Merwin Upstream Trap
Draft Study Plan
September 2007

INTRODUCTION

Section 4.3 of the Final Settlement Agreement for the Lewis River Hydroelectric Projects called for the construction and future operation of an adult trap and transport facility at the Merwin Project. Section 4.1.1 of the Agreement called for studies to inform design decisions regarding upstream and downstream fish passage facilities and stated that the studies should include an evaluation of the movement of fish.

A study conducted in 2005 provided initial baseline information on the performance of the existing trap in attracting and capturing four distinct salmonid stocks migrating upstream in the Lewis River: summer steelhead, coho salmon, winter steelhead, and spring Chinook salmon. A new trap, currently in design, will be implemented with a phased approach as follows:

- Phase I includes a new trap constructed in the eastern upstream corner of the tailrace (the pump room entrance) with an attraction flow of 400 cfs. Phase I will also include a biological evaluation of the trap's performance that would help to determine whether the Phase I trap meets the program goals, or if improvements considered for Phase II would be necessary to improve the trap's performance.

- Phase II, if implemented, includes the potential to expand the attraction flow to 600 cfs for the Phase I trap entrance, the potential to construct a second trap entrance in one of the powerhouse pump bays, or a combination of adding the second trap entrance and adjusting attraction flows for a maximum 600 cfs total attraction.

Construction of the Phase I trap is expected to be completed 4.5 years after issuance of license. Currently, the anticipated Issuance of License date is January 1, 2008, which would indicate a trap on-line date of June 1, 2012.

The proposed monitoring and evaluation study described herein has been designed to evaluate performance of the new trap once the Phase I facilities are operational. If the Phase I facilities do not meet program goals, the study would also inform PacifiCorp and the ACC of the need for and preferred approach of additional trap improvement that would occur during a Phase 2 trap development.

GOALS AND OBJECTIVES

The primary goal of the study plan is to evaluate the performance of the Phase 1 trap location, design, and adequacy of attraction flow for coho and Chinook salmon, and winter steelhead. In addition, the study will provide: 1) information on fish behavior in the tailrace including areas both around and away from the trap entrance, 2) information on downstream movements of adult fish that leave Merwin tailrace, 3) information useful for assessing the need for future trap modifications, and 4) the initial data for SA trap monitoring needs. Specific study objectives follow.

1) Determine trap effectiveness based on: a) trap attractiveness, b) the rate of entry for the trap, c) trap ladder passage time, d) number of entries that lead to capture, e) number of entries that lead to drop back (defined as when a fish enters the ladder but turns and leaves before capture in the trap) and f) trap capture rate.

2) Determine if fish show directed movement to the trap entrance. If some fish do not, what behavior patterns do we see for these fish in the tailrace?

3) Determine if fish in the tailrace spend the majority of their time in the area in front of trap. If some fish do not, are they holding in another zone within the tailrace?

4) Determine the total time fish are present in Merwin tailrace.

5) Describe the movement of tagged fish that do not enter, or choose to leave, the tailrace and move downstream, past fixed telemetry stations.

6) Determine the condition of fish that are captured by the trap. Specifically address descaling and injury.

METHODS
This study involves monitoring the migratory behavior of adult coho salmon, Chinook salmon and winter steelhead via radio telemetry as they move through the Merwin Tailrace. A fixed telemetry array is proposed with coverage in the tailrace that will facilitate obtaining information on the fish attraction to the trap, coverage in the trap that will provide information to assess trap effectiveness, and coverage at selected locations downstream in the Lewis River to document fish leaving the tailrace and inform us of where these fish may be headed. The data from tagged fish will be assumed to be representative of the corresponding fish populations and will inform us of fish behavior as they enter the tailrace, locate the fish trap and are captured.

Fish Collection and Tagging

Approximately 150 adult fish from each of three species/stocks (coho salmon, winter steelhead, spring Chinook salmon) will be collected out of the Merwin Dam fish trap.

We will attempt to tag fish on location at the Merwin sorting facility and immediately haul them for release at the Merwin boat ramp. Our goal would be to tag three groups of up to 50 fish on three separate days across the run. If we are unable to tag fifty fish during each tagging episode we will increase the number of tagging events to result in a total of 150 fish tagged. We intend to use the electro-anesthesia system incorporated into the trap to anesthetize fish prior to tagging. Tags will be gastrically implanted and tagged fish immediately placed into a transport truck. Based on the 2005 study, the time from net capture in the pond to release in the truck is anticipated to take less than one minute per fish.

Fish will be implanted with a tag similar to Lotek MCFT-3A digitally coded transmitters. These tags are 16 mm in diameter, 46 mm in length and weigh 16 g in air and 6.7 g in water. With burst rates of 2.5 seconds these tags should last as long as 394 days. After all fish from a release group are tagged, they will be transported to the Lewis River for release at the Merwin Boat ramp. Tagged fish will be released via the transport truck pipe directly into the water. Tagging personnel will monitor each release; both regurgitated tags and tag mortalities will be collected.

Telemetry Array

The radiotelemetry array has been designed to provide coverage around the perimeter of the tailrace, within the new fish ladder and trap, as well as four distinct locations downstream in the Lewis River. A total of 25 (17 to 25) fixed antennae will be used in this study creating 17 distinct detection zones. Seventeen antennas, including 2 aerial and 15 underwater antennas will be located within the tailrace proper (Figure 1). Six underwater dipole antennas (Grant Engineering Systems) will be used to create six distinct detection zones along the powerhouse and control room walls (Figure 1, Zones 1-6). One underwater antenna, comprised of stripped coax cable will be used to monitor the gallery behind the powerhouse (Zone 7). Two aerial antennas will be located on the access bridge and will cover the right and left edges of the tailrace (Zones 8-9).An additional eight (2-8) underwater antenna, comprised of striped coaxial cable, will be used to create a grid below the access road bridge (Zone 10) that provides coverage across the tailrace and from the water's surface to the bottom (or to 20m, as depth is unknown at this time). This array was designed to provide coverage of the perimeter of the tailrace and to inform us regarding time fish spend in the tailrace proper as well as about fish swimming and holding patterns along the right and left banks and the powerhouse wall.

To help understand behavior of fish in the new trap, three underwater dipole antennas (#18, 19, and 20) will be located within fish trap. The furthest downstream will be the vicinity of ladder slot 2 (Zone 11). A second will be further upstream in the ladder in the

vicinity of ladder slot 3 (Zone 12). A third antenna will be located upstream of the weir inside the trap proper (Zone 13).

Four fixed detection zones will be established downstream of the Merwin tailrace (Figures 2, 3). Zone 14 will be generated by two parallel fixed aerial antennas (#21 and 22) located just downstream of the large pool immediately below the tailrace (Figure 2). The water in this area is relatively shallow and we can obtain complete coverage of the water column using aerial antennae. Two antennas are paired at this location to provide information on direction of movement and thus should allow us to determine when a tagged fish has entered or exited the tailrace.

To describe the disposition of tagged fish that leave the tailrace we will collect data from three aerial antennas located downstream (Figure 3). An aerial antenna (#23) will be placed downstream of the release location at the Merwin Boat ramp near the Aerial gage (Zone 15) to detect fish moving downstream after release. An aerial antenna (#24) will be located near the entrance of the Lewis River hatchery ladder to monitor fish that are aggregating at the hatchery (Zone 16). As part of a separate study an aerial antenna (Zone 17) will be operating in the vicinity of Woodland (Figure 4) at the time this study is conducted. We will obtain and analyze the data from the Woodland receiver to document any adult fish moving downstream to that extent.

The proposed fixed telemetry array provides radio telemetry coverage from Merwin Tailrace to Woodland, WA (Figure 5). The exact locations of each antenna will be modified to obtain the best coverage given the width of the river and water depth at each location. Dummy tags will be dragged through the detections zones during installation of the array to define the boundaries of distinct detection zones and calibrate the telemetry equipment. The associated receiver's gain and blank levels will be adjusted at the time of installation to ensure adequate coverage and within the tailrace proper to prevent overlap between detection zones. If a number of fish leave the array and are unaccounted for, periodic mobile surveys will be conducted within the Lewis River to try and determine the disposition of these fish.

Table 1. Location of detection zones and corresponding antenna array(s).

Location	Antenna	Detection Zone
Tailrace: trap entrance	1	1
Tailrace: downstream of trap	2	2
Tailrace: downstream of trap	3	3
Tailrace: along powerhouse wall	4	4
Tailrace: along powerhouse wall	5	5
Tailrace: along powerhouse wall	6	6
Tailrace: gallery behind dam	7	7
Tailrace: right bank	8	8
Tailrace: left bank	9	9
Tailrace: below bridge	10-17	10
Trap: near slot 1	18	11
Trap: near slot 2	18	12
Trap: upstream of weir	20	13
Lewis River Downstream: holding pool	21 &22	14
Lewis River Downstream: below Merwin boat ramp	23	15
Lewis River Downstream: Lewis River Hatchery	24	16
Lewis River Downstream at the smolt Release Pond.	25	17

Analyses

Within the release groups, the behavior of individual tagged fish moving through the 10 detection zones in the tailrace will be analyzed. Tagged fish will be selected as the unit of replication for the following reasons: 1) individuals with substantially greater

numbers of detections will dominate the analysis if the number of detections aggregated across all fish is analyzed; 2) there are individual behavioral differences among fish, and we want to incorporate this variability; 3) analysis will be completed on the data as it is measured, rather than on an average or summed quantity to avoid obscuring individual fish behavior.

Objective 1. Determine trap effectiveness based on: a) trap attractiveness, b) the rate of entry for the trap, c) trap ladder passage time, d) total number of entries, e) fallback, and f) trap capture rate.

a) Trap attractiveness (A)will be determine by the number of tagged fish the are detected in Zone 1 (T_1) divided by the number of tagged fish that are detected in Zone 10 (T_{10}). $A = T_1/T_{10}$.

b) The rate of trap entry will provide information on how effectively fish enter the trap once they have located it. Trap entry rate (E) will be calculated as the sum of unique detections in Zone 11 (D_{11}) divided by the total time spent in Zone 1 (T_1). This rate will be compared to expected values (based on 2005 data) to determine if tagged fish readily enter the trap. $E = \sum D_{11} / \sum T_1$.

c) Trap ladder passage time (P) will be calculated for individual fish by summing the total time in trap zones 11, 12, and 13 and will be compared to an expected passage time of less than 3 hours. If these times exceed an average of 3 hours, we will analyze time within and transitions among ladder and trap detection zones to isolate any problem area within the ladder. $P = \sum T_{11} + \sum T_{12} + \sum T_{13}$.

d) We will enumerate the fish with unique detections in the three ladder and trap detections zones. Successful entries will include tagged fish that are detected in the trap entrance zone (11) and continue to move through the ladder to the trap (zone 13). In addition, any fish detected in Zone 13 only, even if they were missed in Zones 11 and/or 12, will be included as successful entries. The number of successful entries can be compared to the number of fallbacks to help evaluate trap effectiveness.

e) The number of drop backs (defined as fish that enter but then leave the ladder and return to the tailrace) will be enumerated based on directional transitions between Zone 1 and Zones 11-13. Given the location of Merwin Dam within the lower Lewis River and Lower Columbia River basins we cannot know if all tagged fish are destined for the upper Lewis River fish. In fact, a recent literature review indicated that fish from several of the nearby rivers including the Cowlitz, Kalama, and the Washougal rivers have been shown to stray into the Lewis River (Quinn 2005, Pascual et al 1995, Quinn et al 1991). Rates of straying for hatchery fish have been estimated as high as 22.2% for returns to the Lewis River Hatchery (Quinn 2005). Given this information, it is reasonable to assume that some level of fallback will likely occur at Merwin Dam. Fallback rate during the 2005 study were consistently around 25% for multiple species. A reduction of fallback to 20% would be a reasonable goal.

f) Trap capture rate will be calculated for each species/stock of tagged fish as the number of tagged fish detected in the trap Zone 13 divided by the number of tagged fish detected outside the trap in Zone 1.

These parameters will be considered in concert to evaluate the effectiveness of the trap at attracting and capturing the three species of anadromous salmonids (Transported Species – winter steelhead, spring Chinook, and S-type coho).

Objective 2. Determine if fish show directed movement to the trap entrance. If some fish do not, what movement patterns are evident for these fish in the tailrace?
The number of transitions between tailrace zones and the number of zones used by fish will provide information on effectiveness of the trap location and fish attraction to the trap entrance area. The number of transitions observed by zone for each species/stock will be enumerated and summarized. Directed movement would be indicated by fewer transition and transitions in zones that bracket the trap entrance. If some fish do exhibit a lot of transitions, we will document if they move throughout the array, exhibit focused movement into and out of specific zones, or are they leaving the tailrace proper. In 2005, tag groups where fish showed fewer transitions and greater time in zones downstream of the trap had higher rates of trap efficiency. Tag groups with lower efficiency rates exhibited more wandering among zones and spent more time below the tailrace in the large holding pool downstream of the bridge. Tag groups with higher trap efficiency rates spent more time in Zones 1-3. We will look at how fish behavior at the new trap compares to the 2005 study.

Objective 3. Determine if fish in the tailrace spend the majority of their time in the area in front of trap. If some fish do not, are they holding in another zone within the tailrace?
Time in distinct tailrace zones provides information on effectiveness of the trap location and fish attraction to the trap entrance area. We will compare time spent among the tailrace zones to determine where the most fish for each group spend most of their time in the tailrace. Percentage of total time in Zone 1 (2 and 4) as a function of total time in the tailrace will also be calculated. Tag groups where fish spend most time in Zone 1 would be expected to show higher trap effectiveness. Total time in this zone also will be useful information for Objective 4. In 2005, tag groups with more time in Zones 1 and 2 generally had higher collection rates Tag groups with lower capture rates spent more time in more zones including those far away from the trap entrance and downstream of the tailrace proper. We will compare fish use of tailrace zones between this and the 2005 study.

If some fish appear to be holding in zones away from the trap, as evidence by proportionally greater time spent in these zones, we will document where they are holding and if they are aggregating in any detection zone. Large proportions of tagged fish aggregating in tailrace zones away from the trap without prior detection in Zone 1 or 11 would suggest poor attraction to the trap. Large proportion of tagged fish aggregating in zones away from the trap after initial exposure to it as indicated by detection in Zone 1

or 11 would be indicative of trap rejection. We will compare how fish use of tailrace zones compares between this and the 2005 study

Objective 4. Determine the total time fish are present in Merwin tailrace.
The total time fish are present in the tailrace will provide information on the attractiveness of the new trap to fish. We will compare total times for fish in this study with those from same species/stocks monitored in 2005. The assumption would be that reduced time in the tailrace results in increased trap attractiveness to fish.

Objective 5. Describe the movement of tagged fish that do not enter, or choose to leave, the tailrace and move downstream in the Lewis River, past fixed telemetry stations. Develop fish tracks for fish that move downstream based on detections in fixed telemetry location within the Lewis River. This data will provide information regarding the proportion of tagged fish that moved downstream away from Merwin Tailrace as well as the disposition of those fish within sections of the river.

Objective 6. Determine the condition of fish that are captured by the trap, as a function of rates of descaling and injury.
All fish collected for radio tagging will be assessed for injury and descaling after tagging and prior to release, and then again during collection in the trap. In addition a random sample of approximately 100 run of the river fish from each run should be anesthetized and examined for descaling and injury to correlate levels seen in test fish with the overall migratory population.

SCHEDULE

This is intended to be a 2 year study. Setup should occur during the low flow period sometime between mid July and late August the same year that the trap is constructed. Tagging of coho salmon may need to occur as early as mid-September. To accommodate the study schedule the trap must be operable by early July. Year 1: The trap evaluation will start with the coho salmon run in the fall 2012, continue with winter steelhead in late fall and early winter and through the end of spring Chinook run in spring 2013. A second year of study will be available to focus on any questions or concerns that arise or fill in data gaps from Year 1. A contingency for a third year of study is in place if unforeseen events prevent us from adequately evaluating the trap for all three species in two years. If needed, this contingency would have impact on the implementation schedule for any Phase II modifications.
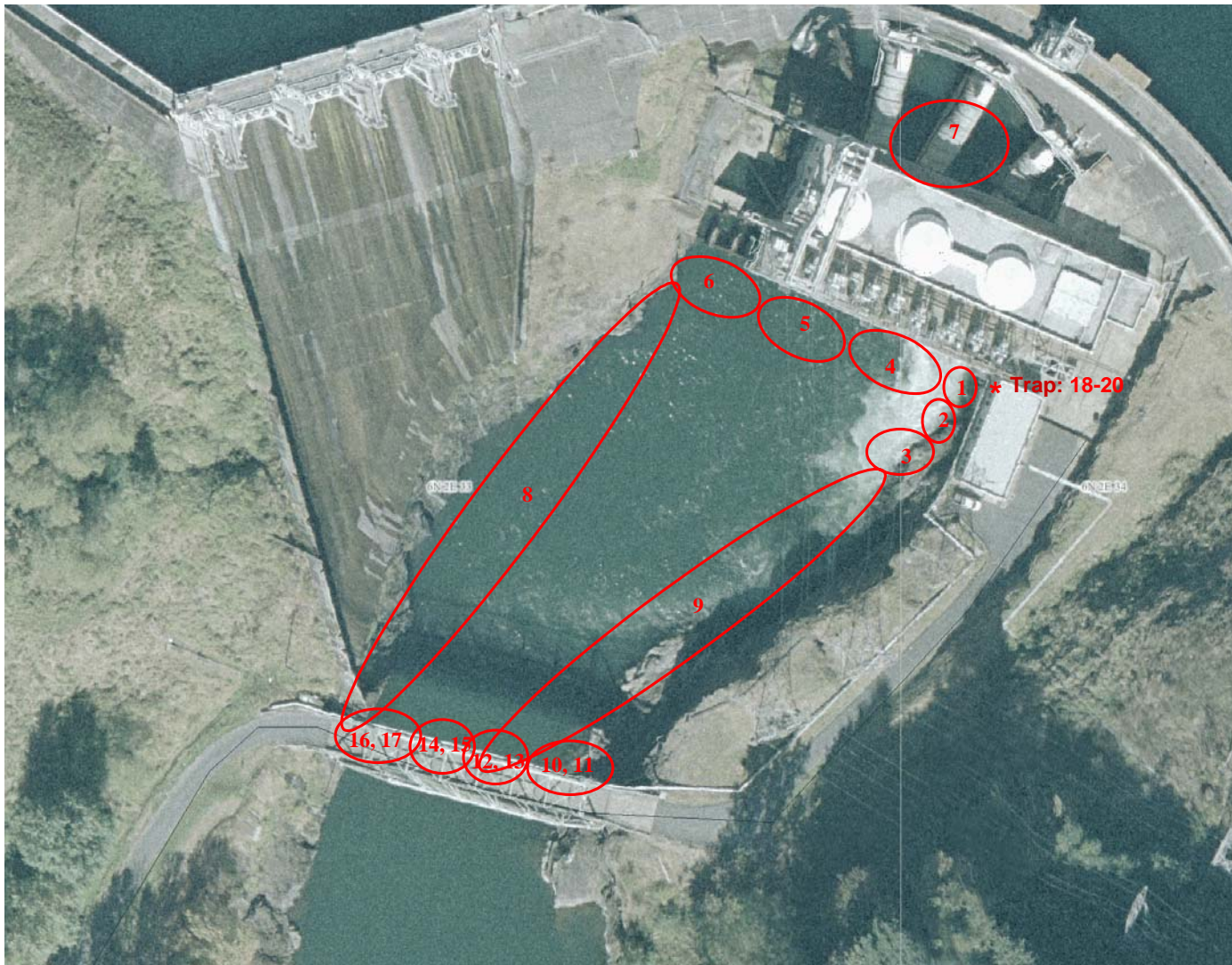
Figure 1. Proposed locations of radio antennas within the Merwin Tailrace.

Figure 2. Proposed locations of radio antennas from Merwin Tailrace to the Merwin boat ramp.

Figure 3. Locations of downstream radio antennas from the Merwin tailrace (1-20) to Lewis River Hatchery (24).

Figure 4. The location of the furthest downstream antenna to be located at the juvenile release facility in Woodland, WA.
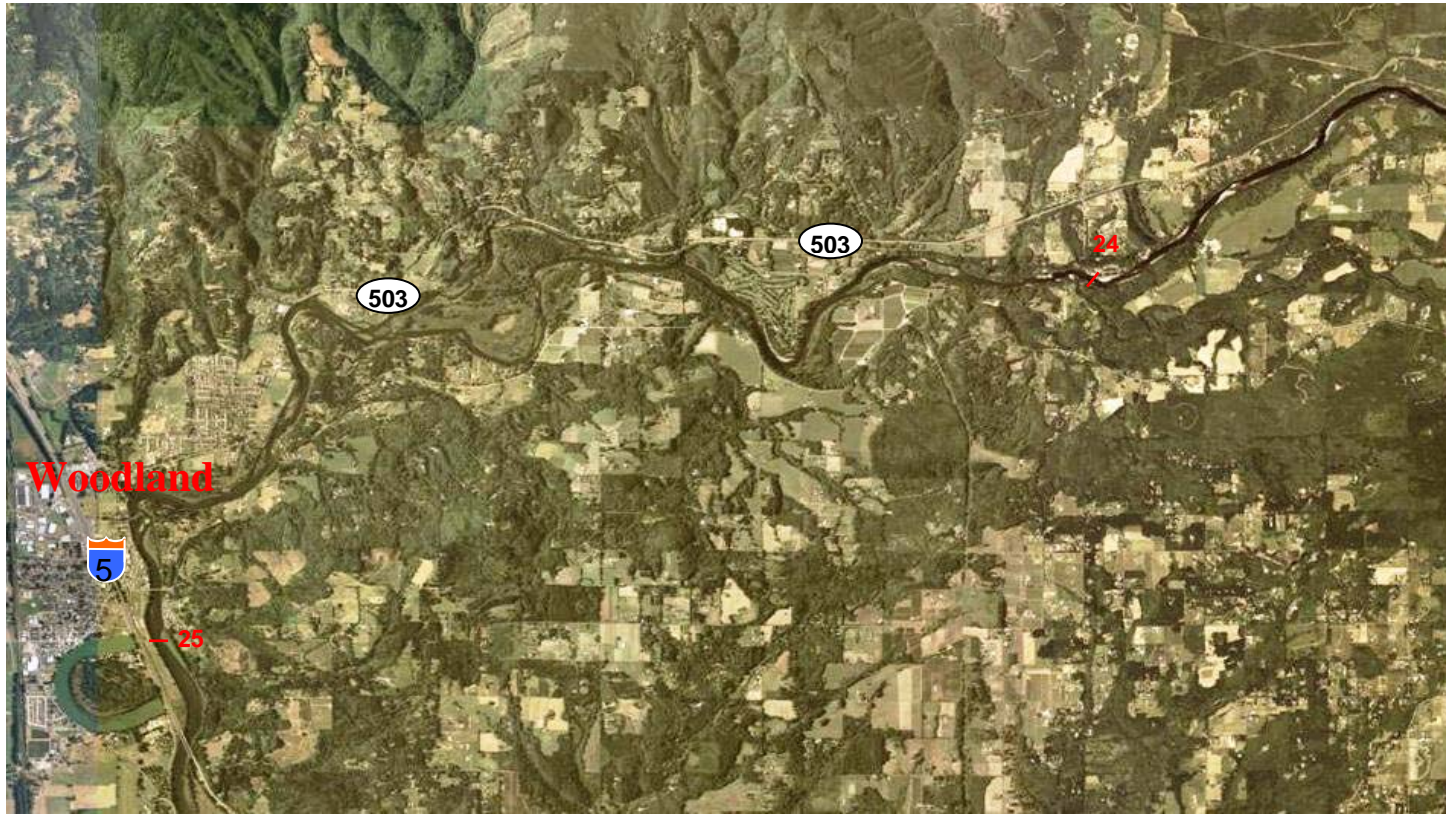
Figure 5. Location of the proposed fixed telemetry array providing coverage from Merwin Tailrace to the juvenile release facility in Woodland WA.