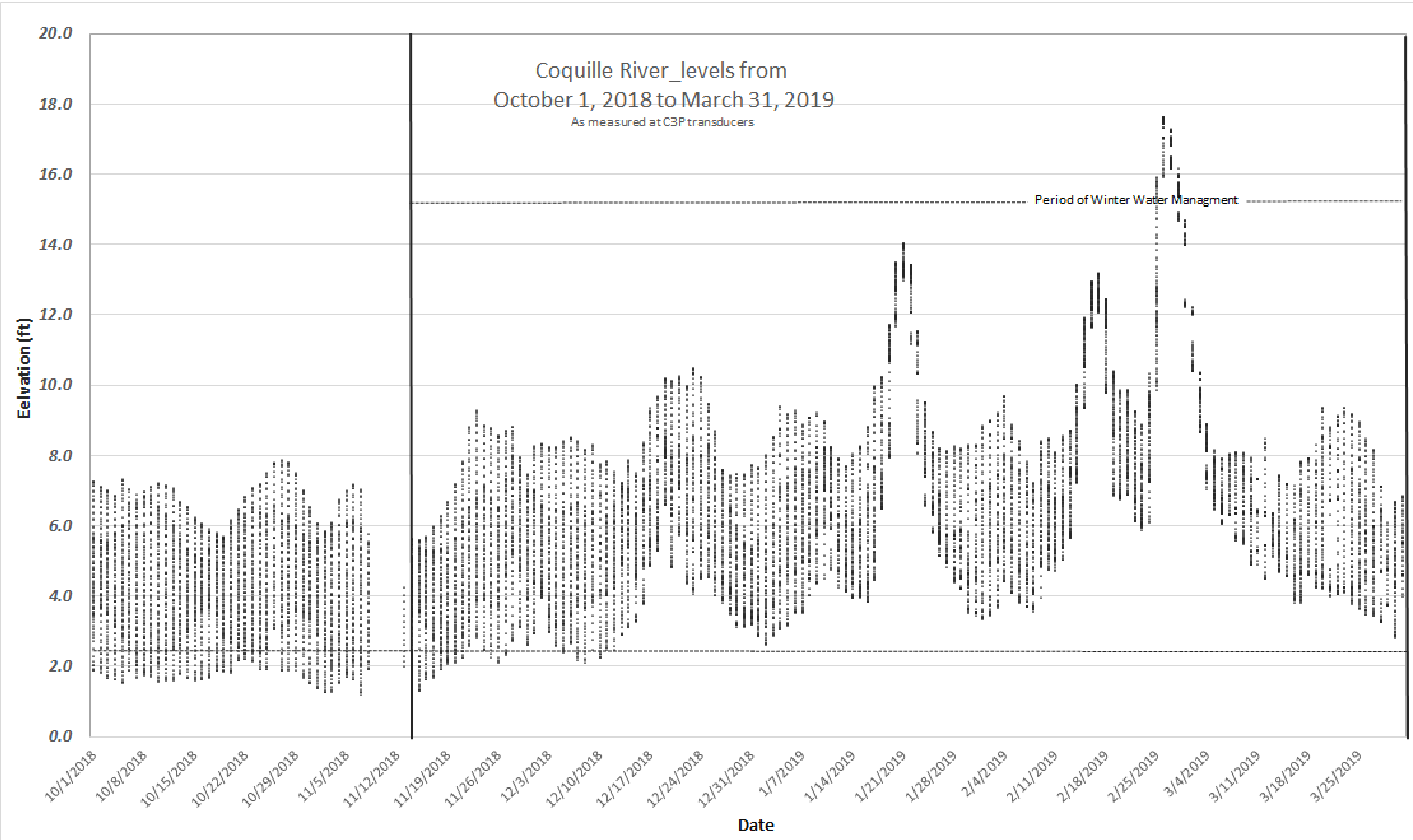

Figure 18. Coquille River water levels as measured at the C3P tidegate from October 1, 2018 to March 31st, 2019.

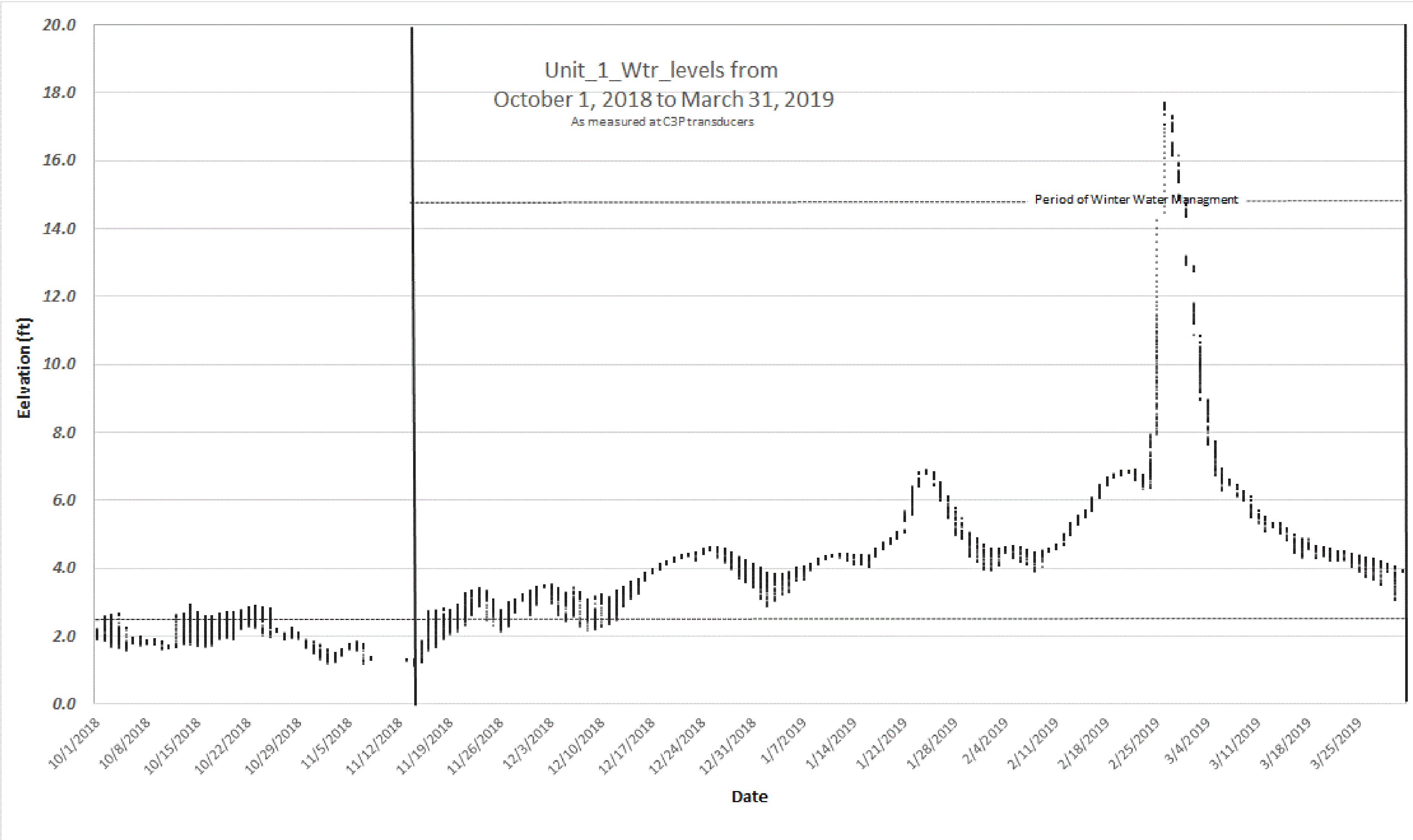

Figure 19. Unit 1 water levels from October 1, 2018 to March 31st, 2019; as measured upstream of the C3P tidegate in the Unit 1 canal.

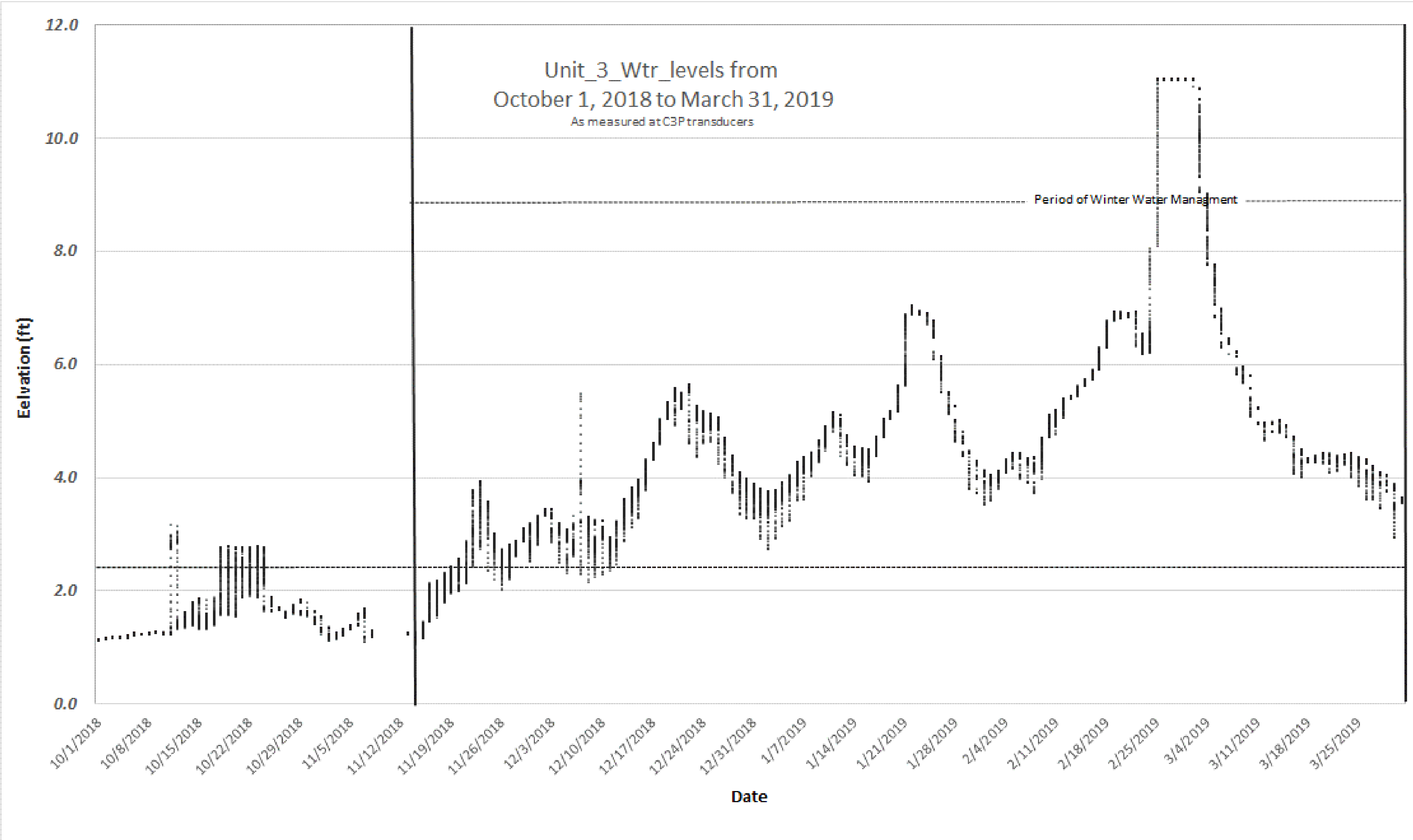

Figure 20. Unit 3 water levels from October 1, 2018 to March 31st, 2019 as measured upstream of the C3P tidegate in the Unit 3 canal.

VII. DISCUSSION

Culverts associated with interior pasture channels will be installed with invert elevation of -1.0 to 0.0ft depending on the individual culvert location on the Phase III project landscape. This will put them at an elevation where they will be backwatered continuously yearlong providing Stream Simulation conditions for fish passage that naturally occur in tidal floodplain wetlands (Appendix B Figure 1). Culverts have been sized to meet or exceed inflow/outflow needs and fish passage using three individual Technical Tactics and Synthesis of those methodologies; 1) overall C3P capacity relationships, 2) Hydraulic Capacity for 100yr floodflows, and 3). ACW relationships to 100yr floodflow and "microwatershed" pasture acreages (Streamflow and groundwater from precipitation is in the calculations). Our culvert sizing proposed exceeds the C3P tidegate inflow/outflow capacity Unit 1 by 148% and 109% in Unit 3. Using peakflow methodology the Phase III culvert sizing proposed exceeded hydraulic capacity needed on average by 215%.

Fish passage to the project area floodplain pastures is accommodated through both inflow and outflow rather than necessity for the weakest lifestage to swim against current outflow conditions as is present with culverts in in non-tidal stream environment conditions. As there is both tidal inflow directed under the DWMP and floodflow entry through the C3P tidegates, resultantly there are substantive periods when fish are able to move with flow into the main canal networks and pasture channels. We offer that this further assists when evaluating standard State and Federal fish passage criteria of 2fps flow velocity to provide for the weakest lifestage fish passage.

We evaluated the proposed interior culverts in regard to the surrogate ACW developed using USGS streamstats and known ACW relationships. The proposed Phase II culverts and channels were found to exceed surrogate ACW relationships, which is in alignment with ODFW 95th percentile fish passage criteria. The culverts on average were sized larger than ACW and we suggest also meet or exceed 1.5x ACW that would apply under NMFS passage TARP or SLOPES V restoration guidelines. Interior pasture channels have been designed with a minimum of 30% greater capacity than culverts and thus will not induce restriction of flow that has moved through appropriately sized culverts. We recognize that sizing based on ACW will fully accommodate precipitation outflow under State and Federal guidelines, however, we acknowledge that combining the afore mentioned culvert sizing methodology based on C3P capacity accommodates for tidal inflow/outflow as well.

The BSDD DWMP dictates the inflow patterns seasonally for Units 1 and 3 upstream of the C3P tidegates. The 35 proposed culverts (in the BSDD) will exceed the Unit 1 and 2 concrete 8.0x10ft box culvert capacity by 148% in Unit 1 and 109% in Unit 3. From the summer DWMP the C3P tidegates are managed to maintain water within the main canals and deeper pasture channels. Other than 18hrs per month when irrigation is likely to occur in June, July, August, and September water is not elevated onto pastures. This results in a condition where during the summer period inflow is managed minimally with water quality improvement strategies. However, interior pasture culverts are only engaged minimally. C3P tidegates are rarely operated during the fall/winter/spring period when native migratory fish are present with door openness >3.0ft from culvert floor or 240cfs inflow capacity. Low-lying culverts within Unit 1 (10 clvrts) exceed 240cfs by 320.8% and within Unit 3 (6 clvrts) by 118.8%. Accordingly, as these low-lying culverts will be connected to a common volume pasture of water they will work as a common assemblage to infill or outflow water from these pastures.

The overall capacity of culverts within Units 1 and 3 exceeds the capacity of C3P as permitted. The interior culvert capacity proposed for both Unit 1 and 3 that would be installed in the low-lying pastures exceeds C3P capacity and the low-lying culverts in both Units 1 and 3 exceed the DWMP inflow volumes that are predicted for the foreseeable future under the framework; accordingly, we would suggest*: a). as the C3P tidegate volume capacity is exceeded by the interior culverts served by C3P, and b). The hydraulic capacity and ACW relationships support the interior capacity methodology c). interior water control structures will be managed in accordance with the BSDD DWMP for the primary fish ingress/egress months of November through March; that the Phase III project aligns with prior Federal and State approvals for fish passage*. In alignment with approval of the C3P concrete box culverts and the BSDD DWMP in accordance with NMFS and ODFW fish passage guidance, we suggest that our supporting evaluation based on synthesis of three methodologies including interior culvert capacity flow volume in comparison to C3P capacity provides foundation for the Phase III project as proposed to meet Federal and State fish passage guidelines.

References

Barber, M. E. and R. C. Downs 1996. Investigation of culvert hydraulics related to juvenile fish passage. Washington State Transportation Center. Washington State University, Dept. of Civil and Environmental Engineering, Pullman, Washington. Prepared for: Washington State Transportation Commission, Department of Transportation.

Beechie et.al. 1994. Estimating coho salmon rearing habitat and smolt production losses in a large river basin, and implications for habitat restoration. North American Journal of Fisheries Management 14:797-811.

Bell, M. C. 1986. Fisheries handbook of engineering requirements and biological criteria. Fish passage development and evaluation program, Corps of Engineers, North Pacific Division, Portland, Oregon. 290 p.

Bustard, D. R. and D. W. Narver. 1975. Aspects of the winter ecology of juvenile coho Salmon *(Oncorhynchus kisutch)* and steelhead trout *(Salmo gairdneri).* Journal of the Fisheries Research Board of Canada 32:667-680.

Foltz, Randy B., P. R. Robichaud, and H. Rhee 2009. A synthesis of post-fire road treatments for BAER Teams: Methods, treatment effectiveness, and decision making tools for rehabilitation. Gen. Tech. Rep. RMRS-GTR-228. Fort Collins CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station: 2009: 152p.

Groot, C. and L. Margolis, eds. 1991. Pacific salmon life histories. UBC Press. University of British Columbia. Vancouver, B.C. 564 p.

Hartman, G. F. and T. G. Brown. 1987. Use of small, temporary, floodplain tributaries by juvenile salmonids in a west coast rain-forest drainage basin, Carnation Creek, British Columbia. Canadian Journal of Fisheries and Aquatic Sciences. 44:262-270.

Normann, M.N. and others. 1985. Hydraulic design of highway culverts. Report FHWA-IP-85-15. Federal Highway Administration.

Oregon Department of Transportation (ODOT) 1990. Hydraulics manual. Oregon Department of Transportation Salem, OR. https://www.oregon.gov/ODOT/GeoEnvironmental/Pages/Hydraulics-Manual.aspx.

E. George Robison, A. Mirati, and M. Allen 1999. Oregon Road/Stream Crossing Restoration Guide: Advanced Fish Passage Training Version. Oregon Department of Forestry, Salem OR. 1999:80p

Powers, P.E. et.al., 1998. Culvert hydraulics related to upstream juvenile salmon passage. June 20, 1996. Washington State Department of Fish and Wildlife Habitat Program.

Robison, George E., A. Mirati, and M. Allen 1999. Oregon Road/Stream Crossing Restoration Guide: Spring 1999. Oregon Department of Forestry 1999:80p.

Reiser, D. W. and T. C. Bjornn. 1979. Habitat requirements of anadromous salmonids. USDA Forest Service General Technical Report PNW-96. 54p.

Strahler, A. (1964) Quantitative Geomorphology of Drainage Basins and Channel Networks. In: Chow, V., Ed., Handbook of Applied Hydrology, McGraw Hill, New York, 439-476.

Schall, James D., Philip L. Thompson, Steve M. Zerges, Roger T. Kilgore, and Johnny L. Morris 2012. HYDRAULIC DESIGN OF HIGHWAY CULVERTS Third Edition. Ayres Associates 3665 JFK Parkway Building 2, Suite 200 Fort Collins, Colorado 80525. 323p.

USGS Streamstats 2020. StreamStats: Streamflow Statistics and Spatial Analysis Tools for Water-Resources Applications. https://www.usgs.gov/mission-areas/water-resources/science/streamstats-streamflow-statistics-and-spatial-analysis-tools

Appendix A:

Beaver Slough Drainage District Water Management Plan and Northwest Hydrology Consultants C3P Tidegate Hydraulic Analysis

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Appendix B:

Culvert Installation Design and Water Control Structures Proposed on Interior Culverts

Appendix B.

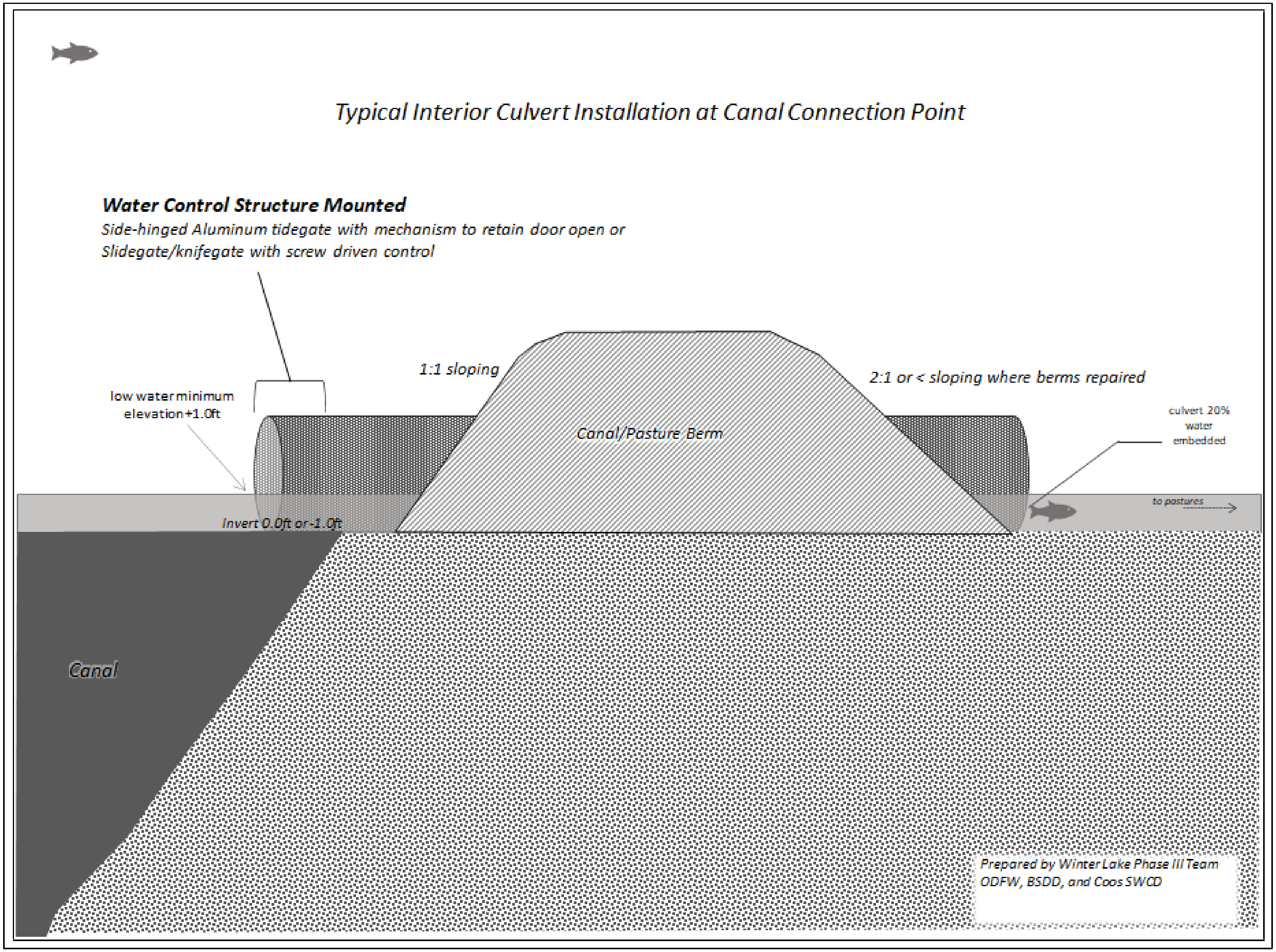

Figure 1. Winter Lake Phase III project typical interior culvert installation design.

Appendix B Cont.

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industries/product-174233-19232.html

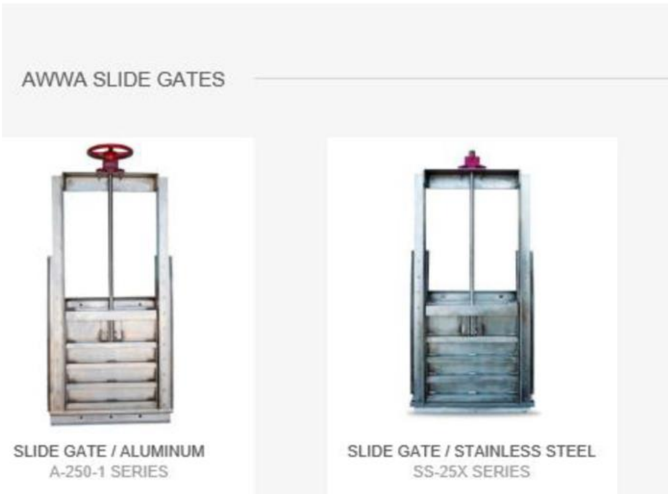


Figure 2. Slide gates proposed for selected interior pasture connection culverts.

Figure 3. Typical side-hinged aluminum tidegate mounted on 6.0ft CMP.

Appendix B Continued.

Figure 4. Side-hinged aluminum tidegate door in working location.

Figure 5. Other water control structures such as louvered gates or baffled water control structures are as of yet in the concept phase; no figure available.

Note: *The team recognizes that ODFW and NMFS will have a requirement to review design drawings of non-traditional water control structures prior to approval and perhaps inspect function of a scaled down prototype model. Non-traditional water control structures will not be installed on the project until that threshold has been met in order to assure agency staff approve that they can meet or exceed both State and Federal fish passage guidelines. Until that time only traditional water control structures will be installed.*

(To Be designed)

Appendix C:

Fish Passage Hydraulic Engineering Tables for Culvert Capacity

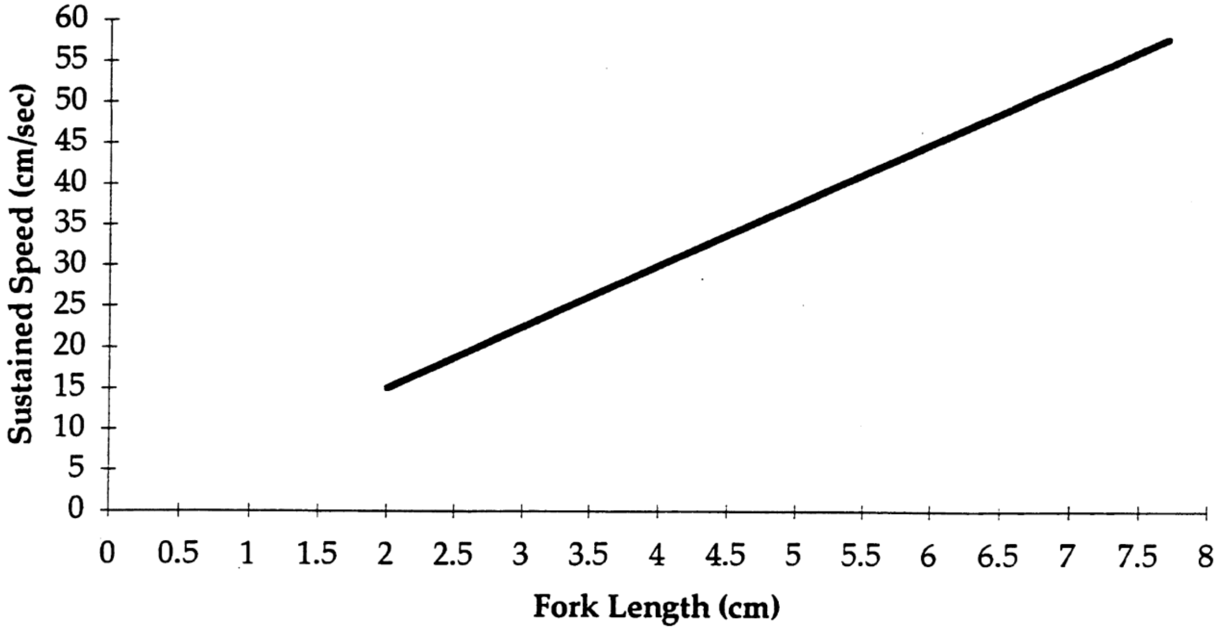


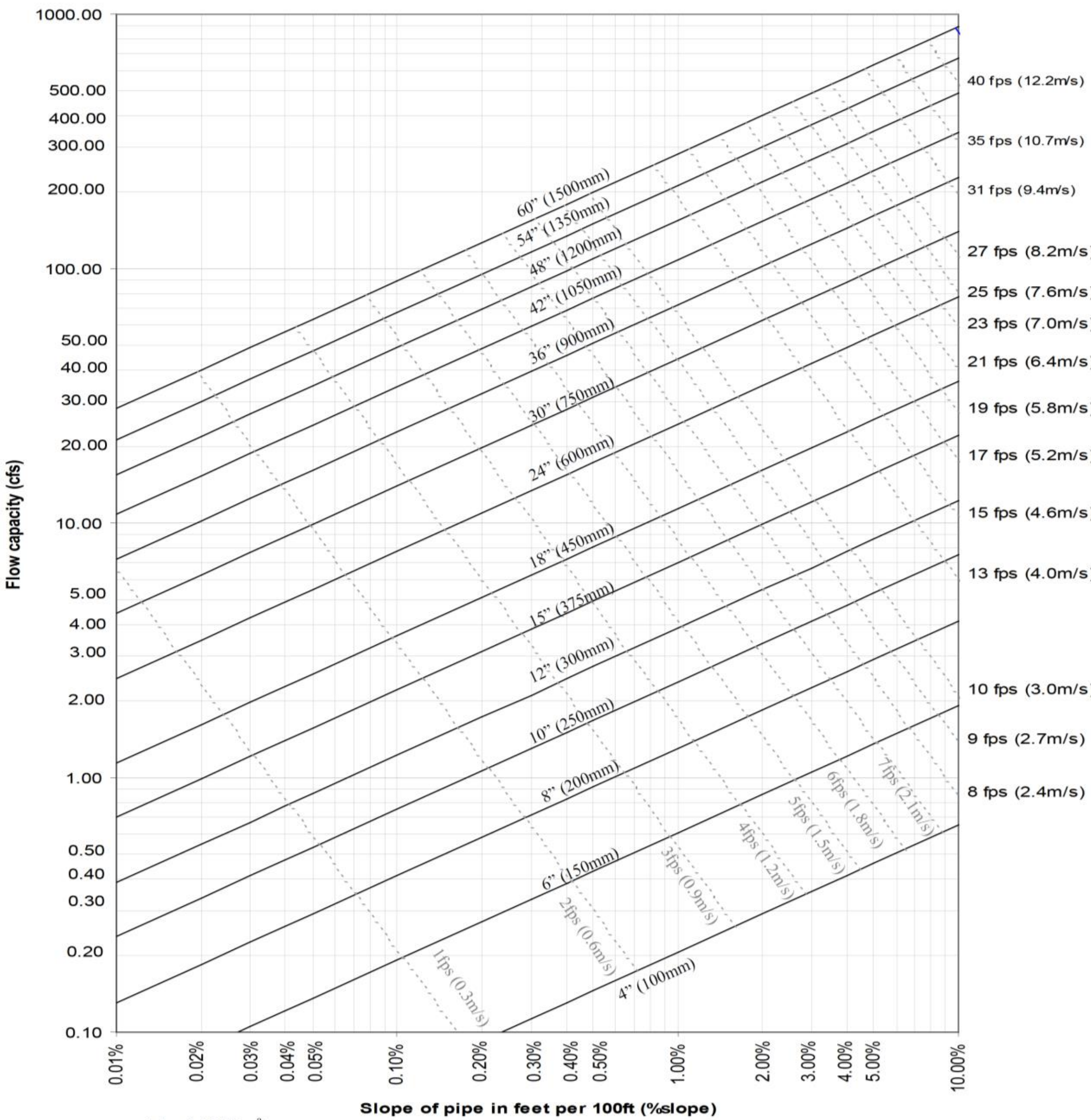
Figure 1. Sustained speed versus fork length for juvenile salmon (Modified Figure 2.2 from USDA Forest Service, 1978). From Barber, M. E. and R. C. Downs 1996.

Table 1. Flow capacity for circular and pipe-arch culverts (Robison and others 1999). Table 23 in Foltz, Randy B., P. R. Robichaud, and H. Rhee 2009. A synthesis of post-fire road treatments for BAER Teams: Methods, treatment effectiveness, and decision making tools for rehabilitation. Gen. Tech. Rep. RMRS-GTR-228. Fort Collins CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station: 2009: 152p.

Circular culverts[a]			Pipe-arch culverts[a]		
Diameter	**Cross-section area culvert**	**Maximum flow in culvert**	**Span × Rise**	**Cross-section area culvert**	**Maximum flow in culvert**
(inches)	(ft^2)	(cfs)	(ft and/or inches)	(ft^2)	(cfs)
15	1.2	3.5	22″ × 13″	1.6	4.5
18	1.8	5	25″ × 16″	2.2	7
21	2.4	8	29″ × 18″	2.9	10
24	3.1	11	36″ × 22″	4.3	16
27	4	15	43″ × 27″	6.4	26
30	4.9	20	50″ × 31″	8.5	37
33	5.9	25	58″ × 36″	11.4	55
36	7.1	31	65″ × 40″	14.2	70
42	9.6	46	72″ × 44″	17.3	90
48	12.6	64	6′-1″ × 4′-7″	22	130
54	15.9	87	7′-0″ × 5′-1″	28	170
60	19.6	113	8′-2″ × 5′-9″	38	240
66	23.8	145	9′-6″ × 6′-5″	48	340
72	28.3	178	11′-5″ × 7′-3″	63	470
78	33.2	219	12′-10″ × 8′-4″	85	650
84	38.5	262	15′-4″ × 9′-3″	107	930
90	44.2	313			
96	50.3	367			
102	56.7	427			
108	63.6	491			
114	70.9	556			
120	78.5	645			
132	95	840			
144	113.1	1,000			

Table 2. Flow Capacity for Circular Culverts and Pipe Arch culverts. Table 6 From E. George Robison, A. Mirati, and M. Allen 1999. Oregon Road/Stream Crossing Restoration Guide: Advanced Fish Passage Training Version.

CIRCULAR CULVERTS			***PIPE-ARCH CULVERTS***		
DIAMETER (inches)	Cross-Section Area Culvert (ft^2)	MAX FLOW in Culvert (cfs)	**SPAN x RISE** (feet and/or inches)	Cross-Section Area Culvert (ft^2)	MAX FLOW in Culvert (cfs)
15	1.2	3.5	22" x 13"	1.6	4.5
18	1.8	5	25" x 16"	2.2	7
21	2.4	8	29" x 18"	2.9	10
24	3.1	11	36" x 22"	4.3	16
27	4	15	43" x 27"	6.4	26
30	4.9	20	50" x 31"	8.5	37
33	5.9	25	58" x 36"	11.4	55
36	7.1	31	65" x 40"	14.2	70
42	9.6	46	72" x 44"	17.3	90
48	12.6	64	6'-1" x 4'-7"	22	130
54	15.9	87	7'-0" x 5'-1"	28	170
60	19.6	113	8'-2" x 5'-9"	38	240
66	23.8	145	9'-6" x 6'-5"	48	340
72	28.3	178	11'-5" x 7'-3"	63	470
78	33.2	219	12'-10" x 8-'4"	85	650
84	38.5	262	15'-4" x 9'-3"	107	930
90	44.2	313			
96	50.3	367			
102	56.7	427			
108	63.6	491			
114	70.9	556			
120	78.5	645			
132	95	840			
144	113.1	1000			



1cfs = 0.02832 m^3/s
1ft/s = 0.30480 m/s
1% = 0.01 ft/ft

1. Applicable products: N-12®, MEGA GREEN®, N-12 STIB, N-12 WTIB, HP STORM, SaniTIte®, SaniTite HP, N-12 Low Head

Note: Based on a design Manning's "n" of 0.012.
Solid lines indicate pipe diameters. Dashed lines indicate approximate flow velocity.
Redeveloped from FHWA HDS 3 – Design Charts for Open-Channel Flow[2]

Figure 2. Figure 3-1 in ADS Inc. Drainage Handbook; discharge rates from ADS corrugated pipe with smooth interior liner.

Appendix D:

Phase III Action Impact Benefit Table

Table 1. Analysis of Impacts and Benefits for Winter Lake Phase III proposed actions.

Note: *All disturbance actions are considered to be recovered/revegetated from disturbance 2yrs post project. Majority of attributes are designed to produce uplift that result in "Net Benefit" ecologically*

Action	Impact	Impact to Ecology Time of Construction Yes/No	Severity of Impact High/Med/Low	Healed by Year 2 Yes/No	Net Ecologic Benefit by Yr 3 Yes/No	Benefit Power Power High/Med/Low	Explanation
Installation of new proper sized culverts	Earth Work interior berms	Yes, due to soil disturbance	**Low**	**Yes**	**Yes, immediate uplift**	**High**	*New culverts allow for more natural hydrologic flow of water to interior pasture channels. greatly improved fish passage and wetland function. Net benefit strong much greater than impacts from time zero forward*
Channel construction/reconstruction; Excavation	Excavation/ soil disturbance	Yes, soil disturbance	**Medium**	**Yes**	**Yes, immediate uplift**	**High**	*New/reconstructed channels provide for more natural hydrologic flow of water to interior pastures, greatly improved fish passage and wetland function. Net benefit much greater than impacts from time zero forward.*
Channel construction/reconstruction; soil thin-spread	Soil distribution to 3" on wetlands	Yes, plant disturbance, unvegetated soils	**Medium**	**Yes**	**Neutral by year 3**	**Neutral by year 3**	*Soils that are distributed on wetland pastures will be thin-spread on average to 3" in depth; they will be integrated into pasture grasses as wetland plants are fully able to grow through this application fall of year 1 with full healing by year 2.*
Channel Reconstruction bank sloping 1:1 and 2:1	Soil disturbance	Yes, soil disturbance	**Medium**	**Yes**	**Uplift by year 2**	**Medium**	*Current pasture drainage channels have vertical banks that lead to bank sloughing and provide little if any edge habitats for fish when winter flows fill channels. Sloping of banks of channels will provide edge for growth of vegetation/fish cover, reduce erosion, and sediments*
Construction of Hydrologic Bulbs	Soil disturbance	Yes, soil disturbance	**Low**	**Yes**	**Yes, immediate uplift**	**High**	*Hydrologic bulbs will be installed at upper reaches of channel networks in selected locations. These bulbs will be excavated to an elevation that during winter months they provide long-term wetted habitat for juvenile coho. These also increase hydrologic exchange of water, which results in greater flushing of channels during tidal inflow/outflow. This prevents channels from accumulating sediments and provides long term channel life expectancy with little or no reexcavation to "clean" sediment. These bulbs also allow for greater volume capacity of channel networks duriing inflow/outflow events, which provide for exchange of water in channels and canals improving water quality.*
Berm Reconstruction		Yes, soil disturbance	**Low**	**Yes**	**Neutral by year 3**	**Neutral by year 3**	*Locations where berms are reconstructed will be be seeded/mulched. They are expected to be fully revegetated by year by end of growing season year 2.*
Fence installation	Some soil disturbance	Minimal	**Very Low**	**Yes**	**Yes**	**Medium**	*Fencing of selected segments of channels provides immediate benefits to water quality and longer term establishment of riparian vegetative and woody plants for fish habitat complexity.*
Large Woody Debris Installation large channels	Some soil disturbance	Minimal	**Very Low**	**Yes**	**Yes**	**High**	*Installation of LWD rootwads in first 500ft of larger channels will fully provide uplift through providing complexity for fish and other aquatic organisms.*
Planting of Trees on large and selected secondary channels	N/A	N/A	**N/A**	**N/A**	**N/A**	**HIgh**	*Skip planting of trees will be implemented on large and selected medium channels in segments where fence is installed. Additionally, individual caged trees will be planted. Skip planting will be three trees planted in a single 8x8ft plot every 100ft on large channels and selected medium channel reaches (Figure xxx). Tree species will be either Oregon Ash, Black Cottonwood, or Spruce.*

Net Ecological Benefit by Year 1	**Medium**
Net Ecological Benefit by Year2	**High**