PacifiCorp and Cowlitz County PUD No. 1

Aquatic Monitoring and Evaluation Plan for the Lewis River – First Revision

Paul Carpenter and Brittany Winston conducting coho carcass surveys on the North Fork Lewis River downstream of Merwin Dam. Photo by Jason Shappart, Meridian Environmental, Inc.

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and

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Acronyms and Abbreviations

ACC	Aquatics Coordination Committee
AER	Adult equivalent run
AOP	Annual Operating Plan
ATE	Adult trap efficiency
C + E	Catch plus escapement
CE	Collection efficiency
CF	Correction factor
cfs	Cubic feet per second
CI	Confidence Interval
CPE	Catch plus escapement
CS	Collection survival
CWT	Coded-wire tag
DART	Data Access in Real Time
FRY	A recently hatched fish that has reached the stage where its yolk-sac has almost disappeared and its swim bladder is operational to the point where the fish can actively feed for itself. Juveniles referred to as fry are < 60 mm based on ability to safely tag
FSC	Floating Surface Collector at Swift (aka Swift Downstream Facility (SDF)
FERC	Federal Energy Regulatory Commission
HOR	Hatchery-origin recruits
HPP	Habitat preparation plan
H&S Plan	Hatchery and Supplementation Plan
MFCF	Merwin Fish Capture and Transport Facility
M&E	Monitoring and Evaluation
NMFS	National Marine Fisheries Service
NOR	Natural-origin recruits
ODS	Overall downstream survival
PARR	A young salmonid that is older than a fry and younger than a smolt, having dark marks (i.e. parr marks) on their sides. Juveniles referred to as parr generally range in size from 60 to 120 mm
PM&E	Protection, mitigation and enhancement
RM	River mile
RMIS	Regional Mark Information System

PIT	Passive Integrated Transponder
SA	Settlement agreement
SAR	Smolt-to-adult survival rate
SASR	Smolt-to-adult survival ratio
Services	US Fish and Wildlife Service and National Marine Fisheries Service
SMOLT	A juvenile salmon that is ready to migrate out to the sea, Smolts can be described as losing their camouflage bars (i.e. parr marks) and are in the process of physiological changes that allow them to survive a shift from freshwater to saltwater. Smolts are silvery in color and shed scales readily. Smolts can range in size from 120 to 300 mm depending on fish species
TCC	Terrestrial Coordination Committee
USFWS	U.S. Fish and Wildlife Service
UPS	Upstream passage survival
USACE	U.S. Army Corps of Engineers
Utilities	PacifiCorp and Cowlitz County PUD
WDFW	Washington Department of Fish and Wildlife
WDOE	Washington Department of Ecology
YOY	Young-of-the-year
ZOI	Zone of influence

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1.0 INTRODUCTION

This plan is designed to meet the monitoring and evaluation (M&E) requirements outlined in the Lewis River Settlement Agreement (Settlement Agreement) entered into by state, federal and local governments, various resource interest groups and the Lewis River Project hydropower licensees (PacifiCorp and Cowlitz PUD 2004). The Federal Energy Regulatory Commission (FERC) issued new operating licenses for all four Lewis River projects (Merwin, Yale, Swift No. 1 and Swift No. 2) on June 26, 2008 and the requirements of these new licenses are also incorporated in this plan.

The primary focus of the M&E plan is the evaluation of upstream fish collection facilities at Merwin Dam and downstream facilities at Swift Dam. As described in Section 9.1 of the Settlement Agreement, the M&E Plan shall provide the approach to:

> *"…monitor and evaluate the effectiveness of aquatic PM&E Measures and to assess achievement of the Reintroduction Outcome Goals. The M&E Plan shall address the tasks, and the methods, frequency and duration of those tasks, necessary to accomplish the monitoring and evaluation items…"*

Anadromous fish reintroduction goals were established in the Settlement Agreement for coho, spring Chinook and steelhead for the portion of the Lewis River basin located upstream of Merwin Dam. The measures to be monitored and evaluated are described primarily in sections 4 and 9 of the Settlement Agreement. The intent of the M&E Plan is to identify monitoring actions to determine the success of constructed fish passage systems and the overall success of the fish reintroduction effort. The reintroduction outcome goal is to:

> *"…achieve genetically viable, self-sustaining, naturally reproducing, harvestable populations above Merwin Dam greater than minimum viable populations ("Reintroduction Outcome Goal")."*

However, it needs to be noted that the metrics for determining whether the Reintroduction Outcome Goal is being met have yet to be developed[1] by the US Fish and Wildlife Service and National Marine Fisheries Service (the Services). Because these metrics are unavailable, the M&E Plan focuses on those studies needed to determine when the performance standards outlined in Section 4 of the Settlement Agreement are achieved. A definition of each performance standard and its benchmark value are presented in Table 1.1.1.

The M&E Plan also provides the methods to be used to monitor and evaluate adult fish spawning escapement, fish passage facility hydraulic performance, flow and ramping rates, resident and anadromous fish interactions, and bull trout and kokanee populations. Monitoring related to Clean Water Act Section 401 certification is identified in the Final Water Quality Management Plan which was submitted for comment to the Washington Department of Ecology (WDOE) in September 2008 and will be finalized in 2009. PacifiCorp and Cowlitz PUD will provide an annual report to FERC (ACC/TCC Annual Report), the Aquatics Coordination Committee (ACC) and the Terrestrial Coordination Committee (TCC) and WDOE in approximately April of

[1] The time frame for the Services to identify this metric is described in Section 3.1.1 of the Settlement Agreement.

each year. The ACC/TCC Annual Report will contain results of all monitoring activities included in the M&E Plan plus all water quality, hatchery, and terrestrial monitoring results from the previous year.

The NMFS has designated populations for the North Fork Lewis basin that include naturally produced fish from the entire North Fork Lewis basin; therefore, evaluation of the reintroduction program, as measured by population status, will require data collected from monitoring efforts called for in this M&E Plan and the Lewis River Hatchery and Supplementation (H&S) Plan (PacifiCorp Energy and Cowlitz PUD 2006). Monitoring needed to implement the H&S Plan is detailed in that plan. H&S monitoring objectives are summarized here (Objective 21) for reader convenience and to demonstrate that all aspects of the reintroduction program are being monitored. Objective 22 of this M&E Plan provides a summary of all monitoring efforts for the North Fork Lewis, including those called for by both the M&E Plan and the H&S Plan. It is also expected that a section of the Annual Report will combine the upper river fish population information from the M&E work along with the lower river fish population from the H&S Plan work to evaluate population status of the listed species in the North Fork Lewis basin annually as part of Objective 22.

Table 1.1.1. Reintroduction performance standard definitions and benchmark values.

Performance Standard	Definition[1]	Benchmark Value
Adult Trap Efficiency (ATE)	The percentage of adult Chinook, coho, steelhead, bull trout, and sea-run cutthroat that are actively migrating to a location above the trap and that are collected by the trap.	Determined by the ACC to be 98%
Collection Efficiency (CE)	The percentage of juvenile anadromous fish of each of the species designated in Section 4.1.7[2] that is available for collection and that is actually collected.	95%
Collection Survival (CS)	The percentage of juvenile anadromous fish of each of the species (designated in Section 4.1.7) collected that leave the Release Ponds alive.	Smolts $\geq$ 99.5% Fry $\geq$ 98% Adult Bull Trout $\geq$ 99.5%
Injury	Visible trauma (including, but not limited to hemorrhaging, open wounds without fungus growth, gill damage, bruising greater than 0.5 cm in diameter, etc.), loss of equilibrium, or greater than 20% descaling . "Descaling" is defined as the sum of one area on one side of the fish that shows recent scale loss. This does not include areas where scales have regenerated or fungus has grown.	$\leq$ 2% for smolts
Overall Downstream Survival (ODS)	The percentage of juvenile anadromous fish of each of the species designated in Section 4.1.7 that enter the reservoirs from natal streams and survive to enter the Lewis River below Merwin Dam by	Interim > 80%

	collection, transport and release via the juvenile fish passage system, passage via turbines, or some combination thereof (calculated as provided in Schedule 4.1.4. of the Settlement Agreement).	> 75% after installation of Yale Downstream Collector
Upstream Passage Survival (UPS)	Percentage of adult fish of each species (designated in Section 4.1.7) that are collected that survive the upstream trapping-and-transport process. For sea-run cutthroat and bull trout, "adult" means fish greater than 13 inches in length.	≥ 99.5%
Active Tag	Tag type that detects and tracks movement of fish (e.g. radio tag, hydroacoustics tag)	N/A

[1] Definitions are taken from Settlement Agreement for the Lewis River Hydropower Projects (PacifiCorp and Cowlitz PUD 2004)
[2] Species designated in Section 4.1.7 of the Settlement Agreement are spring Chinook, winter steelhead, coho, bull trout and sea-run cutthroat trout.

Because the M&E Plan will be updated approximately every five years, this plan continues to emphasize the methods for evaluating the Swift Floating Surface Collector (FSC) and the Merwin Fish Collection Facility (MFCF). The FSC will be used to collect juvenile and adult anadromous salmonids migrating downstream from stream reaches upstream of Swift No. 1 Dam. The Merwin Fish Collection Facility will collect adults returning to this same portion of the basin or to hatchery facilities.

The performance standards shown in Figure 1.1-1 will be used to determine not only the success of the FSC but also provide the justification for making improvements to this facility over time.

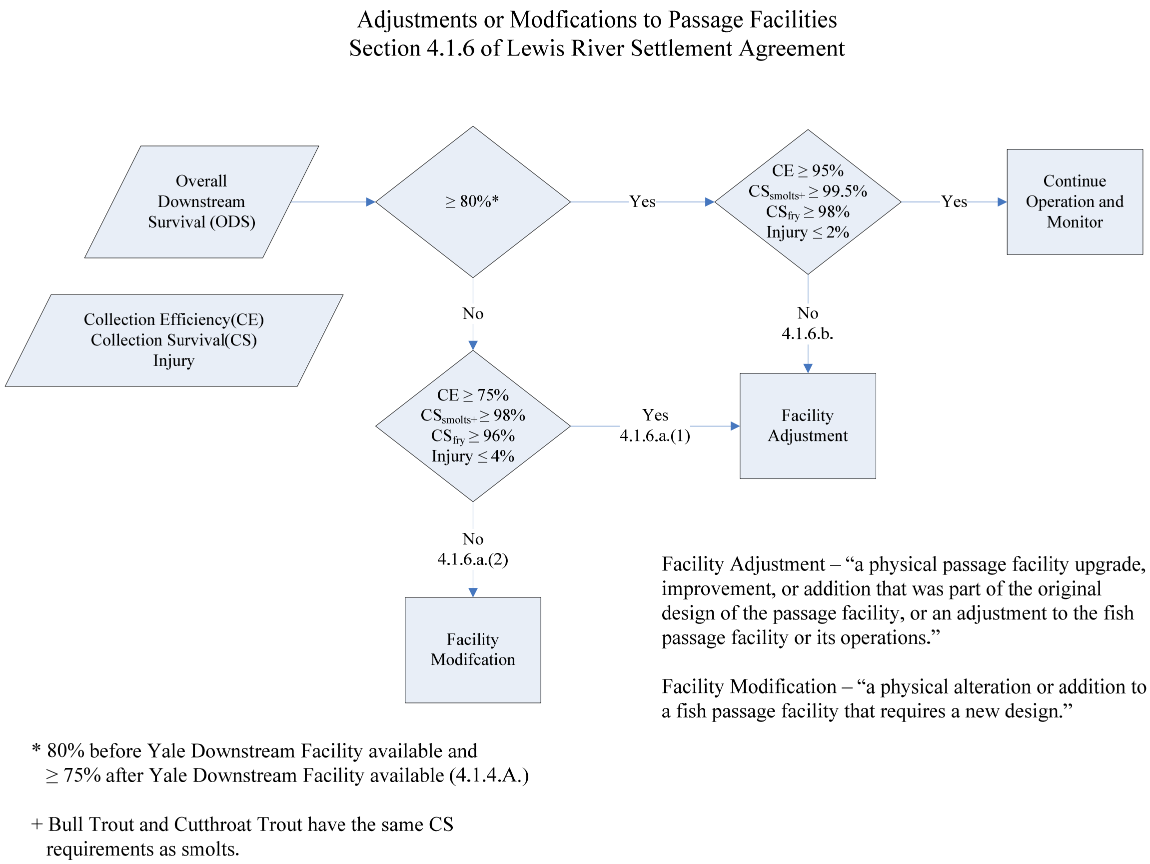

Figure 1.1-1. Swift Floating Surface Collector decision flow chart.

The lessons learned from studies undertaken to evaluate these facilities will be applied to new adult and juvenile passage facilities proposed for Yale starting in year 13 (June 2021) and juvenile passage facilities at Merwin starting in year 17 (June 2025) of the new FERC licenses.

Finally, the need for updating the M&E Plan will be determined as part of the comprehensive periodic review as outlined in the Settlement Agreement (see Sections 8.2.6 and 9.1 of the Settlement Agreement). According to the Settlement Agreement, the Licensees shall Consult with the ACC as necessary, but no less often than every five years, to determine if modifications to the M&E Plan are warranted. This review will occur again after the reintroduction of anadromous fish into Yale Lake and after the reintroduction of anadromous fish into Lake Merwin. Following full or final partial reintroduction the periodic review will take place as needed or requested by an ACC member from that point forward no less often than every five years. This Plan version represents the first review document following Swift Reservoir reintroduction. The ACC has provided input to this new version and their comments are reflected in this final document

2.0 MONITORING AND EVALUATION OBJECTIVES

The M&E Plan has been designed to achieve twenty-two objectives. The objectives are as follows:

Objective 1	Quantify overall juvenile fish downstream survival (ODS) which includes reservoir survival, collection survival, transport survival, and survival at the release ponds
Objective 2	Quantify FSC collection efficiency
Objective 3	Quantify the percentage of juvenile fish available for collection that are not captured by the FSC and that enter the powerhouse intakes
Objective 4	Quantify juvenile and adult collection survival
Objective 5	Quantify juvenile injury and mortality rates during collection at the FSC (includes injury and mortality of adult bull trout, adult sea-run cutthroat, and steelhead kelts)
Objective 6	Quantify the number, by species, of juvenile and adult fish collected at the FSC
Objective 7	Estimate the number of juveniles entering Swift Reservoir
Objective 8	Develop index of juvenile migration timing
Objective 9	Quantify adult upstream passage survival
Objective 10	Quantify adult trap efficiency at each upstream fish transport facility (emphasizes analysis of the Merwin Adult Trapping Facility)
Objective 11	Quantify the number, by species, of adult fish collected at the projects (emphasizes Merwin Dam)
Objective 12	Develop Estimates of ocean recruits
Objective 13	Develop performance measures for index stocks
Objective 14	Document upstream and downstream passage facility compliance with hydraulic design criteria
Objective 15	Determine spawn timing, distribution and abundance of transported anadromous adults
Objective 16	Evaluate lower Lewis River wild fall Chinook and chum populations Note: Objective 16, because it is a lower Lewis River monitoring activity, has been

moved to become a monitoring Objective xx of the Hatchery and Supplementation Plan.

Objective 17 Monitor bull trout populations

Objective 18 Determine Interactions between reintroduced anadromous salmonids and resident fish (Upstream of Merwin dam)

Objective 19 Document Project compliance with flow, ramping rate and flow plateau requirements

Objective 20 Determine when reintroduction outcome goals are achieved

Objective 21 Develop a Hatchery and Supplementation Plan (H&S) to support and protect Lewis River native anadromous fish populations and provide harvest opportunity

Objective 22 Develop a Coordination Table that cross-references Objectives of the Hatchery and Supplementation Plan and the Monitoring and Evaluation Plan

For objectives 1-22, the tasks, methods, frequency and duration of sampling, assumptions, results and reporting are discussed in the sections that follow. For objective 22, a table will be provided in this revised plan to illustrate how the H&S and M&E plans relate to each other and in which document a particular evaluation task can be found.

Although not explicitly repeated for each objective, the fish handling and facility operations listed in the Incidental Take Statements for the Project will be strictly followed. The Incidental Take Statement can be found in Section 9 of the National Marine Fisheries Service (NMFS) Biological Opinion for the Project (NMFS 2007) and the USFWS Biological Opinion (USFWS 2006). The Post-Season Monitoring and Evaluation Form required by NMFS is attached as **Appendix A**. This post-season report will be included in the ACC/TCC Annual Report.

2.1 OBJECTIVE 1: QUANTIFY OVERALL JUVENILE DOWNSTREAM SURVIVAL

The Settlement Agreement requires that the Utilities achieve an overall downstream survival (ODS) rate of greater than or equal to 80%[2]. ODS is defined in Section 4.1.4 of the Settlement Agreement as:

The percentage of juvenile anadromous fish of each of the species designated in Section 4.1.7 that enter the reservoirs from natal streams and survive to enter the Lewis River below Merwin Dam by collection, transport and release via the juvenile fish passage system, passage via turbines, or some combination thereof, calculated as provided in Schedule 4.1.4.

[2] An ODS of greater than or equal to 80% is required until such time as the Yale Downstream Facility is built or the Yale in Lieu Fund becomes available to the Services, after which ODS shall be greater than or equal to 75%. The parties to the Settlement Agreement acknowledge that ODS rates of 80% or 75% are aggressive standards and will take some time to achieve.

In other words, ODS is the percentage of the fish entering the Lewis River hydroelectric project reservoirs (the Project) that migrate, or are transported to the lower Lewis River (i.e., downstream of Merwin Dam) and released successfully (i.e., alive). It should be noted that Schedule 4.1.4 of the Settlement Agreement contains a caveat that the methodology described in the Schedule needs to be ground-truthed and may not be the best method to use.

2.1.1 Task 1.1- Estimate ODS for Anadromous Fish Species above Swift No. 1 Dam

Initially, ODS will be measured from the head of Swift Reservoir to the exit of the Release Ponds located downstream of Merwin Dam (Figure 2.1-1). Estimates of ODS will be developed for coho, spring Chinook, steelhead and sea-run cutthroat trout. ODS estimates for sea-run cutthroat trout will be delayed until data indicate that this cutthroat life history is present in the upper Lewis River basin and that the number of juveniles produced is sufficient, as determined by the USFWS, for experimental purposes.

Passive Integrated Transponder (PIT) tags, compatible with those used throughout the Columbia Basin for salmonid evaluations, and direct enumeration of fish collected and transported from the Swift Floating Surface Collector (FSC) will be used to develop estimates of ODS. All PIT tags used will be entered into the PTAGIS database.

Consistent with the Settlement Agreement, juveniles passing Swift Dam either through the turbines or spill will not be counted toward meeting the ODS standard because they are unlikely to survive passage through multiple dams and reservoirs not equipped with passage facilities. There is however, an allowance to consider turbine survival if it appears to be higher than expected.

2.1.1.1 Methods

The methods proposed for developing estimates of ODS are as follows:

- Test fish will be obtained from a screw trap operated at the head of Swift Reservoir or at the FSC. Fish collected at the FSC will only be used if enough fish cannot be collected at the screw trap. Preference will be to use fish collected at the screw trap as these fish would have not been exposed to the reservoir environment; an exposure that may alter fish behavior, and thus interpretation of study results.

- Fish captured at the traps will be identified to species, measured for length and a subsample tagged with PIT-tags. Only fish greater than, or equal to, 60mm in length will be tagged. On an annual basis, the ACC will evaluate the appropriate size limits for tagging.

- Fish will be released at the head of Swift Reservoir. Releases will be weekly throughout the major part of the migration season (April-June). A total of 996 fish of each species, or a number that is consistent with the calculations found in Table 2.1.1 will be released weekly in the spring in proportion to the run-timing of each species. PIT tag releases will continue into summer or fall as long as a persistent juvenile migration exists

Table 2.1.1. Release sizes to estimate $S_1 = S_{RES} * P_{COL}$ at the Swift Reservoir for alternative values of survival and collection S_1, and detection probability (p_1) at the slide gates for a precision of □ = 0.025, 1 – □ = 0.95 when □ = 1 at the holding ponds.

S_1	P_1	$\varepsilon = 0.025$	S_1	P_1	$\varepsilon = 0.025$
0.50	0.85	1618	0.80	0.85	1114
	0.90	1571		0.90	1038
	0.95	1545		0.95	996
	0.98	1538		0.98	986
0.60	0.85	1573	0.90	0.85	700
	0.90	1516		0.90	615
	0.95	1485		0.95	568
	0.98	1477		0.98	556
0.70	0.85	1405	0.95	0.85	447
	0.90	1339		0.90	357
	0.95	1302		0.95	308
	0.98	1293		0.98	295

- Sample size for the release was based on a reservoir survival rate of 80%, tag detection probability of 95% and a precision of 0.025. The test fish will be held for 24 hours prior to release to quantify handling mortality.

- During the study a control group (100 of each species) will be held in small circular raceways for one week to determine 1) post-release mortality due to tagging, and 2) tag shedding. The facilities will be located in a secure area.

- PIT-tag detectors will be located on the FSC and at the exit of the release ponds and will generate the tag detection histories necessary to estimate ODS.

- The FSC, transport trucks and release ponds will be examined daily by biologists to determine the number of fish killed during the handling and transport processes. All dead fish will be examined for the presence of a PIT tag. Dead tagged fish found in the FSC and release ponds would be assigned to collection loss (S_{COL}) and transport loss (S_{TRAN}), respectively.

- Once CE exceeds 60 percent, 50 dead PIT-tagged fish will be released into the FSC over the course of the season as a check on the ability of the biologists to detect and recover dead fish. If tag recoveries are less than 100%, estimates of ODS will be adjusted based on the calculated error rate.

The single release-recapture model will be used to estimate the probability of surviving passage to the lower Lewis River (Appendix Table B-1).

ODS will be calculated as:

$$ODS = S_1 * (S_{COL} * S_{TRAN})$$

Where:

S_1 = joint survival probability through reservoir (S_{RES}) and collector (P_{COL}),

P_{COL} = proportion of fish arriving at Swift Dam that enter the surface collector,

S_{COL} = survival probability through the collector,

S_{TRAN} = survival probability through the smolt transport system.

A diagram of each of these four parameters (S_{RES}, P_{COL}, S_{COL} and S_{TRAN}) is shown in Figure 2.1-2.

The seasonal ODS estimate will be based on pooling release–recapture data over the season. Because some proportion of tagged fish are likely to overwinter in the reservoir, any fish captured in subsequent years will be retrospectively added to the ODS estimate for their release year.

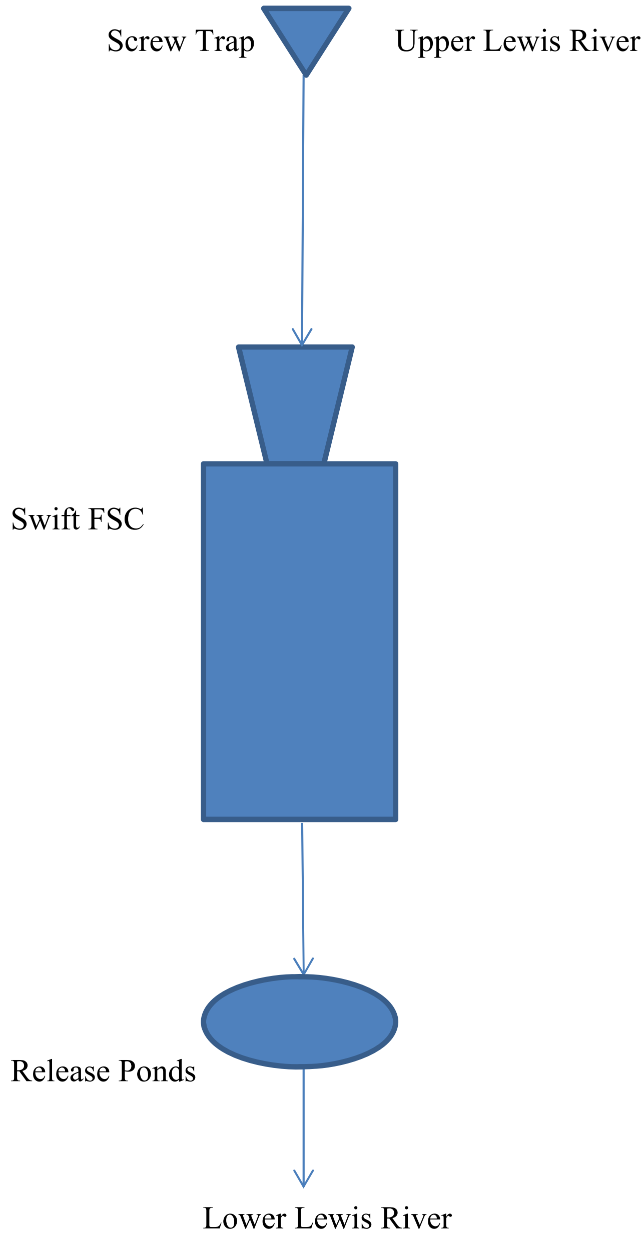

Figure 2.1-1. Schematic showing ODS measurement range from upper river to lower river and associated facilities.

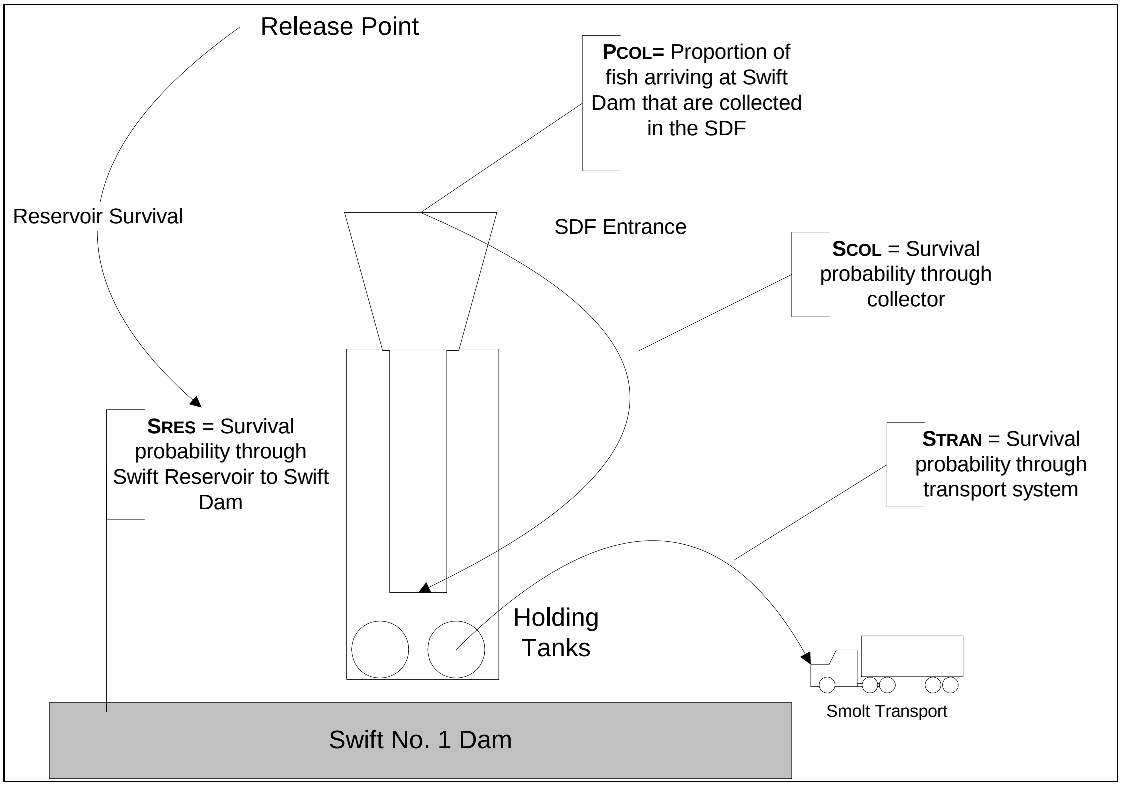

Figure 2.1-2. Schematic showing evaluation parameters for calculating ODS NOTE: SDF is synonymous with FSC.

2.1.1.2 Frequency and Duration

The study will be performed yearly until such time as study results show that the 80% ODS standard has been met for each species for three consecutive years. The study will be repeated upon completion of the Yale and/or Merwin downstream collection facility to determine if the 75% ODS criteria called for in the Settlement Agreement is achieved. Once ODS is met then reassessment will occur at least once every 5 years. If ODS is not met with each reassessment the study will be performed yearly until such time as study results show that the ODS standard has been met for each species for three consecutive years.

2.1.1.3 Assumptions

Assumptions associated with conducting the analysis include:

1. All fish act independently.
2. Release size is known without error.
3. There is no post-release handling mortality, tag failure or loss, or these parameters can be estimated and the survival estimates adjusted accordingly.
4. Downstream detection is conditionally independent of detection upstream.

5. Tagged fish are uniquely identifiable at all detection sites.

6. Fry and parr mortality due to extended reservoir rearing is accepted as a Project impact and does not need to be corrected for.

7. Fish passing through spill and turbine discharge at Swift Dam will not count toward meeting the ODS standard (i.e. these fish will be considered mortalities).

Of the six assumptions listed, number 3 is the most likely to be violated. Tagging and transporting juvenile salmonids can be stressful and result in some mortality both pre- and post-release. To quantify this mortality, a control group will be established as part of the experimental design. These fish will be tagged and handled in an identical fashion as the test fish. However, instead of being released into the reservoir, the fish will be held in small raceways, and then observed for one week to determine mortality and tag shedding rates. This information will then be used to adjust survival rates for the test fish, if needed. Evaluation of control groups will be completed at a minimum of once per season. Additional controls will be needed if changes in environmental and/or procedural (i.e. tagging personnel change) conditions warrant further evaluation and will be determined by PacifiCorp Biological staff with ACC seasonal oversight.

2.1.1.4 Results and Reporting

The results of the study will be recorded weekly and reported in text and tabular format with narrative in the ACC/TCC Annual Report and will include percent ODS, by species, per week of assessment .

A total estimate of ODS for the migration season will also be developed and reported by species. Biologists will investigate and present any information that indicates ODS values vary by fish size class or project operations. This information would be used to adjust study protocols to better estimate ODS and implement corrective actions if ODS is not being achieved.

2.2 OBJECTIVE 2- QUANTIFY FSC COLLECTION EFFICIENCY (P_{CE})

Biotelemetry will be used to measure juvenile collection efficiency (P_{CE}) at the Swift FSC. Section 4.1.4 of the Settlement Agreement defined collection efficiency as:

> *The percentage of juvenile anadromous fish of each of the species designated in section 4.1.7 that is available for collection and that is actually collected.*

In this study, juvenile salmonids will be tagged with radio or acoustic transponders (i.e., active tags) from the Eagle Cliffs screw trap and released at the head of Swift Reservoir. A juvenile that is available for collection is one that is found (detected) within the zone of influence (ZOI) at the entrance of the FSC[3]. The ZOI is defined as the area approximately 150 feet radius immediately outside the exclusion net that is influenced by the flow entering the FSC. The dimensions of the ZOI were determined by the fish passage subgroup and were determined in

[3] The Zone of Influence is the area in front of the FSC entrance where all flow lines upstream of the exclusion nets lead to the collector.

part by the hydraulic influence observed in the fluid dynamics modeling. As stated in the Settlement Agreement, the performance standard for PCE is 95% or greater.

Additionally, estimates of the proportion of fish encountering the FSC (PENC), FSC fish entrance efficiency (PENT), and FSC retention efficiency (PRET) will also be collected as part of this analysis using active tag detections. Collecting these data will give biologists the ability to determine where improvements in the design or configuration of the FSC may be needed to meet the PCE and ODS standards. The importance of each parameter in diagnosing FSC operations are as follows:

- P_{ENC} – A low encounter value indicates that few fish arriving at Swift Dam were detected within the zone of hydraulic influence (i.e. ZOI) of the FSC[2]. This condition would indicate that fish are not finding or transitioning into the ZOI from the upper reservoir. This may be attributed to a high rate of residualization or low reservoir survival. Unfortunately there is not a solution for either condition.

- P_{ENT} – Fish that have encountered the ZOI may not actually enter the FSC. This condition would be indicated by a low entrance efficiency value for P_{ENT}. The problem may be caused by poor or confusing hydraulics at the mouth of the collector or a sudden decrease or increase in water velocity just inside the FSC. Such problems may be corrected by altering system hydraulics.

- P_{RET} – Fish that enter the FSC may also swim back out of the system, resulting in low FSC retention efficiency (P_{RET}). Low FSC retention efficiency may be the result of water velocities through the FSC that are too slow to trap the fish. This condition could be alleviated by increasing flow through the collector or changing screen openings to increase water velocities.

2.2.1 Task 2.1- Estimate FSC Collection Efficiency (P_{CE})

2.2.1.1 Methods

A brief description of the methods to be used in estimating FSC collection efficiency (P_{CE}) is presented below.

- Biotelemetry tags (radio or acoustic) will be used for estimating FSC collection efficiency (P_{CE}).

- The number of fish tagged per species will be determined based on achieving approximately a 90% confidence level (CL) at a 0.05 precision level when FCE and tag detection probability is 95% (Table 2-2.1). Information collected during previous evaluation years will be used to guide sample sizes allocations.

Table 2-2.1. Release sizes to estimate $P_{(CE)}$ at the Swift FSC for alternative values of reservoir survival and detection probability at the ZOI for a precision of □ = 0.05, 1 – □ = 0.90.

		Required n, given reservoir survival						
Detection Probability	**P (CE) (π_obs)**	**100%**	**95%**	**90%**	**80%**	**70%**	**60%**	**50%**
0.95	0.10	103	108	114	128	146	171	205
0.95	0.20	182	192	203	228	260	304	365
0.95	0.30	239	252	266	299	342	399	479
0.95	0.40	273	288	304	342	391	456	547
0.95	0.50	285	300	316	356	407	475	570
0.95	0.60	273	288	304	342	391	456	547
0.95	0.70	239	252	266	299	342	399	479
0.95	0.80	182	192	203	228	260	304	365
0.95	0.90	103	108	114	128	146	171	205
0.95	0.95	54	57	60	68	77	90	108
0.95	0.99	11	12	13	14	16	19	23

		Required n, given reservoir survival						
Detection Probability	**P (CE) (π_obs)**	**100%**	**95%**	**90%**	**80%**	**70%**	**60%**	**50%**
0.99	0.10	98	104	109	123	141	164	197
0.99	0.20	175	184	194	219	250	292	350
0.99	0.30	230	242	255	287	328	383	459
0.99	0.40	262	276	292	328	375	437	525
0.99	0.50	273	288	304	342	390	456	547
0.99	0.60	262	276	292	328	375	437	525
0.99	0.70	230	242	255	287	328	383	459
0.99	0.80	175	184	194	219	250	292	350
0.99	0.90	98	104	109	123	141	164	197
0.99	0.95	52	55	58	65	74	87	104
0.99	0.99	11	11	12	14	15	18	22

- Overall collection efficiency (P_{CE}) will be estimated by the fraction

$$\hat{P}_{CE} = \frac{a_2}{a_1} \quad (10)$$

with associated variance estimator

$$\text{Var}\left(\hat{P}_{CE}\right) = \frac{\hat{P}_{CE}\left(1-\hat{P}_{CE}\right)}{a_1}, \quad (11)$$

where

a_1 = number of unique tagged fish identified in the vicinity of the FSC,

a_2 = number of unique tagged fish identified in the fish collection ponds inside the FSC.

- Sample fish will be collected either at the screw trap located at the head of Swift Reservoir or at the FSC. Fish captured at either location will be identified to species, measured for length and tagged. Preference will be to use fish collected at the screw trap as these fish would have not been exposed to the reservoir environment; an exposure that may alter fish behavior, and thus interpretation of study results.

- Tagged fish from the FSC will be transported by boat and released at the head of Swift Reservoir in the old river thalweg across from the Swift Forest Camp Boat Launch approximately 8.5 miles upstream of the FSC.

- Only fish greater than 90 mm will be tagged, as this is currently the minimum sized fish that can be used for active tag studies. Tagging smaller fish may result in high mortality rates or negatively affect fish behavior (CBFWA 1999). Tagging of fish smaller than 90 mm will not occur until technological improvements make such tagging practicable.

- All fish tagging personnel will be evaluated to quantify bias associated with individual techniques. This will be done each year and prior to the start of the study.

- All test fish will be dual tagged with an active tag along with a PIT tag to quantify tag failure and confirm passage at the FSC.

- Fish will be released in proportion to the natural run timing curve developed in Section 2.6 – Objective 6.

- Monitoring sites will be deployed in and around the Swift FSC. The first monitoring array (A in Figure 2-1.3) will be located at or near the entrance of the FSC; the second, (B in Figure 2-1.3), will be near or within the FSC holding tanks.

- Monitoring array (A) will be tuned to detect fish within the ZOI of the surface collector. The ACC agreed that the ZOI extends from the mouth of the FSC 150 feet upstream into the forebay. A map showing detection locations will be developed and presented to the ACC prior to releasing tagged fish to determine FSC collection efficiency.

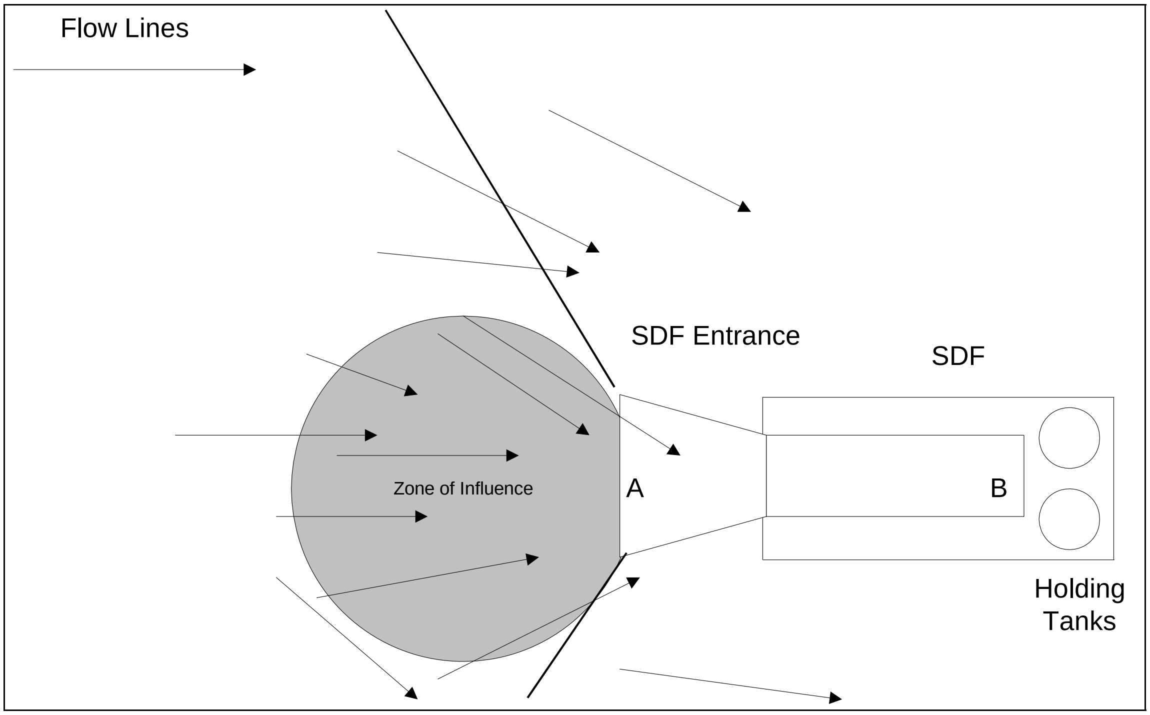

Figure 2.1-3. Schematic of FSC and area of detection associated with the ZOI (diameter of 150 ft.) as well as locations of antenna array (A) and PIT Tag detector (B).

2.2.1.2 Frequency and Duration

Collection efficiency (P_{CE}) will be quantified weekly around the expected peak migration period(s) for each transport species. Annual calculations of (P_{CE}) will be made following the initial pilot study year (2012) for three (3) consecutive years or until the (P_{CE}) standard has been met. After the third year of study, the ACC and the Services will review existing information and decide whether future study is necessary. Future studies would not be implemented if it is determined by the ACC and the Services that improvement in FSC collection efficiency is not possible.

2.2.1.3 Assumptions

All of the assumptions associated with the single release-recapture model described in Section 2.1.1.3 apply here as well. In addition, the estimate for P_{CE} assumes the PIT tag monitoring array (antenna array "B") has a 100% detection efficiency, which is based on efficiency data collected previously from the FSC and evaluated weekly during the migration season(s).

2.2.1.4 Results and Reporting

The results of the study will be reported in the ACC/TCC Annual Report in tabular format with narrative and will include collection efficiency by species per week of assessment.

A total estimate of FSC collection efficiency for the migration season will also be developed and reported by species in the ACC/TCC Annual Report.

2.2.2 Task 2.2- Estimate the Number of Juveniles Encountering the FSC Entrance (P_{ENC})

2.2.2.1 Methods

The number of juveniles (smolts) encountering the FSC will be determined by tracking releases of active tagged fish as they arrive at Swift Dam4. Detection arrays will be placed across the narrow reservoir section in line with Devil's Backbone approximately 0.5 miles upstream of the FSC. This area will be used to define when fish enter the forebay of Swift Dam.

The proportion of the tagged juveniles encountering the FSC (PENC) will be calculated as:

$$P_{ENC} = DET_{FSC} / DET_{SWIFT}$$

Where

DET_{FSC} = number of juveniles detected at antenna array A and/or B on the FSC

DET_{SWIFT} = number of juveniles detected entering Swift Dam forebay and the FSC

P_{ENC} will provide a simple index to describe the proportion of the tagged fish that were available for collection.

2.2.2.2 Frequency and Duration

P_{ENC} estimates will be calculated until the collection efficiency (P_{CE}) standard is achieved or if it is determined by the ACC and the Services that additional improvement in FSC collection efficiency is not possible.

2.2.2.3 Assumptions

The detection array of antenna array A can be determined.

2.2.2.4 Results and Reporting

Results will be reported in the ACC/TCC Annual Report. Data will be presented in tabular format.

2.2.3 Task 2.3- Estimate Juvenile Entrance Efficiency (P_{ENT}) and Retention Efficiency (P_{RET}) for the FSC

2.2.3.1 Methods

Juvenile entrance (P_{ENT}) will be estimated using active tag detections at A (Entrance of FSC channel). Detection history of each tagged fish will be used to determine the pertinent variables as described below.

P_{ENT} will be calculated as: $P_{ENT} = \frac{\#\ of\ tagged\ fish\ detected\ at\ A}{DET_{ZOI}}$ (14)

With associated variance estimator

$$\mathrm{Var}(P_{ENT}) = \frac{P_{ENT}(1 - P_{ENT})}{DET_{ZOI}} \quad (15)$$

Retention efficiency (P_{RET}) will be estimated using active tag detections at B (Retention Zone in the FSC channel). Detection history of each tagged fish will be used to determine the pertinent variables as described below.

P_{RET} will be calculated as: $P_{RET} = \frac{\#\ of\ tagged\ fish\ detected\ at\ B}{\#\ of\ tagged\ fish\ detected\ at\ A}$ (16)

With associated variance estimator

$$\mathrm{Var}(P_{RET}) = \frac{P_{RET}(1 - P_{RET})}{\#\ of\ tagged\ fish\ detected\ at\ A} \quad (17)$$

2.2.3.2 Frequency and Duration

Performed at any time FSC collection efficiency estimates are being developed.

2.2.3.3 Assumptions

Key assumptions of the analysis include:

- Monitoring stations can be adjusted such that detection zones can be estimated.
- Monitoring stations can be placed within the FSC without impacting FSC operations or fish behavior.

2.2.3.4 Results and Reporting

Study results will be provided as a stand-alone report at the conclusion of each evaluation season. A summary of the report will be provided in the ACC/TCC Annual Report.

2.3 OBJECTIVE 3- QUANTIFY THE PERCENTAGE OF JUVENILE FISH AVAILABLE FOR COLLECTION THAT ARE NOT CAPTURED BY THE FSC AND THAT ENTER THE POWERHOUSE INTAKES

The proportion of fish entering the intake of the Swift No. 1 powerhouse will not be quantified until downstream collection systems are installed at Yale and Merwin dams. Once these systems are operational, the M&E Plan will be updated to include study protocols designed to determine turbine entrainment and loss. In the interim, antenna will be located in the Swift No. 2 canal downstream of the Swift No. 1 powerhouse tailrace to detect any active tagged fish passing through the Swift No.1 units. This assumes that active tags remain functional after passing through the Swift No. 1 turbines.

2.4 OBJECTIVE 4- QUANTIFY JUVENILE AND ADULT COLLECTION SURVIVAL

The objective of this task is to quantify survival from the time the fish (Chinook, coho, steelhead, and sea-run cutthroat smolts and fry and adult bull trout and steelhead kelts) enter the FSC to their release downstream of Merwin Dam[5]. This survival rate is defined in the Settlement Agreement as collection survival (CS). The CS standard varies by fish size and species as shown below:

- Chinook, coho, steelhead, and sea-run cutthroat smolts = 99.5%
- Chinook, coho, steelhead and sea-run cutthroat fry = 98%
- Bull trout = 99.5%

The PIT-tag data collected to estimate Overall Downstream Survival (ODS) can be used to estimate CS for smolts, but not for fry. Fry are too small to tag with a PIT tag and therefore calculating survival for this size fish requires that mortality be measured directly at the recovery tank, transport tanks and release ponds.

Because fish mortality may occur both in the collection and/or transport processes, separate estimates of survival through each process will help determine the cause of any observed mortality and will be used to develop appropriate remedial measures. Therefore, CS will be broken into two components, collection survival (S_{COL}) and transport survival (S_{TRAN}).

Estimates of CS, S_{COL} and S_{TRAN} will be developed for coho, Chinook, steelhead, sea-run cutthroat trout (if a run is established) and bull trout captured in the FSC[4].

2.4.1 Task 4.1- Estimate Fish Collection and Transport Survival Rates

2.4.1.1 Methods

The methods to be used for quantifying S_{COL}, S_{TRAN} and CS are presented below.

Determine Fish Survival through the Collection System (S_{COL})
Survival estimates for juvenile fish greater than 60 mm collected at the FSC (S_{COL}) will be collected daily by using a subsample of captured fish prior to their entry into the transport system. Subsampling will be accomplished through the use of gates located on the FSC that can be programmed to automatically divert fish to the subsample tanks. The diverted fish will be physically examined to determine the proportion of fish that die from collection activities.

[5] Bull trout survival estimates will also be made for other release sites identified by the USFWS. Steelhead kelt mortality and injury rates, although not required in the Settlement Agreement will be based on visual observation.

Monthly estimates will be developed which will collectively create an annual estimate of S_{COL} and will be based on binomial sampling with the estimator:

$$S_{COL} = \frac{Fish_{SUB}}{Fish_{EX}} \quad (18)$$

$Fish_{SUB}$ = number of smolts found alive in subsample

$Fish_{EX}$ = number of smolts examined in subsample

With associated variance estimator

$$\text{Var}(S_{COL}) = \frac{S_{COL}(1 - S_{COL})}{Fish_{EX}} \quad (19)$$

Estimates of S_{COL} will be made each month and will then be combined for an annual estimate.

Fry sized fish are captured in one holding tank on the FSC in which all fish are enumerated and inspected for health conditions on a daily basis. Survival calculations for fry collected at the FSC will be developed on a monthly and annual basis by dividing the total number of fry collected alive by the total number of fry collected during the respective time frame.

Determining Survival through the Transport System (S_{TRAN})
Juvenile survival, from the time they enter the transport system until they exit the release ponds downstream of Merwin Dam, is defined as S_{TRAN}.

The method used for determining S_{TRAN} is as follows:

A representative sample of parr and smolts will be marked and released directly into the transport tanks located on the FSC on a weekly basis (one test per week). The test fish used for these releases will be collected from the FSC subsample tanks. A control group will be established to determine mortality associated with handling.

- Test fish releases will be made such that these fish spend a similar amount of time in the holding tanks as the fish that were diverted to the tanks through the FSC.

- Fish in the holding tanks will then be loaded onto trucks, transported and released to the ponds located below Merwin Dam. The current design has three release ponds and one redundant pond. The three ponds are thought to be adequate for the anticipated numbers of out-migrants. The fish will be held in these ponds for approximately 24 hours.

- Prior to releasing fish from the ponds, the ponds will be checked for dead fish. Dead or dying fish will be collected, examined for marks and injury, and identified to species. The pond's gates will then be opened and the fish allowed to volitionally exit over a 24-hour period.

- To test the ability of biologists to identify and collect dead fish from the release ponds, a known number of marked dead fish will be periodically released into the transport system. The results of this test will be used to develop a correction factor (CF) to account for less than 100% detection of dead fish.
- After 24 hours, the ponds will once again be examined for dead fish. Any dead fish will be collected, examined for marks and injury, and identified to species. Live fish remaining in the ponds at this time will be forced out of the ponds.

S_{TRAN} will be calculated using the formula:

$$S_{TRAN} = \frac{Fish_{alive}}{Fish_{REL}} \quad (20)$$

$Fish_{REL}$ = number of marked smolts released in transport system

$$Fish_{alive} = Fish_{REL} - \left(\frac{\#of\ marked\ smolts\ found\ dead\ in\ release\ pond}{CF}\right) \quad (21)$$

$$\text{CF} = \frac{\#\ of\ known\ marked\ dead\ fish\ found\ in\ recovery\ pond}{\#\ of\ known\ marked\ dead\ fish\ released\ into\ transport\ system} \quad (22)$$

With associated variance estimator

$$\text{Var}(S_{TRAN}) = \frac{S_{TRAN}(1 - S_{TRAN})}{Fish_{REL}} \quad (23)$$

An estimate of S_{TRAN} will be developed on a monthly and annual basis for coho, Chinook, steelhead, sea-run cutthroat trout and bull trout (adults and juveniles) captured in the FSC. It should be noted that S_{TRAN} values for bull trout adults (and steelhead kelts) will be based on observed mortalities during transport and release at all release sites identified by the resource agencies.

Calculating Juvenile Collection Survival (CS)
CS is the combined juvenile mortality observed for collection (S_{COL}) and transport (S_{TRAN}), calculated as:

$$\text{CS} = S_{COL} * S_{TRAN} \quad (24)$$

With associated variance estimator

$$\text{Var}(CS) = \frac{CS(1 - CS)}{Fish_{REL} + Fish_{EX}} \quad (25)$$

An estimate of CS will be developed monthly for coho, Chinook, steelhead, sea-run cutthroat trout and bull trout (adults and juveniles) captured in the FSC. The monthly estimates will be pooled to develop an overall estimate of CS for the monitoring season.

2.4.1.2 Frequency and Duration

Collection survival estimates will be developed daily until it is proven that the annual collection standards have been met. Once met, survival estimates will be developed for one week each month to document compliance with the collection survival standard.

2.4.1.3 Assumptions

The major assumptions inherent in the proposed methods include:

1. The subsample fish are representative of the population being collected and transported.
2. Diversion of juvenile fish into the subsample system does not bias mortality estimates.
3. Fish handling protocols for determining S_{TRAN} do not bias juvenile mortality estimates.

2.4.1.4 Results and Reporting

Results of the analysis will be presented in tabular format; in the ACC/TCC Annual Report and will include Collection Survival, Transport Survival and Overall Collection Survival per species on a weekly basis along with an annual summary. The CS standard will be considered met if the calculated confidence interval (CI) spans the target survival rate of smolts with an absolute standard error of 2.5 percent or less.

2.5 OBJECTIVE 5- QUANTIFY JUVENILE INJURY AND MORTALITY RATES DURING COLLECTION AT THE FSC (INCLUDES INJURY AND MORTALITY OF ADULT BULL TROUT, ADULT SEA-RUN CUTTHROAT, AND STEELHEAD KELTS)

The objective of this analysis is to determine the injury rate for fish collected at the FSC. The Settlement Agreement establishes a FSC design performance objective for injury of less than or equal to two percent for all fish examined. . While the original title of this objective in the Settlement Agreement includes mortality rates, this metric is covered under Objective 4 in this M&E Plan.

Injury is defined in Settlement Agreement Table 4.1.4 as:

> *Visible trauma (including, but not limited to hemorrhaging, open wounds without fungus growth, gill damage, bruising greater than 0.5 cm in diameter, etc.), loss of equilibrium, or greater than 20% descaling. "Descaling" is defined as the sum of one area on one side of the fish that shows recent scale loss. This does not include areas where scales have regenerated or fungus has grown.*

2.5.1 Task 5.1- Determine Collection Injury Rate (P_{CINJ})

The method proposed for estimating the proportion of fish injured (P_{CINJ}) each day from collection activities at the FSC is presented below.

2.5.1.1 Method

Estimates of P_{CINJ} will be determined by closely examining a minimum of ten percent of the total juvenile population collected each day. Sample fish will be diverted (through the use of automatic gates on the FSC) into small holding tanks where they will be anesthetized and examined for injury. Injured smolt and fry will be classified into the categories shown in Table 2.5.1.

Table 2.5.1. Categories used for documenting visible injury at the FSC collection and transport system.

Hemorrhaging	Open Wound (No Fungus)	Open Wound (Fungus)[1]
Gill Damage	Bruising > 0.5 cm diameter	Bruising ≤ 0.5 cm diameter
Loss Of Equilibrium	Descaling > 20%	Descaling < or = 20%

[1]Open wound fish with fungus will not be counted as an injured fish. The presence of fungus indicates the wound likely occurred prior to entry into the FSC.

The proportion of juvenile fish injured (P_{CINJ}) will be calculated using the formula:

$$P_{CINJ} = \frac{\#\ of\ fish\ injured}{\#\ of\ fish\ sampled} \quad (26)$$

With associated variance estimator

$$\mathrm{Var}(P_{CINJ}) = \frac{P_{CINJ}(1 - P_{CINJ})}{\#\ of\ fish\ sampled} \quad (27)$$

2.5.1.2 Frequency and Duration

Injury rates will be determined daily for as long as the FSC is operational.

2.5.1.3 Assumptions

The major assumptions for measuring P_{CINJ} include:

1. The subsample fish are representative of the population being collected.
2. Diversion of juvenile fish into the subsample system does not bias estimates of injury.
3. Fish handling protocols do not result in an increase in fish injury.

2.5.1.4 Results and Reporting

Results of the injury analysis will be summarized in the annual ACC/TCC Annual Report in tabular format along with a narrative that shows weekly injury observations by species and an annual summary. The CS standard will be considered met if the calculated confidence interval (CI) spans the target survival rate of smolts with an absolute standard error of 2.5 percent or less.

2.6 OBJECTIVE 6- QUANTIFY THE ABUNDANCE AND MIGRATION TIMING, BY SPECIES, OF JUVENILE AND ADULT FISH COLLECTED AT THE FSC

The objective of this analysis is to quantify the number of juvenile and adult fish collected at the FSC by species.

Prior versions of the M&E Plan called for the number of juvenile fish entering the FSC to be calculated through subsampling and the use of an AquaScan CSE-1600 (Scanner) that would automatically count all fish passing through the FSC. A combination of these two methods were chosen for estimating this parameter as it was unknown how accurate the Scanner would be at enumerating small juvenile salmonids under field conditions[6]. Many tests and calibrations took place during operating years' 2013-2015. The scanners were found to be unreliable and falsely assigned debris and turbulence as fish. Because the automatic fish counters were shown to be unreliable for long term daily operation, estimating total number of fish collected at the FSC will be done by expanding subsampling methods.

2.6.1 Task 6.1- Calculate Juvenile and Adult Collection Numbers Using FSC Subsampling

The methods proposed for quantifying the number of juveniles and adult collected at the FSC are detailed below.

2.6.1.1 Methods

There are three possible routes fish may travel once entering the FSC sorting building. Smaller sized fish (~ 60mm – 120mm) pass through the first set of separator bars and are collected in a "fry" holding tank. Fry will be transported downstream below Merwin until collection efficiency is greater than 50 percent. At that point the destination for fry will be reassessed. All fish collected via this route are enumerated daily. The second route is through the smolt separation system in which smolt size fish (~ 121mm – 220mm) pass through the separator bars and are then distributed to either the general population tank or smolt sample tank. During periods of low collection numbers, all fish that pass via this route are diverted to the sample tank and are enumerated daily (i.e., census of all fish collected in the FSC). During periods of high collection numbers (greater than 500 to 1,000 fish per day), a portion of fish are directed to the sample tanks while the remaining are directed to the general population tanks. Currently the diversion gates are operated one (1) continuous minute of every 10 minutes throughout the entire day to provide a 10 percent subsample rate for all fish entering the facility. Sample rates may be increased if future study protocols require the marking of more test fish. Fish large enough to pass over both separator bars are collected in the "adult" tank and all fish are enumerated daily. In addition to enumeration, all sampled fish are also anesthetized and checked for marks, measured for length, and identified to species.

The estimators below assume that fish in the subsample tank are measured and enumerated once per day. Also it is assumed that during most of the juvenile fish migration period, fish will be systematically sampled at a constant rate (i.e., 10 percent of the time, 1 minute out of every 10 minutes, for 24 hours per day) and varying the subsample rate through the season will not occur. It is also assumed that at the beginning and end of the migration season, when collection numbers are lower, 100 percent of fish will be diverted to the subsample tanks and enumerated.

Total Number of Fish (subsampling period):

$$T = N\bar{y} = \frac{N}{n}\sum_{i=1}^{n} y_i \quad (28)$$

Where,

T = total number of fish during the subsampling period
O = total number of fish during 100% enumeration period
r = subsampling rate
n = number of sampling periods (days sampled)
N = n/r (sampling intensity)
y_i = discrete daily fish count
$\bar{y}$ = average number of fish counted per day
s^2 is the sample variance, and is calculated as shown below
t is the t-statistic for n-1 degrees of freedom and α/2

With associated variance estimator:

$$s^2 = \frac{1}{n-1}\sum_{i=1}^{n}(y_i - \bar{y})^2 \quad (29)$$

And 95% Confidence Interval:

$$O + T \pm t_{(0.025,n-1)}\sqrt{\frac{N(N-n)s^2}{n}} \quad (30)$$

2.6.1.2 Frequency and Duration

Daily counts of the number of fish entering the FSC will continue for as long as the facility is operational. The constant subsampling rate will be developed over time as more is learned about facility effectiveness and total basin fish production.

2.6.1.3 Assumptions

The major assumption inherent in the methodology is that the subsampled fish are representative of the general population. PacifiCorp conducted tests in 2014 and 2015 at various discrete subsample proportions from 1 to 5 of every 10 minutes (i.e., 10%, 15%, 25%, 30%, 40%, and 50%). During each day of operation at a specific subsample rate, fish were enumerated in the subsample tank, as well as the total number of fish captured in the FSC. Several days were assessed at each discrete subsample rate. T-tests showed no significant difference between measured to expected mean subsample proportions at each discrete subsample rate ($\alpha = 0.05$). This suggests that the subsample strategy of continually subsampling fish from 1 to 5 minutes of every 10 minute (throughout the entire day) is representative of the total number of fish captured in the FSC over an extended period.

The equations described above are standard equations for calculating the total and sample variance assuming a random sample is taken (e.g., see Thompson 2002). In this case, the samples are systematic, but we are assuming there is no ordering/cyclic variation introduced by the subsample approach. One advantage of systematic sampling is that it may be more logistically feasible than random sampling, because it involves a regular sampling interval and may be automated. It also maximizes the dispersion of sampling effort. One limitation of systematic sampling is that it can introduce bias if the sampling interval corresponds to periodic variation in the sampling frame. For example, if samples are collected every 12 hours or 24 hours they will be taken at the same time each day, which may bias the sample if fish are more likely to be present (or absent) at certain times. Selecting a sampling interval that ensures sampling occurs frequently and throughout the day (e.g., the 1 in 10 minute interval, throughout the entire 24 hour day) minimizes this potential bias.

Consideration was given to have a stair-step approach of subsampling on the beginning and tail ends of the migration season (i.e. decrease subsample rates from 50% to 25% to 10% as migration increases and opposite as migration decreases). This method was simulated by expanding the 2013 daily fish totals by 10 times in order to produce simulated daily fish totals in excess of 1000 fish. For the stair step sampling rate simulation, 100% of fish were enumerated until total daily fish captures exceeded 500 (144 sample days), then a 50% sample rate was applied until total daily sample catch exceeded 500 (10 sample days), then a 30% sample rate was applied until total daily sample catch exceeded 500 (6 sample days), then a 10% sample rate as applied (46 sample days). A 100% census was again implemented when the estimate of total daily fish entering the FSC fell back to 500 fish or less (72 sample days). The results of the simulation suggested that the stair-step approach resulted in a larger 95% confidence interval width when compared to keeping the sample rate constant at any particular discrete temporal sampling rate interval. Reducing the number of days sampled at any particular discrete sampling rate ultimately increased the confidence interval width. For these reasons a constant sample rate was chosen.

2.6.1.4 Estimator Testing and Verification

Further validation testing will be conducted at the 10% temporal sampling rate. Based on validation testing in 2014 and 2015, the mean fish sampling rate was 14.7% when the temporal sampling rate was set at 10%. However, prior validation testing of the 10% temporal sampling rate only occurred on 11 sample days, which were also clumped within two separate weeks during 2015. In addition, the upper limit of fish sampling rate values observed at the 10% temporal sampling rate may be skewed due to low sample size and/or switching gate malfunction during validation testing. Therefore, further validation testing will be conducted to increase the sample size to construct a robust distribution of the variation in observed fish sample rates associated with the 10% temporal sampling rate. It is suspected that this distribution would remain relatively constant over time as the variation associated with all temporal sampling rate intervals tested appears to be purely from random chance and not associated with season or actual daily number of fish captured. The resultant average fish sampling rate associated with the developed distribution will then be applied as the subsample rate (r) in the estimator. About fifty (50) additional validation testing days will be conducted, which is expected to provide a robust distribution of fish sampling rate values associated with the 10% temporal sampling rate. This will be done during the time period when total daily census counts are being conducted (i.e. less than 500 fish per day), by setting the smolt tank gates to direct fish to the port tank for 1 minute and the starboard tank for 9 minutes of every ten minutes over the 24 hour sample day. Enumeration of the port tank is then treated as the "subsample" and the port tank plus the starboard tank is thus the "total". Additional validation testing will also be conducted when total fish entering the FSC exceed 500 fish per day as feasible. The available testing data indicates that as total fish numbers increase the fish sampling variability associated with any particular temporal sampling rate may decrease.

2.6.1.5 Results and Reporting

The results of the analysis will be presented in tabular format and included in the ACC/TCC Annual Report.

2.7 OBJECTIVE 7- ESTIMATE THE MIGRATION TIMING AND NUMBER OF JUVENILES ENTERING SWIFT RESERVOIR

Estimating the timing and total number of juvenile focal fish species (i.e., Chinook and coho salmon, steelhead and sea-run cutthroat trout) entering Swift Reservoir is required under Section 9.2.1 of the Settlement Agreement. After much discussion with the ACC members it became clear that this requirement is impractical using traditional methods. Therefore, an alternative approach has been developed that uses an index to estimate the total production of juvenile anadromous fish entering Swift Reservoir.

Traditionally, total juvenile salmonid migration estimates are made through operating downstream migrant fish traps (e.g., screw trap, weirs, inclined plane traps, etc.) and making expanded estimates of total juvenile out-migration based on trap efficiency testing throughout the migration season. Several tributaries have the capacity to contribute juvenile salmonids to Swift Reservoir, the largest being the upper North Fork Lewis River subbasin, which contains over 90 percent of available habitat by stream miles. As part of PacifiCorp's monitoring and evaluation program, a screw trap is operated seasonally near Eagle Cliff where the North Fork Lewis River subbasin empties into Swift Reservoir. While it would be impractical to operate downstream migrant traps on all other independent tributaries in Swift Reservoir due to their number and difficult access, operation of the Eagle Cliff screw trap does afford the opportunity to: 1) estimate the number of juvenile salmonids entering Swift Reservoir in the spring from the reservoir's largest subbasin, which can be used as a robust index of total annual juvenile salmonid production that can be tracked overtime; and 2) mark a large number of fish that can then be recaptured at the Swift FSC, which can be used to annually estimate total juvenile focal fish within Swift Reservoir.

2.7.1 Task 7.1– Estimate the Timing and Number of Juveniles Entering Swift Reservoir from the Upper North Fork Lewis River Subbasin

2.7.1.1 Methods

A brief description of the methods to be used in estimating the number of juvenile salmonids entering Swift Reservoir in the spring from the upper North Fork Lewis River subbasin is presented below.

- The Eagle Cliff screw trap will be operated at the head of Swift Reservoir from March through June - which is thought to generally encompass the peak smolt migration for the focal fish species. Operation during the winter and early spring is generally not possible due to high water events and unsafe (e.g., ice/snow) working conditions. Typically by late June and into summer, catch rates have been shown to fall to near zero.

- The trap will be operated daily during the trapping season. Daily operations and placement of the rotary screw trap will follow those methods similar to those described by Volkhardt et al. (2007).

- Sample size for the entire trapping season will be based on achieving a coefficient of variation (CV) of 15% for coho and Chinook, and 30% for steelhead (NMFS 2009). In prior years (2013-2015), total trapping season efficiency for all juvenile salmonids combined has ranged from 2 to 8%. To make total out-migrant estimates for each target salmonid species with 95% confidence intervals at the desired level of precision requires marking and releasing between about 1,000 to 3,000 fish based on the range of annual trap efficiency observed (Figure 1).

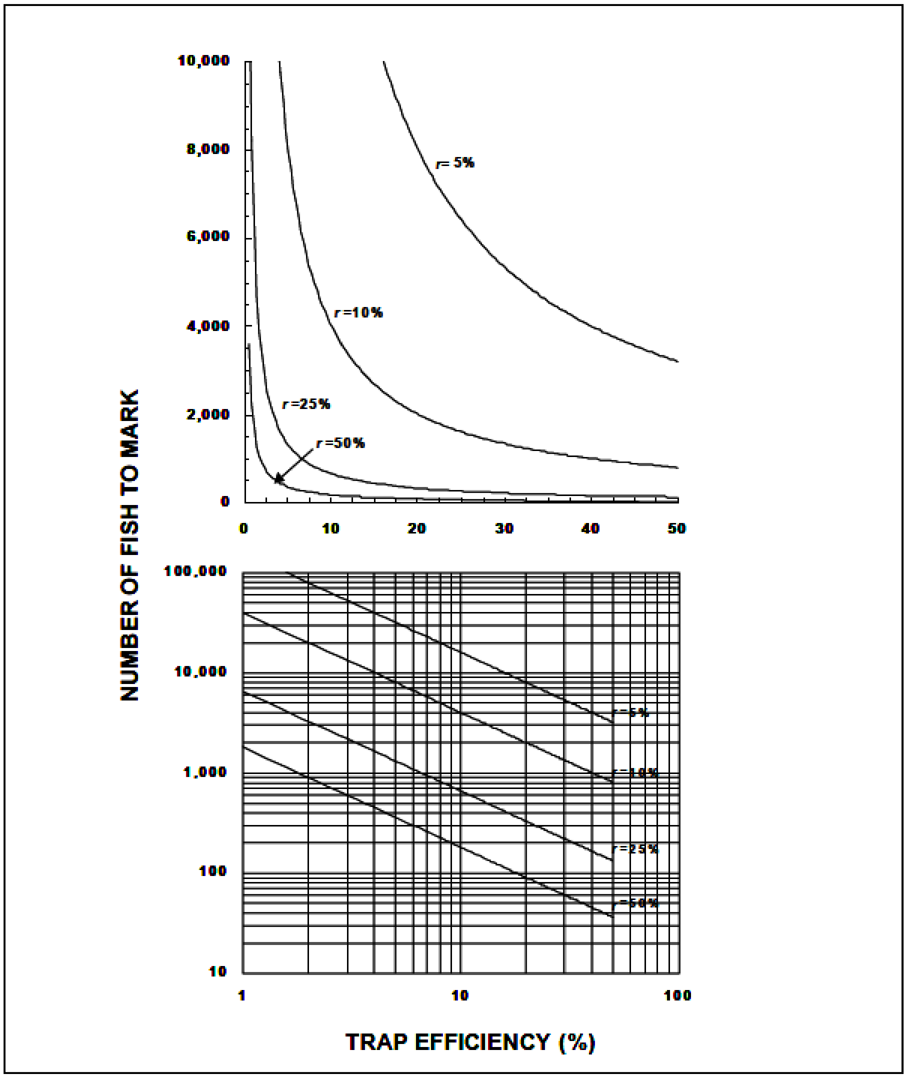

Figure 1. Relationship between trap efficiency (capture probability) and the number of salmon smolts to mark for relative error (r) of 5,10, 25, and 50%. The probability of exceeding r (α) is 5%. The lower plot shows the relationship on logarithmic scaled axes.

- Due to the large sample sizes needed to appropriately estimate trap efficiency it is expected that all maiden captures of juvenile focal fishes will be marked either with PIT tags (≥90 mm fork length) or an external mark (<90 but ≥60 mm fork length) and released (daily) upstream to estimate trap efficiency. Recaptured marked fish will be recorded and released downstream of the trap. A total season trap efficiency will be calculated and used to estimate total juvenile out-migration by focal fish species and life-stage. The M&E subgroup agreed that fish down to 60 mm would be marked and assessed. Fry would be included later once a suitable marking methodology is found that will not compromise fry survival.

- Fish released from the trap will be identified to species and life-stage, and measured for length. Fish smoltification status as indicated by physical appearance and condition will also be recorded.

- Historic data from the FSC (2012 – 2015) indicate that a considerable amount of focal fishes (mostly parr and fry) likely migrate into Swift Reservoir during periods when the Eagle Cliff screw trap is not in operation (Fall - late Winter). These fish are categorized as 'missed catch' by the screw trap. Upon literature review (Buehrens 2015; Kelly and Zimmerman 2012) missed catch of screw traps are typically estimated over shorter time frames when the traps are non-functional or during periods just before and after seasonal trap operations. During brief time frames when the Eagle Cliff screw trap is not in operation, linear interpolation will be used to estimate missed catch. However, a viable method for estimating missed catch of the Eagle Cliff screw trap over this long time period (~ 6 months) has not been realized. It is expected that any formulated way of calculating this missed catch would likely be highly erroneous. Therefore, estimates of focal fishes entering Swift Reservoir from the upper North Fork Lewis River subbasin should be interpreted as an index and compared annually.

- Total monthly juvenile out-migration by species during the trapping season will be calculated using the following formula for use of a single partial trap described in Volkhardt et al. (2007), in which the estimated number of unmarked fish migrating during discrete sample period i ($\hat{U}$), weekly or monthly, is dependent on actual recapture rates observed:

$$\hat{U}_i = \frac{u_i(M_i + 1)}{m_i + 1} \quad (31)$$

Where:

u_i = Number of unmarked fish captured during discrete period i
M_i = Number of fish marked and released during period i
m_i = Number of marked fish recaptured during period i

Discrete sample period variance:

$$V(\hat{U}_i) = \frac{(M_i + 1)(u_i + m_i + 1)(M_i - m_i)u_i}{(m_i + 1)^2(m_i + 2)} \quad (32)$$

- Weekly/monthly estimates of juvenile migration will be combined to calculate the total number of juveniles migrating downstream during the monitoring period using the following formula:

$$\hat{U} = \sum_{i=1}^{n} \hat{U}_i \quad (33)$$

Entire monitoring period variance:

$$V(\hat{U}) = \sum_{i=1}^{n} V(\hat{U}_i) \quad (34)$$

95% Confidence Interval:

$$\hat{U} \pm 1.96\sqrt{V(\hat{U})} \quad (35)$$

- In addition, total season variance and confidence intervals will also be estimated using bootstrap methodology for each focal fish species total estimate (Thedinga et al. 1994).
- As actual mark-recapture rates allow, focal fish species migration timing will be assessed by calculating total weekly/monthly out-migration abundance during the trapping season.

2.7.1.2 Frequency and Duration

Annual monitoring to determine juvenile focal fish species out-migration timing and abundance to Swift Reservoir (following the methods describe above) will be conducted until such time that Ocean Recruit numbers are met. Thereafter estimates will occur when the need arises to re-evaluate or re-verify ODS.

2.7.1.3 Assumptions

Key assumptions inherent in the analysis are:

1. The population is closed;
2. All fish have an equal probability of capture in the first period;
3. Marking does not affect catchability or survival;
4. All fish (marked and unmarked) have an equal probability of being caught in the second sample;
5. The fish do not lose their marks and marks are recognizable;
6. All recovered marks are reported; and
7. Timing of out-migration of the focal fish species from the upper North Fork Lewis River basin is assumed to be representative of out-migration timing from other small independent tributaries to Swift Reservoir.

2.7.1.4 Results and Reporting

Trapping results will be summarized in tabular form along with narrative in the ACC/TCC Annual Report. Tables would be developed for each species and would include an annual summary.

2.7.2 Task 7.2– Estimate the Total Number of Juveniles Entering Swift Reservoir

2.7.2.1 Methods

Utilizing PIT tag records from the FSC, PIT tagged fish used to estimate the Eagle Cliff screw trap efficiency will also be used to estimate the joint probability of focal fishes that survive passage through Swift Reservoir and are captured by the FSC (Section 2.1.1). This information can also be used to make a mark-recapture estimate of total focal fish species juvenile migrants to Swift Reservoir. Annual recapture rates of total juvenile fish marked at the Eagle Cliff screw and recaptured at the FSC over the past three years (2013-2015) ranged from 5 to 16%. Therefore, the sample size needed to estimate total juvenile migration to Swift Reservoir are smaller than those required to meet statistical precision discussed in Section 2.7.1 (Figure 1).

Recent (2016) hydroacoustic tag re-capture information has shown reservoir hold-over/rearing from one year to the next. Comparing size class of fish captured at the screw trap to those at the FSC, in addition to assessment of long-term mark-recapture data may be used to parse yearly estimates of total focal fish entering the reservoir by size/year class as the long-term mark-recapture data set is developed.

Estimated number of juvenile fish entering Swift Reservoir during the entire migration period will be calculated using equation (31) above where:

u_i = Total estimate of unmarked fish captured during the monitoring period at the FSC derived from equation (28) in Section 2.6;
M_i = Number of fish marked and released during the monitoring period from the screw trap;
m_i = Number of marked fish recaptured during the monitoring period at the FSC.

Discrete sample period variance will be calculated using bootstrap methodology (Thedinga et al. 1994). The 95% confidence interval will be calculated using equation (35) above.

2.7.2.2 Frequency and Duration

Annual monitoring to determine total juvenile focal fish species abundance entering Swift Reservoir (following the methods describe above) will be evaluated every five years to determine if this monitoring needs to continue. Thereafter estimates will occur as needed when the need arises to re-evaluate or re-verify ODS.

2.7.2.3 Assumptions

Key assumptions inherent in the analysis are:

- The population is closed;
- Marking does not affect catchability or survival;
- All fish (marked and unmarked) have an equal probability of being caught at the FSC;
- The fish do not lose their marks and marks are recognizable;
- All recovered marks are reported;
- All PIT tags are detected at the FSC;
- Reservoir survival and residence time of juvenile fish migrating from the upper North Fork Lewis River is similar to fish from other independent tributaries to Swift Reservoir; and
- Reservoir survival and residence time of juvenile fish migrating into Swift Reservoir during the "trap outages" (July – February) is similar to fish migrating during the trap season (March – June).

2.7.2.4 Results and Reporting

Mark-recapture results will be summarized in tabular form along with narrative in the ACC/TCC Annual Report. Tables would be developed for each species and would include an annual summary. In addition, data will be provided in the appropriate formatting to be incorporated into WDFW's juvenile outmigration database (JMX).

2.8 OBJECTIVE 8- DEVELOP INDEX OF JUVENILE MIGRATION TIMING

The ACC has determined that, although this was specifically called for in the Settlement Agreement, this metric is covered under section 2.6 and does not need to be duplicated.

2.9 OBJECTIVE 9- QUANTIFY ADULT UPSTREAM PASSAGE SURVIVAL

The adult upstream passage survival (UPS) performance standard is defined in the Settlement Agreement as:

> *Percentage of adult fish of each species designated in Section 4.1.7 that are collected that survive the upstream trapping-and-transport process. For sea-run cutthroat and bull trout, "adult" means fish greater than 13 inches in length.*

The Settlement Agreement requires the Utilities to achieve a UPS rate for all species of 99.5%. Given the UPS definition, it is assumed survival is measured from the point of collection to the point of release

2.9.1 Task 9.1- Quantify Upstream Passage Survival

Methods proposed for measuring UPS for adult fish captured at Merwin Dam are presented below.

2.9.1.1 Methods

The UPS will be measured through the direct enumeration of adult fish at the Merwin Fish Capture and Transport Facility (MFCF) and at transport release sites (Table 2-9.2). Any dead fish recovered at trapping or release sites will be identified to species and examined for signs of physical injury, to the extent possible.

Table 2.9.1. Current transport release sites in the upper Lewis Drainage*

Release Site	Description
Upper Swift Reservoir	Swift Camp Boat Ramp
Eagle Cliffs	Adult Release Structure
Muddy River	At the Acclimation Pond Site
Clear Creek	At the Acclimation Pond Site
Crab Creek	At the Acclimation Pond Site

***sites may be added or deleted upon ACC approval**

UPS will be calculated as follows:

$$\text{UPS} = 1 - \left(\frac{AD_{TRAP} + AD_{REL}}{Fish_{REL}}\right) \quad (36)$$

Where:

$Fish_{REL}$ = Number of total adults collected

AD_{TRAP} = Number of dead adults in trap

AD_{REL} = Number of dead adults in the truck or at release site at the time of each release

UPS will be calculated for each day fish are collected and/or transported from the Merwin UTF. Daily values of UPS will be combined to produce a single per species estimate of UPS for the year.

In order to determine possible causes of any adult mortality observed in the collection and transport process, the following data will also be collected:

Temperature- Water temperatures at the Merwin MFCF, in the transport truck and release site will be collected each day. Transport truck water temperature will be collected and recorded during fish loading and at the time of release. Stream temperature will be recorded for each release group. Stream temperature difference between transport and receiving water will not exceed 10°F. If the difference is greater than 10°F then truck water will be tempered with stream water before releasing adults all according to the Upstream Transport Plan (PacifiCorp 2009).

Dissolved Oxygen- Measurements of dissolved oxygen will be collected and recorded, and monitored in the transport truck from initial loading to release.

Transport Time and Distance- Transport time and distance will be recorded for each load of fish.

Species Mix- The number of fish by species and origin (NOR or HOR) will be recorded for each load of fish.

Loading Density - The number of fish per gallon will be recorded

These data will be reviewed throughout the transport season to determine possible cause and effect relationships between transport conditions and fish loss.

2.9.1.2 Frequency and Duration

UPS will be calculated for each day fish are collected and/or transported from the Merwin MFCF and mortalities and total counts will be summed to provide a seasonal estimate of UPS.

2.9.1.3 Assumptions

A major assumption in the proposed method is that staff operating the adult trapping facility, and transporting and releasing adult fish to the river, will be able to accurately count the number of dead and live adults.

2.9.1.4 Results and Reporting

Results will be presented in tabular format by species in the ACC/TCC Annual Report that includes Total Number of fish captured and transported, Number of trap mortalities, and number of release mortalities and a calculation of Percent Survival. Detailed records of daily loading, water conditions in the truck, etc. will be kept and stored at the MFCF.

2.10 OBJECTIVE 10- QUANTIFY ADULT TRAP EFFICIENCY AT EACH UPSTREAM FISH TRANSPORT FACILITY (EMPHASIZES ANALYSIS OF THE MERWIN ADULT TRAPPING FACILITY UNTIL UPSTREAM PASSAGE IS EXPANDED TO YALE AND SWIFT)

Adult trap efficiency (ATE) is defined in Table 4.1.4 of the Settlement Agreement as:

> *The percentage of adult Chinook, coho, steelhead, bull trout and sea-run cutthroat that are actively migrating to a location above the trap and that are collected by the trap.*

The Settlement Agreement calls for the licensees to consult with the resource agencies and the ACC to develop such a standard as soon as practicable. This effort was completed in 2008 and the ACC selected 98% as the target ATE value for each species.

However, there is an oversight in the Settlement Agreement. During settlement discussions, there was a great deal of focus on the Merwin Trap and its pivotal importance to the success of the reintroduction program. Thus, the need for high ATE. The oversight is that PacifiCorp invested a significant amount of time and money upgrading the adult trap at the Lewis River Hatchery and a large percentage of the adults captured there are transported upstream of Swift. There needs to be some discussion in the ACC about this issue and how we can incorporate the Lewis River Hatchery into the monitoring of adult capture and transport.

2.10.1 Task 10.1- Develop Estimate of ATE for Adult Fish Originating Above Swift No. 1 Dam.

The methods, metrics, and definitions developed by the ACC for this study are included as Appendix C.

2.10.1.1 Methods

Methods are described in Appendix C.

2.10.1.2 Frequency and Duration

Until ATE performance standards are achieved, the Merwin Trap will be adjusted or modified per Settlement Agreement Section 4.1.6. As long as ATE performance standards are achieved, no further adjustments or modifications to the Merwin upstream passage facility will be required in accordance with the Settlement Agreement.

2.10.1.3 Assumptions

Key assumptions inherent in the analysis include:

1. Test fish are captured either at the new Merwin trap or some point downstream of the tailrace will not stray from the Lewis River and will return to the Merwin Fish Collection Facility or the Lewis River Hatchery ladder;
2. All radio-tagged test fish released at the Merwin boat ramp will be recaptured at either the Merwin Fish Collection Facility or the Lewis River Hatchery ladder regardless of their original capture location; and,
3. The tailrace, defined as the entire area of river upstream of the powerhouse access bridge, is the main location for fish that are migrating upstream to congregate.

2.10.1.4 Results and Reporting

Monitoring results that list the number of adults marked and the number of adult anadromous fish detected in the Merwin tailrace and that are captured in the Merwin Fish Capture Facility by species will be provided in the ACC/TCC Annual Report.

2.11 OBJECTIVE 11- QUANTIFY THE NUMBER, BY SPECIES, OF ADULT FISH COLLECTED AT THE PROJECTS (EMPHASIZES MERWIN DAM UNTIL UPSTREAM PASSAGE IS EXPANDED TO YALE AND SWIFT)

The accurate enumeration of adults arriving at Merwin Dam is important not only to determine the success of the anadromous reintroduction program, but is also needed to partially provide escapement numbers that will help calculate the Ocean Recruit metric as defined in the Settlement Agreement.

2.11.1 Task 11.1- Quantify the Number, by Species, of Adult Fish Collected at Merwin Dam

The methods proposed for determining the number of adult fish being collected at Merwin Dam each year is presented below.

2.11.1.1 Methods

All fish (adults, juveniles and jacks) arriving at Merwin Adult Trapping Facility will be anesthetized, enumerated and identified to species and sex. The definition of adult for each species of interest is as follows (length is measured as fork-length)[7] :A subsample of captured fish will have scales and fork length taken for run reconstruction estimates for adults and jacks to achieve a minimum of 120 readable scales per strata taken representatively over the run period..

Bull trout:	≥ 13 inches (~33cm)
Chinook:	≥ 22.5 inches (~57cm)
Coho:	≥ 18.5 inches (~47cm)
Sea-run cutthroat trout:	≥ 13 inches (~33cn)
Steelhead:	≥ 20 inches (~51cm)

The number of live and dead fish captured at Merwin Dam will be summarized on a daily basis. The daily counts will be combined to quantify total adults, jacks and juveniles captured by species for the year.

[7] Note that in some years, jack lengths may actually exceed the values identified for adults.

2.11.1.2 Frequency and Duration

The number of fish entering the facility will be calculated each day the facility is operated.

2.11.1.3 Assumptions

The primary assumption of this analysis is that biologists working the adult trap will be able to accurately count and identify to species all captured fish.

2.11.1.4 Results and Reporting

Results of this analysis will be reported in tabular format that includes the daily number of each species captured at the Merwin Adult Trapping Facility plus a total of all species of adults arriving each day. This information will be available in the ACC/TCC Annual Report.

2.12 OBJECTIVE 12- DEVELOP ESTIMATES OF OCEAN RECRUITS

According to the Settlement Agreement, a juvenile tagging program is needed to determine when the hatchery and natural adult production targets identified in Table 2.12.1 are achieved.

Table 2.12.1. Hatchery and naturally produced adult threshold levels (ocean recruits) for spring Chinook, steelhead and coho.

	Spring Chinook	Steelhead	Coho (Type S and Type N)	Total
Hatchery	12,800	13,200	60,000	86,000
Natural Production Threshold	2,977	3,070	13,953	20,000
Grand Total	**15,777**	**16,270**	**73,953**	**106,000**

These targets are referred to in the Settlement Agreement as Ocean Recruits[8]. This parameter is defined in Section 8.1 of the Settlement Agreement as:

> *"... total escapement (fish that naturally spawned above Merwin and hatchery fish) plus harvest (including ocean, Columbia River, and Lewis River Harvest)."*

The purpose behind this objective is, at least in part, to inform decisions about the size of the hatchery program in the future as natural production of spring Chinook, coho and steelhead is expected to increase.
Specifically, Objective 12 requires estimation of the total production of natural and hatchery origin adult recruits.
In the following discussion, we suggest three approaches for determining adult recruitment and recommend an approach for estimating recruitment. The following are some examples to illustrate the recommended method.

[8] The ACC agreed to change the ocean recruits definition so that jacks are not included or counted as part of the ocean recruits analysis (March 9, 2005 ACC meeting).

2.12.1 Approaches to Determining Ocean Recruits

Recruits for a population or a population component can be determined in at least three different ways:

Return year recruitment. Those adults that matured or were caught in a given year. Returns in the same year may come from different brood years and different migration years. This method requires total spawner abundance, harvest numbers, and mark-selective fishery (MSF) impacts.

Brood year recruitment. Adults produced from a given brood year that matured or were caught over all subsequent years. Recruits from the same brood year may migrate from fresh water to the ocean in different years. This method requires recruit per spawner survival data (information required for return year method partitioned by total age).

Migration year recruitment. Adults produced from a given outmigration year that matured or were caught over all subsequent years. Recruits from the same migration year may come from different brood years. This method requires smolt-to-adult survival data (Smolt abundance information, required for the Brood Year method, partitioned by freshwater and ocean ages.

A population or population component is defined by spawning time and area. For the NF Lewis, there are at least two population components each for coho, spring Chinook and steelhead, separated by Merwin Dam. We assume that the population component to which the ocean recruit target applies is the one that spawns upstream of Merwin Dam. There is a second piece of this requirement which is to calculate the Hatchery Ocean Recruit population. The hatchery component will need to be calculated and monitored until such time that the Natural Ocean Recruit goal is met and hatchery production has been reduced to the Hatchery Floor of 18,000 returning adults (SA 8.3.2.3).

For coho adults (i.e., excluding jacks) definitions 1, 2, and 3 above are the same, because adults that return each year come from the same brood year and migration year:

Return year Y recruitment = Brood year Y-3 recruitment = Migration year Y-1 recruitment.

Chinook and steelhead, however, have more diverse life histories, and the three definitions will generally be different and require different interpretation. A time series of recruitment based on return year will tend to reflect variation in exploitation rates in the return year. Brood year recruitment is needed to estimate recruit per spawner (R/S) ratios and thus provides information about production potential, especially when recruitment estimates are available for a range of spawning escapements. Since mortality is high and variable during the transition from freshwater to the marine environment, migration year recruitment will tend to be correlated with early marine survival. In the examples that follow we will focus on estimation of return year recruitment and brood year recruitment.

2.12.2 Methods of estimation

Return year recruitment estimates are obtained through catch and escapement expansion as follows:
Estimate natural origin spawning escapement, excluding jacks, from Merwin Dam adult counts and/or spawner surveys for the return year.
Estimate fishery related mortality rates in the Lewis River for adults of all ages in the return year from catch sampling, coded-wire tag (CWT) analysis and/or Washington Department of Fish and Wildlife (WDFW) catch reporting.
Estimate Columbia River mainstem exploitation rates on Lewis River adults of all ages in the return year from CWT analysis and/or catch reporting.
Estimate ocean exploitation rates on Lewis River adults of all ages during the return year from CWT analysis and/or Pacific Fishery Management Council (PFMC) reports.
Obtain total exploitation rate from items 2-4 (above) and expand the escapement estimate to obtain total catch.
This is the simplest method to estimate recruitment. For coho and spring Chinook, annual exploitation rates on natural origin, unmarked adults, is estimated from expansion of double index tag (DIT) recoveries. The mortality rate of unmarked fish in selective fisheries is estimated based on the encounter rate of the double-index tag (DIT) groups (one ad-clipped and one not) and assumed mortality rates for fish that are encountered but not retained in the fisheries.

Brood year recruitment estimates are obtained through run reconstruction using the following steps:
Estimate natural origin spawning escapement by age, excluding jacks. Total escapement would be obtained from Merwin Dam counts, and the proportion of natural origin adults would be estimated from CWT mark ratios at the dam and/or from spawner survey samples. Age composition of the unmarked natural origin adults would be estimated from scale samples.

The future proportion of hatchery fish at the dam depends on the abundance of natural origin returns from the upper river and the stray rate from hatchery and natural production below the dam. It will be necessary to sample for CWTs at Merwin Dam to correct for the contribution of strays in estimating escapement of adults originating from above Merwin Dam. In the absence of tagging information, scale sampling may be the most reliable method of estimating age, it may also be possible to sample fish length and use age-length correlation to estimate age composition.

Estimate contribution rates to fisheries and escapement by age and brood year from either:
CWT marked indicator stocks, typically hatchery fish, or
CWT marked natural origin out-migrants.

The most accurate way to estimate exploitation rates would be to mark wild fish. This approach can provide direct estimates of exploitation rates by age for natural origin fish. If hatchery fish are used as indicators, some correction would have to be made for differences in fishing mortality between hatchery fish and natural origin fish, i.e., the use of Double Index Tag (DIT) groups to estimate hooking mortality in mark-selective fisheries. The main concern when using marked natural origin fish is sample size. It may be difficult to mark sufficient numbers of natural out-migrants to obtain useful estimates of exploitation rates without affecting survival.

Further review of required sample sizes versus what can be collected and safely marked is needed if this approach is chosen. With natural origin migrants, variation in size and stage of development is also an issue to be considered. The CWT data required to estimate exploitation rates are readily available from databases (RMIS) maintained by the PSMFC.

Apply the contribution rates from Step 1 to back calculate catch and recruitment by age for each brood year from estimates of brood year spawning escapement.

This is the run reconstruction step. It requires assumptions about age specific natural mortality in the ocean to estimate the number of fish from each brood year that were alive at the beginning of each year. Assumed natural mortality rates by age, used in ocean harvest management models (e.g., FRAM) should be appropriate in the present context as well. Tools are available to perform run reconstruction, which can be relatively easy to customize to routinely generate estimates of brood year recruitment.

The run reconstruction analysis can be used to estimate ocean recruitment in several ways:

As adult equivalents, an estimate of the number of adults that would have returned in the absence of any fishing. This estimate is independent of fishing effort. The fisheries are simply used as sampling devices in the estimation process. However, this method includes untestable assumptions or parameters such as age-specific natural mortality rates in the ocean.

As fishery* plus escapement, an estimate of the number of fish that either escaped (to Merwin Dam), were caught or in a fishery, or died as a result of fishing activity, e.g. hooking mortality. This estimate is affected by when and where fisheries occur relative to natural mortality during the salmon life cycle. This estimate tends to be higher than the adult equivalent number, since here some fish are counted as catch that would otherwise have died from natural mortality. This method is the most straight-forward to calculate however, it does not make any assumptions regarding maturation rates or natural mortality. The method does rely on a release mortality parameter applied to encounters in mark-selective fisheries.
*Definition of fishery=harvest plus post-release mortality

A third way to express recruitment is in terms of what is referred to as Age-3 recruitment. An estimate of this parameter is obtained by back-calculating abundance to the age (usually assumed to be age-3) before fish are recruited into fisheries. This estimate is a precursor to the adult equivalent estimate—the estimates differ by the natural mortality rates between age-3 and escapement. This method also includes untestable assumptions or parameters such as age-specific natural mortality rates in the ocean and uses this rate to back-calculate abundance of age-3 fish.

Recruitment estimates depend on CWT based estimates of fishery mortality rates and numbers. The key to accurate estimating fishery mortality rates using CWTs is to use double-index tag (DIT) groups for annual smolt releases and to implement adequate sampling rates for all fisheries where harvest occurs. For Lewis River steelhead there is limited impact from fisheries in the ocean, Buoy 10 and mainstem Columbia River. WDFW assumes negligible harvest of steelhead occurs in these fisheries; therefore, the Fishery Plus Escapement method would utilize only tributary harvest when estimating mortalities in fisheries. For spring Chinook, fall Chinook, and coho salmon, fishery impacts are expected in the ocean, Buoy 10, and mainstem Columbia River. Estimation of mortalities associated with catch and release fisheries will require use of a DIT groups. DIT groups should be paired releases of coded-wire tagged hatchery fish (ad-clipped fish subject to harvest, non-marked fish subject to catch and release fishing). The difference in run reconstruction numbers of these tag groups represents mortality associated with mark-selective fisheries. For the purpose of estimating release mortality, the pairing hatchery and natural origin fish is not recommended because of likely differences in survival based on different rearing conditions. An MSF mortality rate should be documented as part of the RME reporting process. Using DIT groups to estimate fishery release mortalities requires that DIT groups are appropriately sized to provide accurate mortality estimates. This will require completion of a power analysis that accounts for varying ocean conditions. There is agreement that PacifiCorp and WDFW continue using the Hatchery DIT groups for the present as a surrogate for calculating natural production harvest until the next iteration of the M&E Plan (in five years).

WDFW recommends using the Catch plus Escapement approach. The preference would be to call this approach Fishery plus Escapement which is a more accurate description of this method given that fish are both harvested and released.

The M&E Plan Sub-Group is in general agreement that the second method (Catch plus Escapement) is the best approach. Especially since it more closely aligns with the Settlement Agreement.

12.2.3 Creel Data

Currently, there are adequate creel programs in place to estimate mortalities for Lewis River stocks in Ocean, Buoy 10 and mainstem Columbia fisheries. As mentioned earlier winter steelhead harvest in these fisheries is negligible and can be ignored for ocean recruit analysis.

There is however limited to no data regarding fisheries occurring in the Lewis River. There are three possible ways to address this lack of information as follows:
Do not conduct any in-river creel and assume that there is no fishery related mortality occurring in the Lewis River. This would produce an ocean recruit estimate that is biased low when harvest fisheries occur.
Conduct an in-river creel. This would provide data specific to the Lewis River that could be used to estimate ocean recruits
Use data from other tributaries, preferably lower Columbia River tributaries. This would assume that fishery related mortalities in other tributaries are similar to those occurring in the Lewis River.

WDFW's recommendation is to implement a creel program in the Lewis River to estimate fishery related mortalities for use in the ocean recruits analysis. PacifiCorp understands the need for this effort but does not see implementing any creel work until adequate numbers of spring Chinook return to warrant the work.

2.12.1.2 Frequency and Duration

Estimates of ocean recruits will be developed for each brood year and species throughout the term of the licenses.

2.12.1.3 Assumptions

Key assumptions inherent in completing the analysis include:

1. Sample sizes provide sufficient precision for making management decisions.
2. Tagged fish can be readily and reliably identified in ocean and freshwater fisheries, on the spawning grounds and at trapping facilities.
3. Recovered CWT data will be reported to RMIS in a timely manner.
4. Reliable in-river harvest estimates are available

2.12.1.4 Results and Reporting

The results of the ocean recruits analysis will be documented in the ACC/TCC Annual Report. The data will be presented in tabular format similar to the following:

1. Return Year Method				
		Fishery Mortalities		
Return Year	Spawner Abundance	Harvest	MSF	Ocean Recruits

2. Brood Year Method (Recruit/Spawner)						
	Parent Spawner	Ocean Recruits				
Spawn Year	Abundance	Age 3	Age 4	Age 5	Age 6	R/S

3. Migration Year Method (Smolt-to-Adult Return)						
		Ocean Recruits				
Migration Year	Smolt Abundance	1-Yr Ocean	2-Yr Ocean	3-Yr Ocean	4-Yr Ocean	SAR

2.13 OBJECTIVE 13- DEVEOLOP PERFORMANCE MEASURES FOR INDEX STOCKS

The H&S Plan (PacifiCorp and Cowlitz PUD 2006) recommends that other Lower Columbia River stocks be used as index groups to determine whether the success or failure of the Lewis River reintroduction program is the result of in-basin or out-of-basin factors. This would be determined by comparing the survival rates of hatchery and natural-origin fish produced in other basins (such as the Cowlitz River) with releases made in the Lewis River. The methods that will be used to calculate juvenile-to-adult survival rates are presented below.

2.13.1 Task 13.1- Develop Estimates of Survival for Lower Columbia River Fish Stocks

2.13.1.1 Methods

Performance measures
Natural production performance is typically defined and measured in terms of the four viable salmon population parameters: abundance, productivity, diversity and population structure (McElhany et al. 2000). For the purpose of comparing performance of the Lewis River populations upstream of Merwin Dam, the first two parameters, abundance and productivity, are the most tractable and most directly related to management actions.

Abundance is simply defined as adult recruitment as described in Objective 12.

Productivity, when measured over the entire life cycle, is estimated by the recruit per spawner (R/S) ratio, i.e., the number of adult offspring produced per parent. Productivity can be partitioned into life history segments. If the abundance of smolt migrants is available, it may be useful to estimate brood year freshwater productivity from spawner to smolt and smolt to adult ratio (SAR).

R/S = (Smolt/S) x SAR

Since the exploitation rate (ER) is usually derived from a common source, i.e., the same CWT groups for the index stocks of interest, it will not have any discriminatory value. Therefore, we recommend using R/S and SAR to compare the Lewis River populations with neighboring indicator stocks.

2.13.2 Estimating R/S and SAR

The methods for estimating brood year recruitment[9] were explained above. Brood year escapement is the combined number of natural and hatchery origin adults that escape to spawn naturally. In order to adjust for variation in hatchery-natural origin composition of spawners, it is customary to apply a correction factor to obtain an estimate of the number of natural origin equivalent spawners each brood year (HSRG 2014). Applying this correction factor makes

[9] Recruitment calculated as return year catch plus escapement will NOT provide estimates of SAR or R/S.

comparisons between populations as well as comparisons over time (trends) more informative about conditions other than hatchery-wild composition.

SAR estimation requires monitoring of out-migrant juveniles by brood year. Size and age are potential issues with juvenile monitoring, since mortality rates leading up to smoltification may be high. When a diverse mixture of fish sizes is observed at the monitoring site, or when juveniles of varying size and age are transported downstream of the dam, it will be necessary to make a correction to obtain an estimate of smolt equivalents, or to rely on SAR estimates for hatchery fish .

An alternative to directly observing and estimating SAR for natural origin out-migrants is to estimate SAR from hatchery releases of the same brood year to estimate annual variation in SARs. The correlation between hatchery and natural SARs may be estimated by marking a sample of natural origin smolts for several years. A relatively frequent assumption has been that the hatchery SAR is about 50% of the natural SAR; this might be considered a default until better estimates become available.

Choosing indicator stocks
Indicator stocks should be chosen from neighboring watersheds in the Lower Columbia region. The table below lists the candidate populations that are suitable indicators for the Lewis River populations. Several of these stocks report spawning escapement and have CWT marked groups in the RMIS database.

Table 2.13.1. Candidate Index stocks: Wild stocks and hatchery stocks.

Spring Chinook	Coho	Winter Steelhead
Upper Cowlitz wild SPC	Lower Cowlitz R. hatchery coho	Coweeman wild STHD
	Kalama R. hatchery coho	
Sandy R. wild SPC	Sandy R. hatchery coho	
		Kalama wild STHD
	Upper Clackamas wild coho	Upper Cowlitz LW hatchery STHD
Cowlitz hatchery SPC	Upper Cowlitz wild coho	Upper Cowlitz LW hatchery STHD
	Lower Cowlitz hatchery coho Upper Cowlitz hatchery coho	Lower Cowlitz LW hatchery STHD Kalama LW Hatchery STHD

Key issues
The methods described above for estimating recruitment are used extensively in the region. As always, the sample size required to achieve a precise estimate is an issue. The standard for precision is typically a maximum coefficient of variation (CV) of 25%, so it is not unreasonable

to assume that fisheries are sampled to achieve this standard. Bias is also an issue that should be reported when preparing estimates of recruitment.

Once the tools are set up to perform the run reconstruction analysis, preparing annual summaries of recruitment, R/S and SAR will be a matter of routine. Such tools are available that can be adapted to the purposes of the Lewis River M&E program.

2.13.3 Recommendations

Coho:

Since it can reasonably be assumed that adults return predominantly at age 3, return year and brood year recruitment are the same and scale sampling for age is not needed.
Issue 1: Strays of natural origin coho not originating from upper Lewis River may pass Merwin Dam, resulting in over estimates of recruits from parents spawning above Merwin Dam.
Solution: Tag a known proportion of the out-migrant juveniles.
Issue 2: Harvest contributions for the variable mix of Type N and Type S NORs produced above Merwin Dam.
Solutions: Option A, estimate the annual composition of Type S and Type N in the NOR escapement and used weighted estimates of catch contributions from DIT groups for Type S and Type N hatchery releases each year. Option B, tag (CWT but no ad clip) a random sample of out-migrant juveniles each year. Due to uncertainty in distinguishing Type N from Type S, partly due to overlap in run timing and partly due to introgression over time, Option B is preferable.

Recommendation for coho: Enumerate out-migrant smolts at Merwin Dam, tag (cwt) 50,000 and expand adult recoveries to estimate catch and escapement of NOR originating from upper Lewis River. Enumerate and mark sample (for both CWT- only and CWT plus ad clip) adults (3-year olds) passed upstream at Merwin Dam. This approach would solve issues 1 and 2 and also make it possible to estimate SARs as well as recruit per spawner ratios. Estimates of SAR for NORs make it possible to apportion natural mortality between the spawner to out-migrant and the out-migrant to ocean recruit phases of the life history.

Spring Chinook:

Since Chinook exhibit a diverse life history, with multiple return ages and two migration ages, enumeration, and scale sampling for age composition at Merwin Dam will be necessary.
Issue: Estimate age composition of adult NORs returning to Merwin Dam.
Solution: Collect and read scales from one out of every four natural origin (i.e. unmarked) adults returning to Merwin Dam, but no fewer than 100 should be sampled.
Issue: Estimate pre-terminal harvest of NORs
Solution: Use Lewis River hatchery DIT mark groups to estimate pre-terminal harvest rates.
Issue: Estimate fishery induced mortality on NORs in the Lewis River terminal fishery
Solution: Sample catch (e.g. via creel surveys) to estimate the number of unmarked adults encountered in the fishery. Use literature values10 for mortality rates on encountered fish to estimate the number of NORs that die as a result of fishing.

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[10] For example, Lindsay et al. (2004) estimated a mortality rate of 12.2 % for Chinook caught and released in a sport fishery.

Note: While we are using DIT Groups as a surrogate estimator of harvest rates, it is not necessary to mark (CWT) out-migrant spring Chinook juveniles in order to estimate R/S using SAR values. The long-term goal is to replace DIT groups with NOR CWT marks when an adequate number of NOR fish become available.
Issue: Estimate mortality from outmigration (smolts at Merwin Dam) to adult recruits (i.e. SAR).
Recommendations for spring Chinook: If estimates of SARs are a priority, they could be derived either through marking of juveniles at Merwin Dam or by using SAR estimates from marked indicator stocks (see Table 1).

A study should be implemented to assess a) the feasibility of obtaining and marking a representative sample of juveniles at Merwin Dam, and b) whether useful estimates of SAR can be obtained from marking juveniles at Merwin Dam. This study would entail monitoring size and age of a representative sample of the out-migrant population for a period of three to five years, depending on the variability in size/age observed. Presumably, the value of estimating SAR is to separate effects of survival conditions downstream of Merwin Dam form those above. If the year to year variability in size/age of out-migrants is high, SARs are likely to also be affected by conditions above Merwin Dam, via delayed mortality.

In the meantime, we recommend relying on indicators to estimate annual variability in SARs.
Issue: Calculating annual estimates of ocean recruits by brood year and run year
Solution: Run reconstruction tools are readily available to estimate both ocean recruitment and recruit per spawner ratios very quickly, once the data has been collected and made available. The tool we provide illustrate how this might be done. It is provided as an example, without documentation.

Steelhead:

Assuming that no directed harvest on unmarked steelhead occurs, recruitment would be estimated from counts at Merwin Dam and estimates of hooking mortality in mark selective fisheries.
Issue: Estimate age composition of adult NORs returning to Merwin Dam. Age composition is needed to estimate brood year recruitment and recruit per spawner ratios, but is not required for estimating return year recruitment.
Solution: Collect and read scales from one out of every four natural origin (i.e. unmarked) adults returning
Issue: Estimate harvest rate in Columbia mainstem.
Solution: Use harvest rate on stock aggregates, i.e. assume harvest rates and hooking mortalities for Lewis River steelhead are similar to the average rate of all Lower Columbia winter steelhead. Whether current catch sampling for steelhead in the Columbia mainstem is adequate is uncertain. More information is needed to obtain reliable estimates of mainstem fishery impacts on unmarked steelhead.
Issue: Estimate incidental harvest and hooking mortality on NORs in the Lewis River sport fishery.
Recommendations for Steelhead: Use same approach as for spring Chinook. Possibly, over time, a linear relationship might be developed between harvest rate on marked hatchery fish and incidental mortality on NORs.

Issue: Estimate SAR for NOR steelhead from above Merwin Dam.
Solution/Considerations: The estimation of SAR for natural origin steelhead depends upon the ability to define and enumerate out-migrants at Swift Dam and Merwin Dam (if steelhead are reintroduced to the reach between Merwin Dam and Yale Dam). If initial studies, indicate that an out-migrant population can be identified, marking a representative sample should be considered if SAR estimates are or become a priority.

EXAMPLE REPORTS

The results summarized below are based on data for the Lower Lewis River spring Chinook population and are presented as an example of some of the variables produced from a run reconstruction analysis. The results presented here are strictly illustrative and are not to be interpreted otherwise. Data for brood years 2000 to 2009 were used, thus return year recruitment estimates were limited to years 2004 to 2013. Brood year estimates were calculated for years 2000 to 2009.

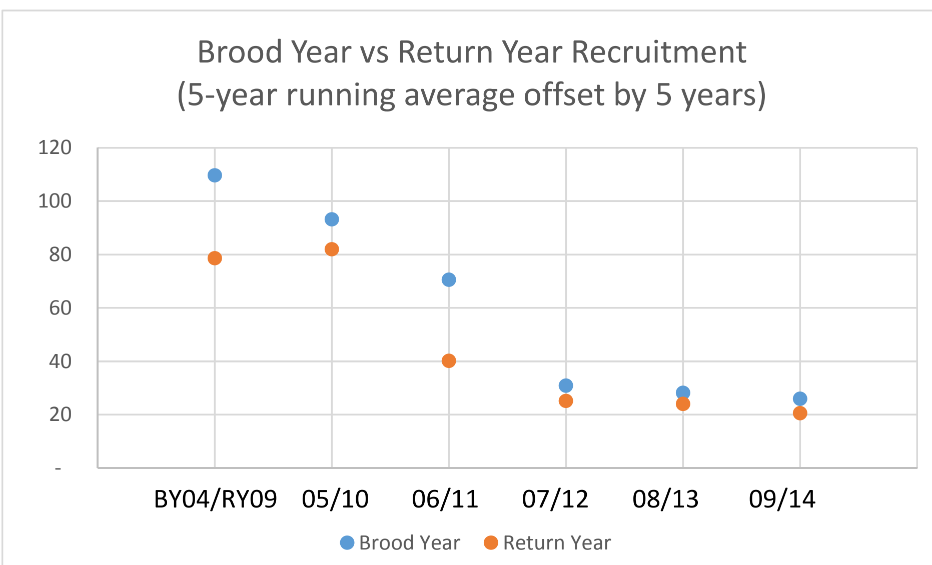
The inputs to the tool that generated these summaries are a CWT data file from RMIS and a time series of (undocumented) natural escapement data.

Table 2.13.2 Return Year Recruitment

Return Year	Return Year Escapement (all ages)	Return Year Catch	Recruitment (Catch plus Escapement)
2000			
2001			
2002			
2003			
2004	148	41	**189**
2005	35	18	**53**
2006	254	86	**341**
2007	79	25	**105**
2008	8	2	**10**
2009	17	3	**20**
2010	52	8	**60**
2011	45	7	**52**
2012	4	1	**5**
2013	2	0	**2**
2014	-	-	**-**

Brood Year Recruitment					
		Recruitment from Brood Year Escapement			
Brood year	Brood Year Escapement *	Age 4 Recruits	Catch plus Escapement	Adult Equivalents	Recruits/ Spawner **
2000	407	142	**98**	97	**0.24**
2001	583	250	**167**	162	**0.28**
2002	424	358	**251**	248	**0.58**
2003	584	28	**19**	19	**0.03**
2004	425	18	**12**	12	**0.03**
2005	100	23	**16**	16	**0.16**
2006	728	74	**54**	53	**0.07**
2007	227	73	**53**	53	**0.23**
2008	22	8	**6**	6	**0.27**
2009	50	2	**1**	1	**0.02**
2010	136	-	-	-	-
2011	81	-	-	-	-
2012	153	-	-	-	-
2013	48	-	-	-	-
2014	322	-	-	-	-

*NOR escapement plus 80% of HOR escapement
** Recruits/Spawner based on recruits measured as adult equivalents



The return year plot is advanced 5 years to account for the approximate 5-year generation length. The difference between points in the graph is due to variation in maturation (e.g., significant numbers of four year old returns). For coho, where the great majority of adults mature as 3-year olds, the brood year and return year recruitments would be very nearly the same.

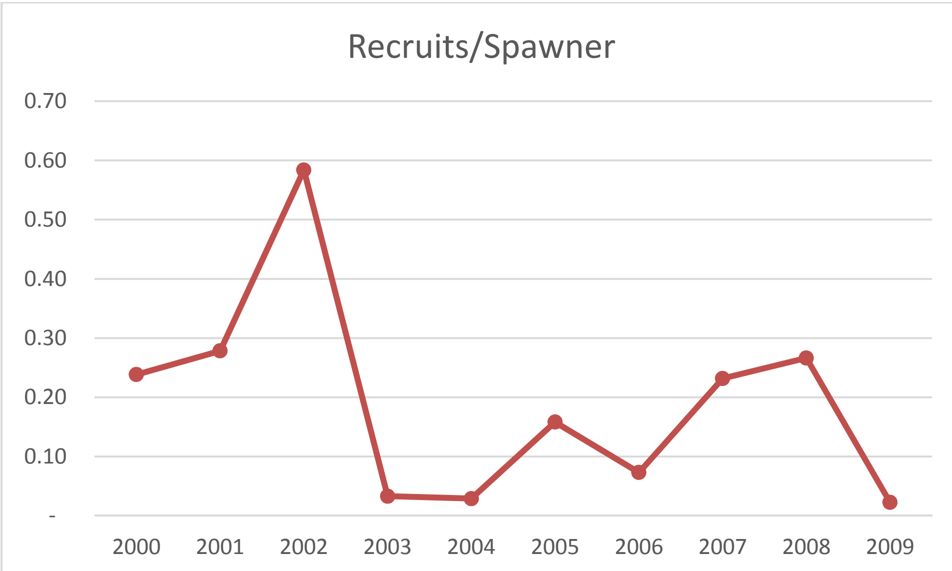


Figure 2. Trend in natural productivity of spring Chinook in the lower Lewis River. Similarities among index stocks in annual variation of R/S point to shared survival factors. Trends in fresh water productivity can be estimated by factoring out annual brood year SARs.

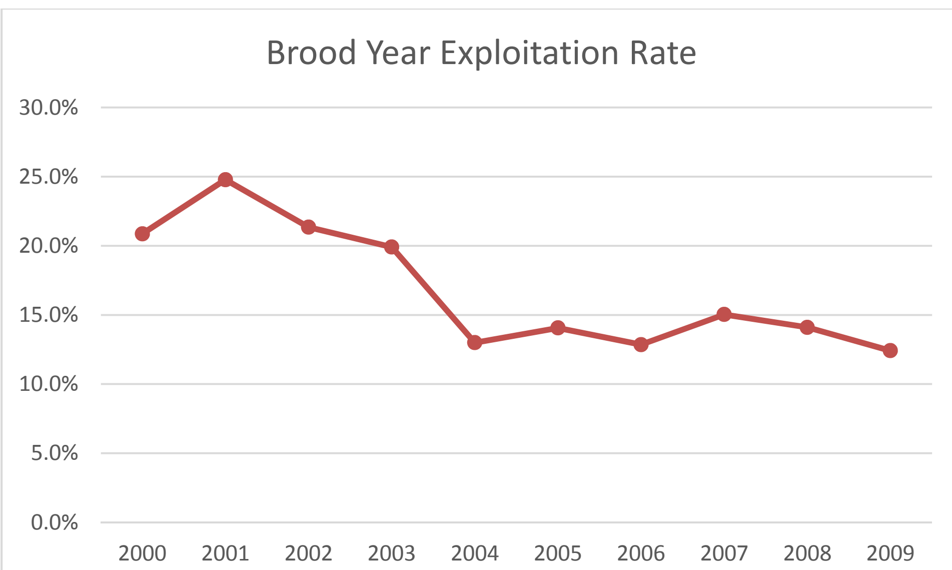


Figure 3. Trends in fishery impacts on unmarked spring Chinook. The difference between brood year recruitment and the spawning escapement from each brood year is largely due to the effects of harvest, including fishery induced mortality. The exploitation rates in this graph include hooking mortality in mark selective fisheries.

2.14 OBJECTIVE 14- DOCUMENT UPSTREAM AND DOWNSTREAM PASSAGE FACILITY COMPLIANCE WITH HYDRAULIC DESIGN CRITERIA

As new fish passage facilities are implemented, they will be tested to determine if they are operating as designed. For the FSC, the key design variables are total attraction flow and water velocities passing through and past the screens. At the Merwin MFCF, adult attraction flows, water drop in elevation over weirs, and uniformity of flow across attraction flow diffusers are the indicators of facility performance to be tested.

2.14.1 Task 14.1- Confirm FSC System Compliance with Hydraulic Design Criteria

The method used for determining the hydraulic performance of the FSC is discussed below.

2.14.1.1 Methods

Both acoustic Doppler and hand-held water velocity meters will be used to determine the hydraulic performance of the FSC. The two systems will collect data on flow velocity and direction at the following locations (see Figure 2.14-1 for FSC schematic):

- Collection entrance
- Collection enhancement structure
- Primary and secondary dewatering screens (including floor screens)

Water velocity and directional measurements will be collected over the full range of FSC operational conditions. The results will be compared to the FSC design criteria to document system compliance.

2.14.1.2 Frequency and Duration

Flow measurements required to document compliance with design criteria will be conducted until it is proven that these criteria have been achieved.

2.14.1.3 Assumptions

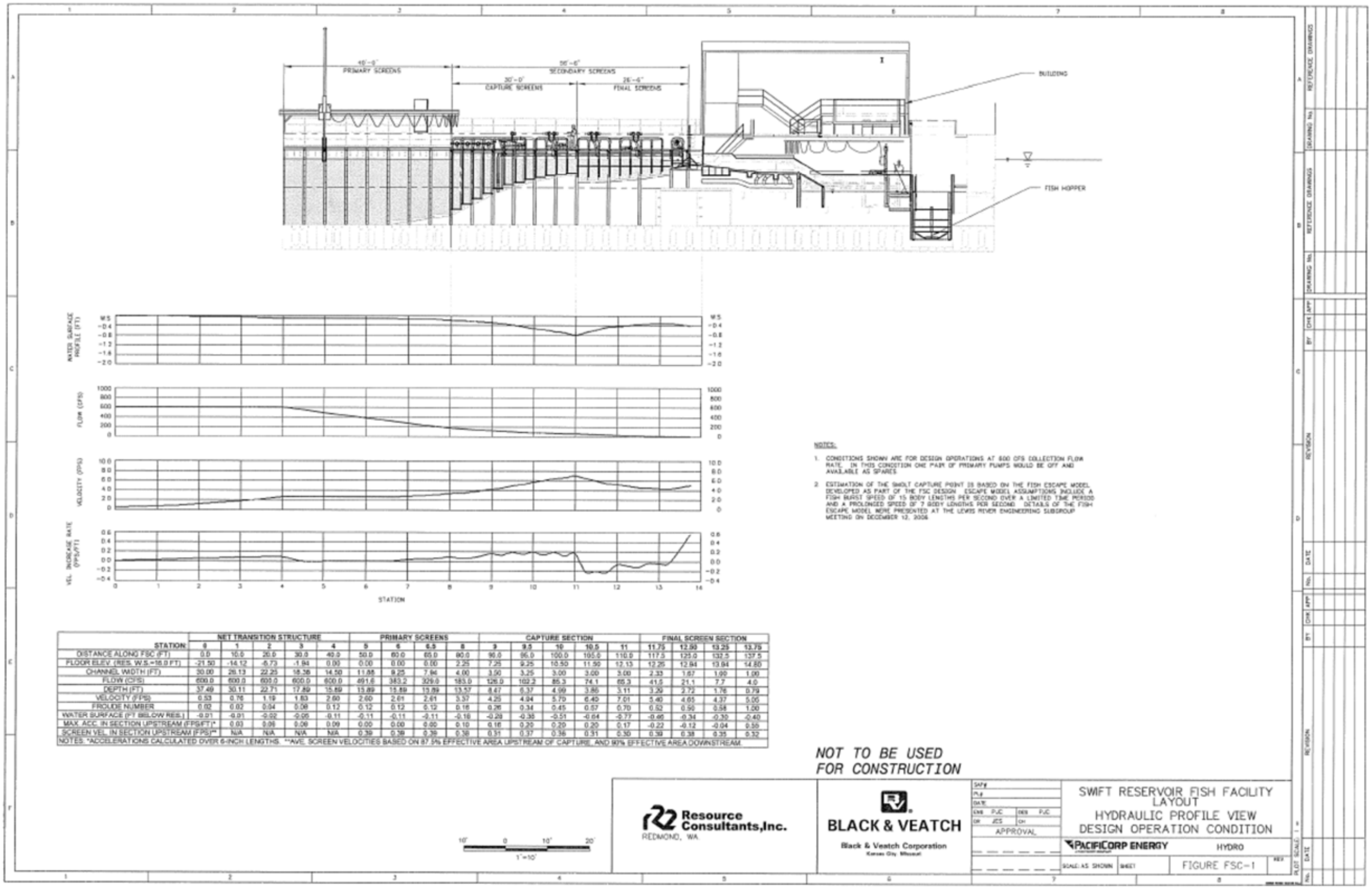
Key assumptions inherent in completing the analysis include:

- Measurement points are readily accessible to staff.

2.14.1.4 Results and Reporting

Hydraulic analysis of the Swift Floating Surface Collector and the Merwin Fish Capture and Transport Facility were completed in their respective first year of operation. Both were found to be compliant with design criteria with NOAA Fisheries approval.

There’s no real need to retest these facilities unless flow amounts or elevations are changed over the course of the license period or if a major component in a facility is replaced. In addition, if features are added to the facility such as additional pumps or additional trap entrances at the Merwin Facility, then those new features will need to be validated.



STATION:	NET TRANSITION STRUCTURE 0	1	2	3	4	PRIMARY SCREENS 5	6	6.5	8
DISTANCE ALONG FSC (FT)	0.0	10.0	20.0	30.0	40.0	50.0	60.0	65.0	80.0
FLOOR ELEV. (RES. W.S.=16.0 FT)	-21.50	-14.12	-6.73	-1.94	0.00	0.00	0.00	0.00	2.25
CHANNEL WIDTH (FT)	30.00	26.13	22.25	18.38	14.50	11.88	9.25	7.94	4.00
FLOW (CFS)	600.0	600.0	600.0	600.0	600.0	491.6	383.2	329.0	183.0
DEPTH (FT)	37.49	30.11	22.71	17.89	15.89	15.89	15.89	15.89	13.57
VELOCITY (FPS)	0.53	0.76	1.19	1.83	2.60	2.60	2.61	2.61	3.37
FROUDE NUMBER	0.02	0.02	0.04	0.08	0.12	0.12	0.12	0.12	0.16
WATER SURFACE (FT BELOW RES.)	-0.01	-0.01	-0.02	-0.05	-0.11	-0.11	-0.11	-0.11	-0.16
MAX. ACC. IN SECTION UPSTREAM (FPS/FT)*		0.03	0.06	0.08	0.09	0.00	0.00	0.00	0.10
SCREEN VEL. IN SECTION UPSTREAM (FPS)**		N/A	N/A	N/A	N/A	0.39	0.39	0.39	0.38

STATION:	CAPTURE SECTION 9	9.5	10	10.5	11	FINAL SCREEN SECTION 11.75	12.50	13.25	13.75
DISTANCE ALONG FSC (FT)	90.0	95.0	100.0	105.0	110.0	117.5	125.0	132.5	137.5
FLOOR ELEV. (RES. W.S.=16.0 FT)	7.25	9.25	10.50	11.50	12.13	12.25	12.94	13.94	14.80
CHANNEL WIDTH (FT)	3.50	3.25	3.00	3.00	3.00	2.33	1.67	1.00	1.00
FLOW (CFS)	126.0	102.2	85.3	74.1	65.3	41.5	21.1	7.7	4.0
DEPTH (FT)	8.47	6.37	4.99	3.86	3.11	3.29	2.72	1.76	0.79
VELOCITY (FPS)	4.25	4.94	5.70	6.40	7.01	5.40	4.65	4.37	5.06
FROUDE NUMBER	0.26	0.34	0.45	0.57	0.70	0.52	0.50	0.58	1.00
WATER SURFACE (FT BELOW RES.)	-0.29	-0.38	-0.51	-0.64	-0.77	-0.46	-0.34	-0.30	-0.40
MAX. ACC. IN SECTION UPSTREAM (FPS/FT)*	0.16	0.20	0.20	0.20	0.17	-0.22	-0.12	-0.04	0.55
SCREEN VEL. IN SECTION UPSTREAM (FPS)**	0.31	0.37	0.36	0.31	0.30	0.39	0.38	0.35	0.32

NOTES: *ACCELERATIONS CALCULATED OVER 6-INCH LENGTHS. **AVE. SCREEN VELOCITIES BASED ON 87.5% EFFECTIVE AREA UPSTREAM OF CAPTURE, AND 90% EFFECTIVE AREA DOWNSTREAM.

Figure 2.14-1. 60% draft Swift Dam floating surface collector schematic.

2.14.2.2 Frequency and Duration

Compliance activities will be conducted yearly.

2.14.2.4 Results and Reporting

Evaluations to document that the facility continues to operate as designed will take place on an as-needed basis per NOAA Fisheries.

2.15 OBJECTIVE 15- DETERMINE SPAWNER ABUNDANCE, TIMING AND DISTRIBUTION OF TRANSPORTED ANADROMOUS ADULTS

Article 9.2.2 of the Settlement Agreement requires the licensees to identify the spawn timing, distribution, and abundance for transported anadromous species that are passed upstream of Merwin Dam. This is to be achieved by monitoring a statistically valid sample of each stock. According to the Settlement Agreement, the primary objective of this task is to identify preferred spawning areas in order to: (1) inform revisions to the H&S Plan and the Upstream Transport Plan; and, (2) guide the ACC in determining how to direct restoration efforts with the Aquatics Fund. To fulfill this requirement, the licensees will conduct comprehensive spawning ground surveys for spring Chinook and coho in the potentially accessible river and stream reaches upstream of Swift Dam to determine their spawn timing, distribution, and spawner abundance in the upper basin. Winter steelhead spawn timing, distribution and abundance will be determined by a combination of on-the-ground spawning surveys of reservoir tributaries and radio tracking using both fixed stations and aerial surveys. Steelhead abundance estimates for reservoir tributaries may use on the ground telemetry and redd surveys to estimate the number of spawning adults.

2.15.1 Task 15.1- Chinook and Coho Spawning Surveys

2.15.1.1 Sampling Design and Estimator

Monitoring of transported adult coho and Chinook salmon released into Swift Reservoir currently incorporates a census of all potentially accessible stream habitat by surveyors upstream of Swift Dam (about 68 miles) over a three-year period. Because all reaches are surveyed (except for a few reaches with access constraints), the sample reach draw is essentially a random ordering of the sampling frame that is then allocated equally across three years creating a 3-year rotation of individual survey reach panel sample draws. There is no repeat of individual survey reaches over the 3-year period (i.e. each of the three survey panels comprises a unique subsample of reaches within the total accessible stream network).

Streams vary in length across the target population, ranging from 0.1 to 13.8 miles. Individual streams are broken up into survey reaches, with most reaches being 0.3 miles long but varying from 0.1 to 0.3 miles. Overall, the sampling frame is divided into 256 reaches. Each year, a third of the accessible stream habitat upstream of Swift Dam(i.e., the sampling frame) is surveyed, corresponding to ~23 miles and ~ 85 reaches. The goal is to survey every stream reach once every 14 days during the spawning season (i.e., survey all 23 miles each week).

The sampling design incorporates stratification within each of four stream network basins upstream from Swift Dam: the North Fork Lewis River and minor tributaries, the Muddy River watershed, the Pine Creek watershed, and all other independent Swift Creek Reservoir tributaries. To increase efficiency of surveys of longer streams, additional strata were formed by categorizing streams as less than or at least 8 miles long; "short" and "long" streams, respectively. Within the stratum of "long streams", one-stage cluster samples were drawn from the set of primary sampling units defined as three contiguous reaches to improve sampling efficiency by survey crews. Within the stratum of "short" streams (less than 8 miles long) , 0.3-mile reaches served as the primary sampling unit.

Estimates of total redds were calculated with a ratio estimator for a one-stage cluster sample of clusters of unequal size (Lohr 1999). The density (*y*) of the outcome of interest (count of redds) was calculated for each segment by dividing the count by the length of the segment. The following terms are defined as:

N = number of clusters in the population,

n = number of clusters in the sample,

M_i = number of segments in the i^{th} cluster,

m_i = the number of sampled segments in the i^{th} cluster,

l_i = the total length of the i^{th} cluster,

$L = \sum_{i=1}^{N} l_i$ = the total length of segments in the population,

and

y_{ij} = the density (count / segment length) in j^{th} segment of the i^{th} cluster.

The segment-level densities were then used to obtain an estimate of the total redds as follows:

$$\hat{t}_r = L\hat{\bar{y}}_r,$$

$$\text{where } \hat{\bar{y}}_r = \frac{\sum_{i=1}^{n} t_i}{\sum_{i=1}^{n} M_i} \text{ and } t_i = \frac{M_i \sum_{j=1}^{m_i} y_{ij}}{m_i}. \quad (37)$$

The standard error of the estimate of the total is calculated as:

$$SE\left(\hat{t}_r\right) = N\sqrt{\left(1 - \frac{n}{N}\right)\frac{1}{n}\frac{\sum_{i=1}^{n} l_i^2\left(\bar{y}_i - \hat{\bar{y}}_r\right)^2}{n-1}}, \quad (38)$$

where $\bar{y}_i = \frac{\sum_{j=1}^{m_i} y_{ij}}{m_i}$.

The proportion of spawning females was calculated as the estimated number of redds divided by the total number of transported coho (and spring Chinook when available) females, and confidence intervals are constructed from the variance obtained from the ratio estimator. A primary assumption is that total coho or spring Chinook redds observed estimate the proportion of spawning females. The proportion represented by each redd identified will use regionally accepted values to account for redd detection probabilities that are assumed to be less than perfect. The values assigned for either female coho or spring Chinook may be modified based on new data or detection probability evaluations specific to the upper Lewis River system. Given this assumption, the known number of transported coho females represents the known total number of females in the population upstream of Swift Dam. Therefore, the estimated number of redds is equivalent to the estimated number of spawning females. Given the total number of transported coho females (*f*), the proportion of spawning females and total spawning abundance when the known sex ratio is applied, $\hat{p}_r$, and its standard error were calculated as:

$$\hat{p}_r = \frac{\hat{t}_r}{f} \text{ and } SE\left(\hat{p}_r\right) = \frac{SE\left(\hat{t}_r\right)}{f}. \quad (39)$$

Over the initial three-year monitoring period (2012-2014), coho spawning distribution was observed to be patchy. Large concentrations of spawning occurred in relatively small areas that contain abundant potential spawning habitat, such as specific side channels of the North Fork Lewis River and specific tributary streams such as Drift, Clear and Diamond creeks. Surveyors noted numerous long sections of stream with little or no potential spawning habitat due to steep gradient and dominance of coarse substrate. In general, surveyor observed few carcasses compared to the number of redds observed. Therefore, carcass counts were not used to estimate the total spawner abundance; only redd counts were used. Data analysis over this time period suggested relatively low spawner abundance (low proportion of transported females estimated to have spawned) for coho and Chinook (assuming one redd per female and not incorporating redd detection probability). However, juvenile coho abundance within Swift Reservoir suggests the current methodology may be underestimating the total number of redds. Two primary factors are the most likely sources of error for underestimating total redds and spawner abundance: 1) survey interval in relation to redd visibility; and 2) the average number of redds expected per female. To evaluate redd life (e.g., using WDFW protocol), a subset of reaches will be surveyed once per week instead of once every 14 days to evaluate if the current survey time interval (one survey for each reach at least every 14 days) is sufficient to census redds, or whether a shorter time interval may be warranted.

Up to twenty reaches (i.e. 6 total miles) will be selected each year to receive weekly surveys in 2016 and 2017. The remaining reaches will continue to be surveyed once every two weeks. Reaches to receive weekly surveys will be the twenty reaches with the highest spawning density the last year the panel was surveyed (subject to logistical constraints). For example, Panel 1 was first surveyed in 2012, Panel 2 in 2013, and Panel 3 in 2014. Panel 1 was surveyed again in 2015. Panel 2 is scheduled for survey in 2016. For the 2016 survey season, the 20 reaches with the highest spawning density observed in 2013 will receive weekly surveys in 2016 (subject to logistical constraints) and all other Panel 2 reaches would be surveyed once every two weeks in 2016.

Table 2.15.1. Accessible survey lengths and sample frame organization upstream of Swift Dam.

Sample Frame	**Stream Name**	**Accessible Reach Length (miles)**
NF Lewis River and Minor Tributaries	Mainstem NF Lewis River	12.8
	U8	0.3
	Spencer Creek	0.6
	Pepper Creek	1.35
	Rush Creek	0.6
	Little Creek	0.3
	Big Creek	0.3
	Cussed Hollow	0.3
	Chickoon Creek	0.3
	Total Miles	**16.9**
Muddy River Watershed	Muddy River	11.7
	Clear Creek	7.8
	Clearwater Creek	6.0
	Smith Creek	5.4
	M1	0.9
	Total Miles	**31.8**
Pine Creek Watershed	Lower Pine Creek	7.6
	P1	0.9
	P3	0.9
	P7	0.9
	P8	3.6
	P10	0.3
	Total Miles	**14.2**
Swift Creek Reservoir Tributaries	Swift Creek	0.5
	Diamond Creek	0.4
	Range Creek	0.7
	S10	0.3
	Drift Creek	1.5
	S15	1.2
	S20	0.7
	Total Miles	**5.3**
Total Miles in the Sample Universe		**68.2**

2.15.1.2 Field Survey Methods

Two crews of two surveyors working in pairs will conduct the annual spawning ground surveys[11]. The following methods will be employed for surveying each individual sample reach. In general, these methods will follow those recommended in Johnson et al. (2007) and ODFW (2009). Surveyors will be trained in field survey methods and fish identification prior to the start of data collection each year. Project leaders will conduct periodic field assessments of survey crews to ensure proper data collection during the survey season. The start and end points of each sample reach will be located by GPS and clearly marked in the field during the first survey of each year.

Biologists will walk in an upstream direction on opposite sides of the stream bank, at a pace adapted to weather and viewing conditions. It is anticipated that crews will be able to survey two to three miles (i.e., XX – XX reaches) during each survey day; however, some of the more remote sites may require more time to survey due to difficult access conditions. Surveyors may also elect to float selected mainstem reaches in rafts or kayaks as logistics and safety dictate. To minimize stress on pre-spawning salmonids, surveyors will move carefully and quietly through holding and spawning areas and avoid stepping on redds.

Stream visibility in each sample reach will be scored using the following codes:

- Code 1: Can see bottom of riffles and pools
- Code 2: Can see bottom of riffles only
- Code 3: Cannot see bottom of riffles or pools (survey crews will check several areas before making this determination).

Surveys will not be conducted in a given sample reach if the visibility is determined to be code 3 or if the sample reach is inaccessible (e.g., unsafe conditions, snow accumulation, or where the distance is such that a survey could not be reasonably conducted within one day). However, a data sheet will be filled out to document the survey attempt and reason why the survey was not completed.

The following data will be recorded during surveys of each sample reach.

1) Surveyor names
2) Survey sample reach identification code (each sample reach will be uniquely identified)
3) Survey date
4) Stream visibility code (as defined above)

[11] One crew is composed of two PacifiCorp fish biologists responsible for surveying the North Fork mainstem sample frames each year.

5) All salmon carcasses will be counted by species and sexed (if possible), measured for fork length and examined to determine egg retention for females[12]. After examination, tails will be excised to prevent recounting.

6) Surveyors will count all unflagged redds or groups of redds, and flag such after counting. Number and species of fish on the redd will be recorded. Redd locations will be documented by GPS.

7) Each redd counted will be marked with a flag hung on the most permanent feature on the stream bank upstream, as close to the redd as possible. Each flag will be marked with the date, sample reach identification code, redd number for the survey, location (i.e., left bank, right bank, mid-channel, etc.), and indication of redd type (single or redd cluster).

8) Each redd will be recorded as a possible test dig, single redd (i.e., one pocket and one mound), or redd cluster, with estimate of the number of pocket/mounds present for each cluster.

9) Redds recorded as test digs will be re-examined upon each re-survey to determine if the redd was actually completed at a later time. If the test dig becomes a completed redd, it will be recorded to revise the final database of total redd counts.

10) Redd visibility of previously identified and flagged redds will be recorded during each subsequent survey by recording the reach and redd number and visibility. Redds will be scored as either still visible or not visible on subsequent surveys. After a redd is scored as "not visible" on subsequent surveys, the redd flag will be removed. In high use areas it may be helpful to add different colored flagging on redds that are no longer visible to document redd superimposition over the entire spawn timing.

11) Any relevant notes regarding survey attributes or difficulties.

2.15.1.3 Frequency and Duration

Work crews will work 4 – 10 hour days each week. Surveys will start September 1 and continue on a weekly basis until December 31 each year[13]. The panel sample draw for each year (about 23 miles) will be fully surveyed during every two week period. This assumes a redd life of 14 days. On average, each survey crew must complete about 7 miles of surveys each week to complete the rotation in two weeks. Additional surveys may be done as time allows on a given day to provide more time to access difficult and remote areas that may be part of the sampling area. Survey reaches will be approximately 0.3 miles in length for tributary streams. Survey reaches along the North Fork Lewis River will be floated using pontoon boats or kayaks. As discussed above, in

[12] All salmon are wanded for CWT prior to transport upstream

[13] The start of spawning surveys depends on whether adult spring Chinook are transported and released upstream in the year of the survey. September 1 represents the start of surveys if spring Chinook have been released. October 1 is the survey start date if only coho have been released.

2016 and 2017, a subset of survey reaches (with prior high spawning density) will be surveyed once every week to evaluate the survey time interval.

2.15.1.4 Assumptions and Discussion of Bias and Error

The sampling design outlined in Section 2.15.1.1 minimizes the overall survey bias through the use of a probabilistic allocation of sites to revisit panels at a high annual subsampling rate (i.e., 33 percent), and provides a rigorous statistically valid basis for estimating the total number of redds and spawners in each stratum and in the total sampling frame. Estimates of total spawner abundance will be calculated based on redd counts and WDFW regional estimates of redds per spawner. Presented below is a list of major survey assumptions and a brief discussion of how this monitoring plan addresses each assumption. The major assumptions associated with the Chinook and coho spawning surveys are consistent with those identified in Johnson et al. (2007).

<u>Assumptions applicable to redd counts:</u>

1. All possible spawning areas are included in the sampling universe

The survey universe encompasses all potentially accessible stream reaches in the upper Lewis River basin (below migration barriers), not just areas with potential spawning habitat. Over time, if spawners are observed up to the current expected limit of accessible habitat and are found to be able to migrate even farther upstream (unlikely as most identified barriers are large waterfalls), these additional areas will be incorporated into the sample universe.

2. Spawning occurs during the time frames identified in Sections 2.15.1.3 and 2.15.2.3.

The annual start of surveys depend on the fish transport timing. Spawn timing is not expected to deviate from spawn timing of stocks downstream of Merwin Dam because it is these same stocks that are used for supplementation. Over time, there may be some changes to the spawning curve and this should be evaluated in the next revision of this plan in 2021. Survey duration is also based on lower river stocks. For coho, the end date is December 31 of each year. This end data is based on spawning curves and environmental conditions (e.g., snow accumulation, river stage, safety, etc.).

3. Identified stream reaches are and remain accessible to surveyors during the sampling period.

If a large number of survey reaches cannot be accessed, there is a risk that sampling will not achieve the desired level of precision. This study minimizes this risk by drawing a large subsample for surveying each year (i.e., 33 percent), which provides a substantial buffer if some reaches are not accessible. Surveyors are competent and conduct surveys as designed.

Surveyors will be thoroughly trained prior to the field season each year, and project leaders will conduct periodic field assessments of survey crews to ensure proper data collection during the survey season.

4 Surveyors are able to accurately count the number of redds.

Several studies have shown that over and under counting errors of large salmonid redds occur due to several factors such as identifying natural scour patterns as redds, discerning the number of individual redds in a redd "cluster", missing actual redds, etc., and that there is a difference between the magnitude of such error between "experienced" and less experienced surveyors. This study will thoroughly train surveyors in redd identification prior to the field season. Redd detection error may be adjusted with WDFW data and a study of redd persistence.

5 Surveyors are able to discriminate redds between species

Chinook and coho spawning distribution can overlap in time and space. Often no fish are present on redds when they are counted to aid in species origin. However, based on location and size of gravel the ability to differentiate Chinook and coho redds is possible with reasonable certainty. Spawn timing overlap is also considered to be minimal between these two species based on the frequency of surveys. That is, new redds formed in October are most likely coho. In late September, the location, redd size and gravel size may be used to define species.

6 The assumption of the number of redds per female is valid and remains constant over time.

Several studies have quantified the average number of redds constructed per female by species. This study proposes to use 0.3 to 0.6 redds per female coho as currently used by WDFW survey crews. Values for spring Chinook will be developed using existing WDFW assumptions at the time spring Chinook are reintroduced to the upper basin. These values are preliminary and may be adjusted as more regional data on redd detectability is presented. The values used represent the detection probability of each surveyor. This value has substantial variability based on the experience of the surveyor and the water conditions (e.g., flow and clarity) at the time of each survey. We realize that this variability is inherent within all redd surveys.

7 Redd life is 14 days or more for each species.

If average redd life is significantly less than 14 days for each species, redd counts would result in underestimation of total redds. Underestimation of total redds would result in underestimation of total spawners. Redd visibility could be determined similar to the methods employed by Hemmingsen et al. (1997). The redd visibility analysis conducted in 2016 and 2017 will inform this assumption. If redds are visible for significantly less than 14 days on average, then the overall survey time interval will be decreased, which may warrant an adjustment to the number of survey panels employed to balance survey effort with precision (i.e. survey fewer reaches more frequently, instead of surveying a larger number of reaches less frequently). Any adjustments to the survey time interval and number of survey panels will be made in consultation with the ACC M&E subgroup after the redd visibility analysis is completed following the 2017 survey season.

2.15.1.5 Results and Reporting

Survey results will be provided in the Utilities' ACC/TCC Annual Report. The report format will follow the standards and format of the American Fisheries Society. At a minimum, results will summarize the number of live and dead fish, and redds counted by species by reach, and provide a GIS map of sample reaches and redd locations. Sex ratios by sample frame and sample universe, any identified marks, and egg retention in carcasses will also be reported.

For each sample frame and sample universe, the estimate of total spawners and redds by species will be reported along with the calculated coefficient of variance (CV) at a 95% confidence level. Total spawners will incorporate the value adopted for redds per female and known sex ratio of coho or spring Chinook released. Regionally applied fish-per-redd expansion factors will be used to calculate total number of spawners.

If the confidence interval of the estimated spawner abundance encompasses the number of known or potential spawners (i.e., the number released into Swift Creek Reservoir), then the estimate of total spawners (based on redd counts) and known spawners will be compared to determine if a statistical difference exists. Also in this case, the probability distribution of the estimate will be recalculated to account for the known potential maximum spawner number.

2.15.2 Task 15.2-Winter Steelhead Surveys

2.15.2.1 Sampling Design

Developing sampling designs to monitor winter steelhead spawner abundance, distribution and timing upstream of Swift Dam are particularly challenging due to several factors including: iteroparous life history, poor access from snow accumulation and increased turbidity from snow melt during the spawning season. As a result, winter steelhead sampling requires a different approach than those proposed for spring Chinook and coho salmon.

A combination of targeted redd surveys and radio tracking will be used to evaluate winter steelhead spawning abundance, distribution and timing. Winter steelhead are released primarily at Eagle Cliff. However, there are also a minimum of three "seed" locations upstream of Eagle Cliff where a portion of transported fish are released. These seeding sites are used to improve spawning distribution of transported winter steelhead, coho and possibly spring Chinook if necessary.

Study Area: The study area is all available spawning habitat upstream of Swift Dam. Available spawning habitat will be separated into two groups: (1) habitat upstream of Eagle Cliff Bridge and (2) habitat downstream of Eagle Cliff Bridge including Swift Reservoir and its tributaries. This separation is made because conditions upstream of Eagle Cliff are expected to have higher turbidity and snow accumulations relative to habitat downstream of Eagle Cliff.

Sampling upstream of Eagle Cliff Bridge: Monitoring upstream of Eagle Cliff Bridge will rely entirely on radio telemetry including both fixed stations and aerial tracking surveys. Fixed stations will be located at Eagle Cliff, the FSC, and (if necessary) Swift Forest Campground. The Swift Forest Campground site would only be necessary if directionality is unclear with respect to steelhead migrating past the Eagle Cliff site. Aerial surveys and the fixed station at the FSC are expected to provide sufficient coverage to determine directionality of each tagged fish.

Up to three aerial flights are planned during the peak spawning period for winter steelhead. Based on past experience and transportation logs, flights would be scheduled approximately for March 15, April 15 and May 15. In addition, fixed telemetry stations will be installed at Eagle Cliff and the FSC to monitor migratory behavior and provide an estimate of the number of steelhead residing in the reservoir as compared to those upstream of the reservoir (Eagle Cliff Bridge) as well as when steelhead pass the Eagle Cliff Bridge. Fixed station data will be compared to aerial survey data to improve the ability to track individual fish throughout the spawn timing and assess potential pre-spawn mortality. Distribution of spawning steelhead will rely on aerial surveys during the peak spawn time for winter steelhead.

Spawner abundance upstream of Eagle Cliff will use detections from the fixed station at Eagle Cliff. Detections provided by this station in combination with aerial surveys and the FSC fixed station will determine if released steelhead are upstream or downstream of Eagle Cliff Bridge. Steelhead that migrate upstream of the Eagle Cliff station and spend a minimum of 5 days upstream of Eagle Cliff (at any time during the study) are assumed to have spawned. Tagged steelhead released at seed locations are also assumed to have spawned upstream of Eagle Cliff Bridge if they remain upstream of Eagle Cliff for more than 5 days post release. Aerial tracking will be used to confirm the location of fish upstream of the Eagle Cliff site and distribution of seed plantings.

<u>Sampling downstream of Eagle Cliff Bridge:</u> Monitoring will include both reservoir telemetry boat surveys and redd foot surveys of reservoir tributaries. Boat and foot surveys done on the same day as fish detections will be obtained from traveling to each tributary mouth. Telemetry surveys will be used to confirm the presence and specific location of tagged steelhead in the reservoir. Redd surveys will be used to count the number of redds during the peak spawning downstream of Eagle Cliff Bridge to estimate both distribution and spawner abundance. A minimum of three surveys (boat and foot) will occur during the peak spawn timing (March – May). All tributaries will be accessed by boat; therefore, all foot surveys will begin at the mouth of each tributary. The ability to walk all tributaries in one day may not be possible. If not, a fixed survey length for all tributaries will be applied that allows the surveys to be completed in one day. For example, all tributaries will be surveyed for redds from the mouth upstream 0.5 miles. Because redd surveys have not been completed for reservoir tributaries in the past, and tributary surveys are a peak index count, modifications may be needed to more accurately estimate the total number of redds downstream of Eagle Cliff.

2.15.2.2 Frequency and Duration

Table 2.15.2. Frequency and duration of surveys to evaluate steelhead distribution, timing and abundance.

Survey	Frequency	Duration
Aerial Distribution Surveys	Up to 3 surveys	March - May
Boat and Reservoir ground surveys	Up to 3 surveys	April - June
Fixed Radio Telemetry Monitoring	Daily	March - June

2.15.2.3 Assumptions and Discussion of Bias and Error

The radio telemetry study serves two primary purposes; (1) to estimate the survival of transported steelhead (which would be applied to the total number of transported steelhead to estimate total spawner abundance), and (2) to determine the distribution of spawners. Error in determining the actual position of each active tagged fish observation will be minimized by using helicopter surveys rather than fixed-wing surveys, and by using experienced personnel to conduct the tracking. Assessment of the full tag detection histories for each fish will be conducted to determine if the fish was actually alive or if a predator may have caused some movement.

This study will tag up to 50 adult steelhead each year (10 percent of the target number for transport). Tags will be distributed based on the planting location for all the steelhead released. That is, if 80 percent of fish are released at Eagle Cliff, then 80 percent of the radio tagged group will be released at Eagle Cliff. Females will have the priority for tagging. Tagging will occur between February and May 1. It is assumed that survival and spawning of tagged fish is not influenced by tagging (i.e., no tag effect). All tags will be gastric tags and tag loss is assumed to be insignificant. This assumption is based on past surveys where all tags have been detected at the FSC during two consecutive years of radio tracking studies.

A key assumption for estimating spawner abundance upstream of Eagle Cliff is that steelhead will not spawn in less than 5 days upon passing upstream of Eagle Cliff. Five days was suggested by the M&E subgroup as a reasonable amount of time to determine spawning success. That is, a steelhead upon moving upstream of Eagle Cliff must take a minimum of 5 days to migrate to the desired spawning location, construct redd(s), successfully spawn and migrate downstream to be detected at the Eagle Cliff site. Because each fish will have a complete movement history, the length of time of each tagged steelhead will be reviewed and changes may be recommended.

2.15.2.4 Results and Reporting

Study results will be provided in the ACC/TCC Annual Report. Study results will summarize the detection histories of each tagged steelhead (including foot, boat and aerial detection histories) using tables and GPS locations (maps). Survival of each tagged steelhead will also be made based on movement patterns during the study period. Steelhead spawner abundance upstream of Eagle Cliff Bridge will be estimated by applying the 5 day residence time factor to the total number of transported steelhead. Spawn timing curves will be based on radio tagged steelhead movement patterns and distribution metrics will be monitored and illustrated using maps of GPS locations during aerial, reservoir boat surveys and tributary foot surveys. Redd counts in reservoir tributaries will be used to estimate spawner abundance downstream of Eagle Cliff Bridge.

Redd expansion methods are based on peak surveys (i.e. not a census) and a sample (index area) of available habitat. Redd expansion to estimate spawner abundance will follow the same redd per female assumptions used for steelhead redd surveys in the lower river. Sex ratios will use actual ratios obtained from released steelhead. However, because steelhead surveys only represent redds during peak spawn timing there will need to be additional assumptions based on spawner abundance before and after the designated peak. Area under the curve models may need to be developed and tested to estimate spawning outside of the peak period. Also the proportion of steelhead spawning upstream and downstream of Eagle Cliff Bridge will be reported annually.

2.16 OBJECTIVE 16 - EVALUATE LOWER LEWIS RIVER WILD FALL CHINOOK AND CHUM POPULATIONS NOTE: THIS OBJECTIVE, BECAUSE IT IS A LOWER LEWIS RIVER MONITORING ACTIVITY, HAS BEEN MOVED TO BECOME MONITORING OBJECTIVE 1 OF THE HATCHERY AND SUPPLEMENTATION PLAN

The ACC made a decision to separate tasks originally identified in the Settlement Agreement into monitoring upstream of Merwin dam (M&E Plan Tasks) and monitoring downstream of Merwin dam (H&S Plan Tasks). Because of that distinction, this section, which is a downstream activity, has been transferred to the H&S Plan and is covered under Objective 1 of that plan.

2.17 OBJECTIVE 17- MONITOR BULL TROUT POPULATIONS

These bull trout objectives represent the mutual obligations of PacifiCorp and Cowlitz PUD. Methods to achieve these objectives will be provided in the Utility's Lewis River Bull Trout Annual Operating Plan.

Bull trout populations affected by the Lewis River Hydroelectric Project are monitored to 1) inform Project management decisions and 2) provide information to assist in gauging whether recovery goals and objectives are being met. Bull trout recovery goals and objectives are identified in the Recovery Plan for the Coterminous United States Population of Bull Trout (USFWS 2015a) and the associated Coastal Recovery Unit Implementation Plan for Bull Trout (RUIP; USFWS 2015b). Both plans seek to reverse declining trends and to ensure long-term persistence of bull trout and their habitats.

The Recovery Plan describes recovery criteria and lists five key points as the general range-wide strategy for recovery of bull trout: "(1) conserve bull trout so that they are geographically widespread across representative habitats and demographically stable in six recovery units; (2) effectively manage and ameliorate the primary threats in each of six recovery units at the core area scale such that bull trout are not likely to become endangered in the foreseeable future; (3) build upon the numerous and ongoing conservation actions implemented on behalf of bull trout since their listing in 1999, and improve our understanding of how various threat factors potentially affect the species; (4) use that information to work cooperatively with our partners to design, fund, prioritize, and implement effective conservation actions in those areas that offer the greatest long-term benefit to sustain bull trout and where recovery can be achieved; and (5) apply adaptive management principles to implementing the bull trout recovery program to account for new information."

Recovery unit implementation plans were developed for each of the six bull trout recovery units in the Unites States by individuals familiar with the populations within the recovery unit. The RUIPs describe threats to population persistence, recommend actions necessary to promote recovery, and identify research, monitoring and evaluation needs. The specific actions necessary to achieve recovery are identified at the Core Area spatial scale (e.g. Lewis River basin) and are included in their respective RUIP. The Lewis River Bull Trout Recovery Team (LRBTRT), comprised of federal, state, and non-governmental biologists and scientists, provided the aforementioned information for the Lewis River Core Area, which was subsequently included in the Coastal RUIP.

The LRBTRT took the RUIP one step further with the additional development of a Lewis River Bull Trout Recovery Monitoring Plan, which details specific methods and direction for population monitoring of bull trout in the Lewis River basin.

Bull Trout Objectives:

The bull trout objectives were developed by the Utilities in collaboration with the LRBTRT and are consistent with the: 1) Bull Trout Recovery Plan, 2) the Coastal RUIP, and 3) the Lewis River Bull Trout Recovery Monitoring Plan. The monitoring objectives are intentionally broad in scope to allow for flexibility in specific actions as monitoring needs evolve. At a minimum, elements of the following objectives will be monitored annually:

- Demographic Characteristics
- Vital Rates
- Spatial Distribution

- Movement Patterns
- Genetic Diversity

Operating plans and reports will be reported annually.

Achieving these monitoring objectives annually will provide information necessary to evaluate population response to recovery measures implemented and to assess the recovery progress of bull trout in the Lewis River Core Area. Additional monitoring and evaluation objectives may be included over time, in accordance with the Lewis River Bull Trout Recovery Monitoring Plan, and identified in the Lewis River Bull Trout Annual Operating Plan.

The Lewis River Bull Trout Annual Operating Plan will identify the specific monitoring actions that will be implemented by the Utilities each year to achieve the monitoring objectives. Each year, the Plan will be developed in consultation with the USFWS and the LRBTRT. The Plan may change through time as new scientific information becomes available or as monitoring needs change. The results of the monitoring actions identified in the Plan will be provided in the annual ACC/TCC report.

The USFWS sees the development of the Bull Trout Annual Operating Plan as an opportunity for a bull trout sub group of the ACC (i.e., LRBTRT) to meet, at a minimum, annually. The primary purpose of this annual meeting will be to discuss progress in meeting Monitoring and Evaluation Plan requirements for bull trout monitoring in the past year, and to collaboratively develop an annual operating plan for the next year's activities.

2.18 OBJECTIVE 18- DETERMINE INTERACTIONS BETWEEN REINTRODUCED ANADROMOUS SALMONIDS AND RESIDENT FISH (UPSTREAM OF MERWIN DAM)

In 2013 through March 2016, USGS-Bozeman, along with Univ. of Washington, performed several tasks to inform the future fish passage decision in February 2017 regarding the quality of habitat in Merwin and Yale reservoirs and their tributaries. One of the required tasks was to assess anadromous fish interactions with resident fish as it relates to this objective 2.18.

The following is a description of methods used by USGS – Bozeman and the University of Washington to address this objective. The goal of this objective was to design and implement studies to assess the effects of anadromous fish introduction on resident species, and, conversely, assess the effects of resident fish on the reintroduced anadromous fish.

Juvenile anadromous salmonids will utilize Lake Merwin, Yale Lake, and Swift Reservoir as migratory corridors and rearing habitats to varying degrees. Juvenile Chinook salmon tend to rely heavily on lake and reservoir habitats for significant fractions of their freshwater rearing period (Connor et al. 2002; Koehler et al. 2006;

Lowery and Beauchamp 2010), whereas volitional reliance on lentic habitats by juvenile coho and steelhead is more variable (Lowery and Beauchamp 2010). Therefore, the magnitude and duration of interactions with resident species will vary among anadromous salmonids. By quantifying existing seasonal, size-structured food web interactions for the key fishes and invertebrates likely to interact directly or indirectly with anadromous salmonids in the three reservoirs, potential limiting factors can be evaluated with regard to whether production or survival are inordinately constrained by temporal availability, quality, or accessibility of food, competition, or predation, and the role of environmental conditions (temperature, water transparency, light, DO) in mediating these constraints (e.g., Beauchamp et al. 2004; Beauchamp and Shepard 2008). Since reintroduction of anadromous salmonids is already underway in Swift Reservoir, the trophic relationships among potential predators, competitors, and prey can be compared based on stable isotope patterns from samples taken before the reintroduction and those obtained directly from field sampling described above in this objective.

Investigators mapped the δ15N and δ13C signatures for each species and size class (as available from existing samples) from both the pre- and post-reintroduction periods to determine trophic position and predominant energy pathway used by each key species and juvenile salmon (e.g. benthic or terrestrial invertebrates versus pelagic zooplankton). Swift Reservoir currently supports a catchable rainbow trout fishery that also includes larger, potentially piscivorous individuals. Stable isotope analysis can help evaluate dietary overlap or partitioning between salmon and resident trout and also examine the role of larger trout as potential salmon predators. High diet overlap potential between resident trout and reintroduced salmon would be suggested by strongly overlapping δ15N and δ13C, whereas potential predation by trout on salmon could be suggested by elevated δ15N in post-reintroduction samples compared to pre-introduction samples. The association of predator body size with increased piscivory can be identified by an increase in δ15N with increasing fork length.

The sampling and bioenergetics modeling approach was extended to key resident-anadromous food web interactions in all three reservoirs is described as follows:

Collected stable isotope samples and supplementary diet analysis to effectively describe trophic interactions among species, size classes and seasons. The stable isotope data are most valuable for identifying sizes or life stages associated with the onset and magnitude of piscivory or shifts between benthic and pelagic prey (e.g., McIntyre et al. 2006). Diet analyses provide valuable complementary information for improving taxonomic and temporal resolution by identifying the specific prey species and sizes that contribute to the diet among seasons and size classes of consumers, and is especially valuable for improving the resolution for the diets of piscivorous fishes (Beauchamp et al. 2007). Investigators analyzed the data, identified the trophic relations and highlighted critical information gaps that could be filled with directed field collections for additional key species or sizes, and identified where ambiguity in the stable isotope signatures might necessitate diet samples to adequately differentiate among key prey with similar signatures and estimate the sizes of prey fishes consumed by different sizes and species of piscivores.

Performed laboratory analyses of field samples for muscle tissue for stable isotope analysis, stomach dissections for diet analysis, and scales for age and growth of predators and key prey species. Stomach contents were identified to species for prey fishes, genus for zooplankton, and by functional group for other invertebrates (e.g., terrestrial and adult or pupal forms of aquatic insects versus other immature forms by Order, key benthic macroinvertebrates, etc.). When possible, reconstructed fork or standard lengths were recorded for prey fishes from the stomach contents along with the size, species, date and location of the predator. Diet composition was computed as the proportional contribution of each prey category in the stomach of individual fish by wet weight. Mean diet composition and sample size was calculated for predator species by size class and season for use as inputs to the bioenergetics mode simulations (Beauchamp et al. 2007).
The investigators used information regarding the abundance and size structure of piscivore populations, annual growth rates, seasonal diet composition, and thermal experience information as well as existing data within the Wisconsin Fish Bioenergetics Model (Hanson et al. 1997) to estimate the prey biomass consumed (i.e., predation impact) by each age/size class of predators, including northern pikeminnow, tiger muskellunge, and other piscivores on anadromous salmon and other species. The primary data inputs for these model simulations were derived from existing information and targeted field sampling. Species-specific parameter sets were used from peer-reviewed estimates for northern pikeminnow, tiger muskellunge, bull trout, rainbow-steelhead trout, kokanee, Chinook and coho salmon, and other species in the Columbia River Basin (ISAB 2011).

Investigators utilized the bioenergetics simulations to generate average feeding rates and estimates of predator consumption of salmonids. These consumption estimates were combined with the size structure and abundance information to expand individual rates to size-structured population-level consumption rates (Beauchamp et al. 2007). For potential predators of anadromous salmonids, the total biomass consumed and the biomass of fish prey eaten formed the basis for estimating expected predation rates on the salmonids during periods when predators and prey likely overlapped in the reservoir and were not thermally segregated. Different predation scenarios were generated based on contribution of alternative prey fishes in the baseline diet composition.
Archived stable isotope samples, collected by ACC members in 2009 prior to the anadromous fish reintroduction, were processed and analyzed to map the pre-introduction trophic interactions in Lake Merwin, Yale Lake and Swift Reservoir, based on the $\delta15N$ and $\delta13C$ signatures for different size classes and species of the key predators, competitors, and prey for these waters. These data were supplemented by new field collections (as described above) for stable isotope samples, as needed to fill any important gaps in key species or sizes, plus seasonal diet, distribution, and size structure of the predator-prey-competitor community in all three reservoirs.

Specific Objectives

1) Utilize existing data (e.g., pre-introduction isotope data from Swift Reservoir) and empirical field data to identify the structure of the food webs in Swift Reservoir, Yale Lake, and Lake Merwin.
2) Estimate predation potential and consumption of juvenile salmonids by resident native and non-native species across different seasons in each system.

3) Estimate potential competition among different resident species and anadromous salmonids for resources.
4) Quantify spatial overlap within Pine Creek[1] (Swift Reservoir) and habitat use by anadromous smolts and resident fishes.
5) Estimate predation and competition among species in Pine Creek using stable isotope methods.

Methods Task 6

Archived stable isotope samples were processed and analyzed to map the existing trophic interactions in Lake Merwin, Yale Lake and Swift Reservoir, based on the δ15N and δ13C signatures for different size classes and species of the key predators, competitors, and prey for these waters. These data were supplemented by new field collections (as described in Task 5 above) for stable isotope samples, as needed to fill any important gaps in key species or sizes, plus seasonal diet, distribution, and size structure of the predator-prey-competitor community in all three reservoirs.

Investigators used bioenergetics modeling to calculate the seasonal, "population-level" consumption demand by the potential major predators and competitors for the presumptive primary food sources utilized by juvenile anadromous salmonids in lentic habitats (Independent Scientific Advisory Board 2011). This has proven to be a useful approach for determining the relative importance of interactions among potential competitors or predators and prey, and can provide compelling justification and guidance for subsequent phases of research or monitoring. The bioenergetics simulations also generate an estimate of the average feeding rate required by the consumer over the simulation interval, which can be interpreted as an indicator of whether food supply, food quality, or temperature is an important limitation to growth for consumers at different life stages or sizes (Beauchamp 2009).

Given the inadequacies of gillnets in sampling pelagic fishes, the limnetic community was assessed with hydroacoustic and midwater trawl surveys to quantify the abundance and seasonal-diel vertical distribution patterns and trophic interactions of these species (Beauchamp et al. 2009). Investigators conducted a quantitative hydroacoustic survey during peak summer stratification to estimate the abundance, distribution, size structure, and diet of kokanee and any other pelagic species in each reservoir. A Biosonics model DE-2000 echosounder with 200 kHz splitbeam, multiplexed down- and side-looking transducers were deployed at night along zigzag transects from inlet to forebay where bottom depths exceed 5m. The density of fish-sized targets (e.g., TS > -55 dB) by size and depth interval were computed for pelagic and nearshore-slope zone regions of each reservoir. A closing midwater trawl (Enzenhofer and Hume 1989) sampled discrete depths that span the modal fish densities to identify the species and size composition of acoustic targets and provide samples for growth, diet, and stable isotope analysis, and to compute time-depth weighted thermal experience for the bioenergetics simulations of pelagic species (Beauchamp et al. 2007).

In addition, specific nearshore-offshore transects were selected where a day-dusk-night (diel) sequence in the vertical distribution patterns of fish was recorded with hydroacoustic gear. Similar quasi-quantitative hydroacoustic surveys were conducted with reduced numbers of transects during the spring outmigration period and mid-autumn before complete thermal destratification. The primary objectives for these additional surveys were to:

- Obtain diet, growth, and diel vertical distribution data during the spring outmigration and growth period and the fall growing period.

- Quantify spatial overlap and overlap in habitat use for resident fishes and anadromous fishes in Pine Creek1. Conduct spatially-balanced sampling within Pine Creek and georeference the locations of capture by species, across different periods of the year (flows permitting).
- Collect field samples of tissue from captured fish and macroinvertebrates for isotope analyses. Analyze isotope data to quantify potential competition and predation rates during the stream-rearing life-stage.

[1]USGS selected the location of Pine Creek as it helped to identify multiple objectives/tasks in the investigation.

Reporting

The elements of this objective were completed over a period of 3 years from 2012 to 2015. A report was prepared and issued to the ACC in February 2016. That report will be attached as an appendix to the 2016 Annual Report.

Next Steps

The M&E subgroup has suggested that this effort be repeated to some degree to assess resident/anadromous interactions once the reintroduction program is fully operational and full complements of the reintroduced species are present. This could take some time since, for the past three years, there have not been enough Chinook available to transport upstream and the coho availability is intermittent. Dr. Dave Beauchamp recommended and PacifiCorp proposes that, sometime within years 5-10, repeat a very streamlined version of some elements of this study, focused on questions guided by what we observe from smolt trapping (size, abundance, survival and timing) and adult returns (smolt-adult survival rates related to smolt size & abundance, etc.).

2.19 OBJECTIVE 19- DOCUMENT PROJECT COMPLIANCE WITH FLOW, RAMPING RATE AND FLOW PLATEAU REQUIREMENTS

PacifiCorp has agreed to document project flow, ramping rate, flow plateau, and flood storage requirements of the new Licenses for the Project. Pending approval of the High Run-Off Procedures, PacifiCorp has also agreed to document flood storage. The monitoring locations for stream flow-related requirements will be at the Ariel Gage located in the lower Lewis River, and at two sites in the Lewis River bypass reach below Swift No. 1 Dam. Flood storage requirements will be monitored at each of the project dams.

2.19.1 Task 19.1 – Monitor River Flow, Ramping Rate and Flow Plateau for the Lewis River Projects

2.19.1.1 Monitoring Locations

Minimum stream flow values for the Lewis River are measured in real-time at the USGS Gage No. 14220500 (Ariel Gage) located downstream of the Merwin Dam. This gage is the official compliance point for minimum stream flow releases, ramping rates and plateau operations downstream of Merwin Dam.

Flow into the Swift bypass reach will be measured in two locations in accordance with Section 6.1 of the Settlement Agreement. These locations are the "Upper Release Point" in the upper end of the bypass reach, and at the "Canal Drain", located approximately one-third the length of the canal downstream of the Swift No. 1 tailrace. [14]

The methods used for determining Project compliance with all flow and ramping rate license requirements at these monitoring locations are presented below.

2.19.1.2 Rating Tables and Gage Station Maintenance

Where used, rating tables will be maintained by PacifiCorp or a qualified contractor. Maintenance of relevant monitoring instrumentation will meet PacifiCorp's need for real time access to flow data. Instruments will be maintained by PacifiCorp or other qualified contractors.

2.19.1.3 Data Management and Publication

Data will be managed by PacifiCorp. Any data deficiencies discovered during the review and publication process (e.g., rating table shifts, stage offsets) will be edited to produce an accurate record.

Ariel Gage

Real-time 15-minute provisional data from the Ariel gage will be logged by PacifiCorp to monitor hourly average flow and hourly ramping rates downstream of Merwin Dam. Minimum stream flow, ramp rate and plateau operations reporting will occur on an excursion basis only as provided in Section 2.19.1.4.

Swift Bypass Reach: Upper Release Point

Real-time 15-minute data from the Swift bypass reach and Upper Release Point will be logged by PacifiCorp and/or a qualified contractor to monitor hourly average flow. Minimum flow at these locations will be reported on an excursion only basis in the annual report. All reviewed records will be stored by PacifiCorp in a permanent repository.

In the event of an extended unplanned interruption to flow from the upper release point, PacifiCorp will provide flow via the spill gates (or other means) to allow at least the

[14] PacifiCorp will pay for the maintenance, operation and replacement, if necessary, of both gages.

required minimum flow into the upper bypass reach. During this particular scenario, flow will be calibrated by PacifiCorp at the most suitable point downstream of the spillway to verify that the temporary flow release is equal to the flow required by the 401 Certification. The spill gates will be adjusted until such time as the appropriate minimum flow is achieved and the spill gates fixed to this opening. In addition, PacifiCorp will send a notice by electronic mail (email) to the ACC members within 48 hours after each adjustment or change to the flows in the bypass reach (unless the Parties agree upon an alternate method of notification). In the case of planned interruptions (e.g., for canal maintenance) flow will be provided to the Upper Release channel using a pump or siphon until the flows can be restored.

Swift Bypass Reach: Canal Drain

Flow into the lower Swift bypass reach from the canal drain will be monitored by logging 15-minute stage data in the Swift canal. This data will be used to calculate hourly average flow into the lower Swift bypass reach. Since the required flow release from the canal drain remains constant throughout the year (14 cfs), the canal drain opening will be fixed to release required flows at the lowest possible stage in the canal. Most of the time, flow from this release point will likely exceed the required minimum since the stage in the canal generally is operated higher than this minimum elevation, thereby increasing the head at the release point. Mean hourly stream flow values measured at the canal drain will be published in the ACC/TCC Annual Report. All reviewed records will be stored by PacifiCorp in a permanent repository.

In the event of a planned or unplanned interruption of flow release from the canal drain, PacifiCorp will place a pump siphon or use other means to allow at least the minimum flow into the bypass reach from this location. During this particular scenario, flow will be calibrated by PacifiCorp or a qualified contractor at the most suitable point downstream of the canal drain to verify that the temporary flow release is equal to the flow required by the 401 Certification. Flow will be adjusted until such time as the appropriate minimum flow is achieved and set at this level. As is the case for the Upper Release Point, PacifiCorp will send a notice by email to the ACC members and WDOE within 48 hours after each adjustment or change to the flows in the bypass reach via the canal drain (unless the Parties agree upon an alternate method of notification).

2.19.1.4 Flow and Ramp Rate Monitoring and Excursion Reporting

Flow Monitoring and Excursion Reporting

If flows at gage sites are discovered to be less than the required minimum flows, or ramping occurs that exceeds the compliance limits, PacifiCorp will correct these conditions as rapidly and prudently as possible. Any excursions from the flow requirements will be clearly documented by date, time and duration and reported as discussed below.

Ariel Gage

PacifiCorp will review hourly average flow data for compliance with the minimum stream flow requirements in the new license (Table 2.19.1). Excursions from hourly minimum stream flow requirements will be reported to FERC, WDOE, and the ACC within 24 hours of verifying the excursion. Notification will include a detailed explanation of why the event occurred and corrective actions implemented.

These initial notifications will be distributed via email, and will describe the location, time, duration, magnitude, and cause of the event; what immediate corrective actions were taken; and any long-term plans to prevent repetition. Comprehensive reports may be requested by the agencies for individual circumstances.

Minimum flow excursions measured at the Ariel Gage site will be described in the ACC/TCC Annual Report.

Swift Bypass Reach Upper Release

PacifiCorp will review hourly average flow data for compliance with the minimum stream flow requirements in the new license (Table 2.19.1). Excursions from minimum stream flow requirements will be reported to FERC, WDOE, and the ACC within 24 hours of verifying the excursion. Notification will include a detailed explanation of why the event occurred and corrective actions implemented.

These initial notifications will be distributed via email, and will describe the location, time, duration, magnitude, and cause of the event; what immediate corrective actions were taken; and any long-term plans to prevent repetition. Comprehensive reports may be requested by the agencies for individual circumstances. Minimum flow excursions measured at the Upper Release site will be described in the ACC/TCC Annual Report.

Swift Bypass Reach Canal Drain

Flow in the lower Swift bypass reach from the canal drain will be monitored by logging 15-minute stage data in the Swift canal. PacifiCorp will review mean hourly average stage data for compliance with the minimum stream flow requirements in the new license (Table 2.19.1). Excursions from minimum (stage) stream flow requirements will be reported to FERC, WDOE and the ACC within 24 hours of verifying the excursion. Notification will include a detailed explanation of why the event occurred and corrective actions implemented.

These initial notifications will be distributed via email, and will describe the location, time, duration, magnitude, and cause of the event; what immediate corrective actions were taken; and any long-term plans to prevent repetition. Comprehensive reports may be requested by the agencies for individual circumstances.

Minimum flow excursions measured at the canal drain will be described in the ACC/TCC Annual Report.

Table 2.19.1. Minimum flow releases in the Lewis River from Merwin Dam and the Swift bypass reach from the Swift canal as required by the FERC licenses and Section 401 Certifications.

Lewis River Downstream of Merwin Dam	
Date	**Minimum Flow (cfs)**
October 16 through October 31	2,500
November 1 through December 15	4,200
December 16 through March 1	2,000
March 2 through March 15	2,200
March 16 through March 30	2,500
March 31 through June 30	2,700
July 1 through July 10	2,300
July 11, through July 20	1,900
July 21 through July 30	1,500
July 31 through October 15	1,200
Swift Bypass Reach*	
Date	**Minimum Flow (cfs)**
January	65
February	89**
March	90
April	90
May	90
June	68
July	68
August	68
September 1-23	68
September 24-30	69
October	75
November 1-15	90
November 16-30	70
December	65

* Flow levels were taken from the WDOE 401 Certification for the Swift No. 1 Hydroelectric Project (WDOE 2006) and are the “Combined Flow Schedule” for the required stream flow releases from the “Upper Release Point” and the “Canal Drain.”
** During leap years, 88 cfs shall be released for the first 7 days in February and 89 cfs for the rest of the month.

Ariel Gage Ramp Rate and Plateau Operations Monitoring and Excursion Reporting

When ramping occurs that exceeds compliance limits, PacifiCorp will correct these conditions as rapidly and prudently as possible. If plateau operations are violated, PacifiCorp will not attempt to correct the action by returning to the flow level preceding the event since plateau operations seek to limit flow changes.

PacifiCorp will review hourly Ariel gage stage data to ensure compliance with Project ramping rate restrictions and plateau changes downstream of Merwin Dam[15]. Stage will be measured in tenths of feet per hour, and will be calculated using available 15-minute Ariel gage flow data to calculate an hourly average. The ramping rates will then be compared with the Settlement Agreement required ramping rate and flow plateau requirements on an hourly basis.

The requirements are as follows:

1. PacifiCorp will limit the up-ramping rate as observed at the Ariel gage (downstream of Merwin Dam) to 1.5 feet per hour for all periods when flows below Merwin Dam are at or less than the hydraulic capacity of the Merwin Project turbines (currently 11,400 cfs).

2. PacifiCorp will limit the down-ramping rate to 0.17 feet per hour for all periods when flows are at or less than 8,000 cfs. From February 16 through June 15, no down-ramping shall occur (1) commencing one hour before sunrise until one hour after sunrise and (2) commencing one hour before sunset until one hour after sunset.

3. PacifiCorp will further restrict daily flow fluctuation from February 16 through August 15 of each year by maintaining flow plateaus (periods of near-steady discharge) as described in Section 6.2.2 of the Settlement Agreement.

Excursions from hourly ramp rate requirements or plateau changes will be reported to FERC, WDOE, and the ACC within 24 hours of verifying the excursion. Notification will include a detailed explanation for why the event occurred and corrective actions implemented.

These initial reports will be distributed via email, and will describe the location, time, duration, magnitude, and cause of the event; what immediate corrective actions were taken; and any long-term plans to prevent repetition. Comprehensive reports may be requested by the agencies for individual circumstances.

PacifiCorp will describe ramping rate and plateau operation excursions as measured at the Ariel gage in the ACC/TCC Annual Report.

[15] "Ramping" means those Project-induced increases ("up-ramping") and decreases ("down-ramping") in river discharge and associated changes in river surface elevation over time below Merwin Dam caused by Project operations or maintenance (Section 6.2.1 of the Settlement).

High Run-Off Procedure Monitoring and Reporting

The reporting requirements described here are pending approval of PacifiCorp's Lewis River High Run-Off Procedures by FERC and the U.S. Army Corps of Engineers (USACE)). However, neither FERC nor FEMA are willing to sign off on the HRP so PacifiCorp is defaulting to the historic protocols. Documentation of compliance with the historic protocols will be reported directly to FERC at the end of each flood season.

The High Run-Off Procedures define vacant storage requirements for flood control purposes throughout the flood control season extending from September 20 through April 30 or April 15 in years of low snowpack (Table 2.19.2). Generally, vacant storage is a function of reservoir elevation relative to the normal full operating level in the reservoir[16]. PacifiCorp will report daily average vacant storage to the nearest tenth of a foot for the flood control season to the FERC by July 31, annually. In the event that the average daily storage requirement is encroached upon for flood control purposes or other reasons, this will be reported to the FERC within 24 hours of verifying the reservoir storage encroachment. Notification will be provided via email and will include an explanation for the need/use of the vacant storage. Notification will occur when the vacant storage requirement (as measured to the nearest tenth of a foot) is encroached upon by more than 0.2 feet for 6 hours or more. PacifiCorp will report daily average reservoir elevation for each project, to the nearest tenth of a foot for the flood control season to the FERC by July 31, annually.

Table 2.19.2. Vacant storage requirements for the Lewis River Project reservoirs (Merwin, Yale and Swift reservoirs)

Date	**Vacant Storage (feet)**
Normal Vacant Storage	
Sept. 20	0
Oct. 10	8.5
Nov. 1 thru Apr. 1	17.0
Apr. 15	8.5
Apr. 30	0
Vacant Storage in Low Snowpack Years	
Sept. 20	0
Oct. 10	8.5
Nov. 1 thru Mar. 15	17.0
Apr. 1	8.5
Apr. 15	0

The high runoff procedure also defines elevations at which the reservoirs are considered "full" under normal operating conditions. However, during some high flow events, it may be necessary to surcharge the reservoirs beyond these normal operating limits. When this occurs in any of the three project reservoirs, PacifiCorp will notify the FERC of this occurrence within 24 hours of verifying the reservoir surcharge. Notification will

[16] Vacant storage is measured in feet of depth between the current reservoir water levels and elevation 1,000 feet-msl at Swift, elevation 490 feet-msl at Yale, and elevation 239.6 feet-msl at Merwin. Because the average storage space in the top foot of the three Lewis River reservoirs is approximately the same, depth can be summed over multiple reservoirs.

be provided via email and will include an explanation for the need to surcharge. Notification will occur when the normal maximum elevation in each reservoir is exceeded by more than 0.2 feet (measured to the nearest tenth of a foot) for 6 hours or more.

Reservoir elevation monitoring devices are located at the Project dams and are operated and maintained by PacifiCorp. Data from these devices will be archived in PacifiCorp's operations databases.

2.20 OBJECTIVE 20 - DETERMINE WHEN REINTRODUCTION OUTCOME GOALS ARE ACHIEVED

The Settlement Agreement notes:

> *…the Services, after discussion with the ACC, shall determine how they will assess whether Reintroduction Outcome Goals have been met, e.g., metric, model, qualitative factors ("Evaluation Methodology"). The determination shall take into account the variability of the factors influencing the success of the comprehensive aquatics program over time such as cycles of ocean conditions and will include an appropriate temporal component in developing and applying the Evaluation Methodology.*

Although the responsibility of the Services, the Utilities are interested in playing a significant role in putting forth viable approaches for the Services to consider in establishing the reintroduction Evaluation Methodology. The H&S Plan (PacifiCorp Energy and Cowlitz PUD 2006) provides some ideas as to what type of information should be considered in determining program success. In general the H&S Plan suggests:

1. Using other lower Columbia River spring Chinook, coho and steelhead as index stocks to track out-of-basin effects on the success of the Lewis River program.

2. Tracking similar reintroduction efforts on the Cowlitz River and other lower Columbia River tributaries.

3. Calculating yearly harvest rates, smolt-to-adult survival rates, juvenile production etc., to estimate when runs are self-sustaining.

<u>Methods</u>

Methods for conducting each of the three analyses are presented in different sections of this M&E Plan. Yet to be defined is a numeric adult goal that dictates when run-size is sufficient for achieving both recovery and harvest goals. Until the Services develop numeric goals, the natural adult abundance targets presented under Objective 12 (Ocean Recruits) will be used as the benchmarks for determining the success of the reintroduction effort.

2-21 OBJECTIVE 21. DEVELOP A HATCHERY AND SUPPLEMENTATION PLAN (H&S) TO SUPPORT AND PROTECT LEWIS RIVER NATIVE ANADROMOUS FISH POPULATIONS AND PROVIDE HARVEST OPPORTUNITY

A plan has been established and is revised and updated on a 5-year cycle by the Hatchery and Supplementation ACC subgroup. This plan was updated in 2015. A major component of the H&S Plan is an Annual Operating Plan (AOP) that is generated by the H&S Plan subgroup of the ACC. The steps and timeline for developing the AOP are described in the H&S Plan.

2-22 OBJECTIVE 22 - DEVELOP A COORDINATION TABLE THAT CROSS-REFERENCES OBJECTIVES OF THE HATCHERY AND SUPPLEMENTATION PLAN AND THE MONITORING AND EVALUATION PLAN

2-22.1 Introduction

The purpose of this new objective is to show what data is collected by the M&E and H&S plans and how these data can be used to provide information at a population level in terms of abundance and Viable Salmonid Population (VSP) point estimates. Reporting from this objective will include information that identifies VSP parameter or metric being measured, methodology used to collect data, statistical methodology used to analyze data, and if point estimates with precision will be produced for each metric, as per NOAA Fisheries monitoring recommendations.

NOAA Fisheries recommends a specific regimen designed to monitor the Columbia River ESA listed salmon and steelhead and to demonstrate viability of each Evolutionarily Significant Unit (ESU) and each Distinct Population Segment (DPS). Those recommendations and guidelines are included in a document titled: *Guidance for Monitoring Recovery of Pacific Northwest Salmon & Steelhead listed under the Federal Endangered Species Act.* This document was prepared for the National Marine Fisheries Service by Crawford and Rumsey (2011) and was published one year after completion of the first version of this M&E Plan. In that document, the authors' state, "It is our intention that these recommendations will be considered as the desired level of monitoring to be conducted and will provide consistency across recovery domains. The relative importance of each recommendation is left to the reader to determine based on their own circumstances and biological and physical conditions." They go on to state, "This document is not intended to establish new requirements or modify any existing requirements set by a currently approved biological opinion or habitat conservation plan."

In light of this document, PacifiCorp and Cowlitz PUD, in the spirit of cooperation, are willing to provide any desired information that relates to the NOAA Fisheries document to the extent that information is included in the required Monitoring and Evaluation Objectives as part of the Lewis River Settlement Agreement.

An example report framework by species is shown below that addresses the parameters in Crawford and Rumsey (2011) and how these parameters are aligned with metrics measured as part of the M&E and H&S Plan objectives. Those metrics that do not align or are not required by either the M&E Plan Objectives or the H&S Plan Objectives are not included or noted as not applicable (NA).

Methodology necessary to combine data from both the M&E and H&S plans to develop annual point estimates with precision estimates for these metrics at the population scale has not been developed. Combining data to estimate these metrics at the population scale is necessary to fully evaluate the success of PacifiCorp funded reintroduction and hatchery production programs.

The specific detailed methodology for developing metric estimates at the population scale will not be completed during the 90-day review period. WDFW and PacifiCorp will develop this methodology and it will be included as part of annual reporting for Objective 22.

2.22.2 Frequency and Duration

Data will be collected daily or weekly during each applicable fish run. Annual summaries will be prepared for the ACC/TCC Annual Report.

2.22.3 Results and Reporting

At a minimum, the tables listed (Tables 2.22.1 through 2.22.6) below will show numbers associated with each metric for above Merwin dam (M&E Objectives) and below Merwin dam (H&S Objectives).

Results will be provided in the ACC/TCC Annual Report in the form of these tables with the numbers filled in if they are available. Results reported will include point estimates with precision estimates for each metric addressed by an M&E or H&S Plan objective. Additionally, individual estimates for the lower and upper North Fork Lewis basin will be combined to provide a single estimate for the entire North Fork Lewis basin. For populations that also include the East Fork Lewis (Tule Fall Chinook and Chum) WDFW will combine estimates for the North Fork Lewis with estimates for the East Fork Lewis to produce a single population estimate. WDFW will be responsible for reporting results at the population level, provided that WDFW determines that estimates are unbiased and include precision estimates consistent with NMFS guidance and WDFW standards. WDFW will provide information regarding the status of each population to the NMFS annually via WDFW's SCoRE web page.

2.22.4 Future Actions Summary

Detailed methodology for Objectives 1-22 are presented this M&E Plan. Implementation of these objectives will require adaptive management to achieve the goals of each objective; therefore, changes to methodology presented in this plan may occur on an annual basis. These changes will be captured in the annual report for each Objective. Table 2.22.7 will present and summarize these changes.

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Table 2.22.1: Lewis River spring Chinook salmon cross-walk table that summarizes the monitoring activities in the lower Lewis River (downstream of Merwin Trap), and upper Lewis River (upstream of Swift Reservoir) as they pertain to individual viable salmonid population (VSP) parameter metrics and the corresponding objectives, data collection, and analytical methods, which are detailed in the Lewis River Hatchery & Supplementation (H&S) Plan and the Lewis River Monitoring & Evaluation (M&E) Plan. Metrics for which estimates and precision levels will be calculated according to M&E and H&S objectives are indicated with a "Y" (Yes).

		Lower River					Upper River					Total Population		
VSP Parameter	**Metric**	**e**	**Data Collection**	**Analysis**	**Estimate**	**Precision**	**e**	**Data Collection**	**Analysis**	**Estimate**	**Precision**	**Analysis [1]**	**Estimate**	**Precision**
Abundance	Total Escapement (adults and jacks)	NA	-	-	-	-	M&E 11	Trap returns	Census	Y	Y	NA	-	-
	Spawner Abundance (Adults)	H&S 13	Stream surveys	Jolly-Seber	Y	Y	M&E 15	Stream surveys	TBD	Y	Y	TBD	Y	Y
	pHOS	H&S 2	Stream surveys	Spawning Ground Ratios	Y	Y	M&E 15	Stream surveys	Spawning Ground Ratios	Y	Y	TBD	Y	Y
	Juvenile Abundance (migrants)	H&S 13	Screw Trap	Petersen M-R	Y	Y	M&E 6&7	Screw Trap / Fish Surface Collector	Petersen M-R	Y	Y	TBD	Y	Y
Productivity	Spawner to Spawner (recruits per spawner)	M&E 12	Stream surveys	Spawner-recruit	Y	Y	M&E 12	Stream surveys / Trap returns	Spawner-recruit	Y	Y	TBD	Y	Y
	Freshwater survival	NA*	Smolt trap / Stream surveys	Spawner-to-smolt	-	-	NA*	Stream surveys / Screw Trap / Fish Surface Collector	Spawner-to-smolt	-	-	NA*	-	-
	Ocean survival	M&E 12	Stream surveys / Trap returns / Screw Trap	Smolt-to-adult (SAR)/ Ocean Recruit	Y	Y	M&E 12	Stream surveys / Trap returns / Screw Trap / Fish Surface Collector	Smolt-to-adult (SAR)/ Ocean Recruit	Y	Y	TBD	Y	Y
Spatial Structure	Redd Distribution	H&S 14	Stream surveys	Redd count/mapping	Y	-	M&E 15	Stream surveys	Redd count/mapping	Y	-	TBD	Y	-
	Reach Occupancy	NA	-	-	-	-	M&E 15	Stream surveys	GRTS/TBD	Y	Y	NA	-	-
	Redds and/or fish per mile	NA	-	-	-	-	NA	-	-	-	-	TBD	-	-
Diversity	Age Structure	H&S 13	Stream surveys / Trap returns	Age Ratios	Y	Y	M&E 11&15	Stream surveys / Trap returns	Age Ratios	Y	Y	TBD	Y	Y
	Sex Ratios	H&S 13	Stream surveys / Trap returns	Sex Ratios	Y	Y	M&E 11&15	Stream surveys / Trap returns	Sex Ratios	Y	Y	TBD	Y	Y
	Jack Ratio	H&S 13	Stream surveys / Trap returns	Age Ratios	Y	Y	M&E 11&15	Stream surveys / Trap returns	Age Ratios	Y	Y	TBD	Y	Y
	Stock composition	H&S 13	Stream surveys / Trap returns	CWT analysis	Y	-	M&E 11&15	Stream surveys / Trap returns	CWT analysis	Y	-	TBD	Y	-
	Genetic Diversity	NA	-	-	-	-	NA	-	-	-	-	NA	-	-
	Genetic Effective Population Size	NA	-	-	-	-	NA	-	-	-	-	NA	-	-
	Run and/or Spawn Timing	H&S 14	Stream surveys	Cumulative spawner proportion	Y	-	M&E 11&15	Stream surveys / Trap returns	Cumulative Arrival/ spawner proportion	Y	-	TBD	Y	-

NA - The parameter/metric is not applicable.
NA* - There are no PacifiCorp related objectives pertaining to this metric, but WDFW may either collect data or conduct the analysis for this metric.
[1] Analytical methods to estimate population level metrics have not been fully developed
TBD - To Be Determined.

Table 2.22.2: Lewis River coho salmon cross-walk table that summarizes the monitoring activities in the lower Lewis River (downstream of Merwin Trap), and upper Lewis River (upstream of Swift Reservoir) as they pertain to individual viable salmonid population (VSP) parameter metrics and the corresponding objectives, data collection, and analytical methods, which are detailed in the Lewis River Hatchery & Supplementation (H&S) Plan and the Lewis River Monitoring & Evaluation (M&E) Plan. Metrics for which estimates and precision levels will be calculated according to M&E and H&S objectives are indicated with a "Y" (Yes).

		Lower River					Upper River					Total Population		
VSP Parameter	**Metric**	**ve**	**Data Collectio**	**Analysis**	**Estimate**	**Precision**	**e**	**Data Collection**	**Analysis**	**Estimate**	**Precision**	**Analysis [1]**	**Estimate**	**Precision**
Abundance	Total Escapement (adults and jacks)	NA	-	-	-	-	M&E 11	Trap returns	Census	Y	Y	NA	-	-
	Spawner Abundance (Adults)	H&S 13	Stream surveys	Jolly-Seber/GRTS	Y	Y	M&E 15	Stream surveys	GRTS/TBD	Y	Y	TBD	Y	Y
	pHOS	H&S 2	Stream surveys	Spawning Ground Ratios	Y	Y	M&E 15	Stream surveys	Spawning Ground Ratios	Y	Y	TBD	Y	Y
	Juvenile Abundance (migrants)	H&S 13	Screw Trap	Petersen M-R	Y	Y	M&E 6&7	Screw Trap / Fish Surface Collector	Petersen M-R	Y	Y	TBD	Y	Y
Productivity	Spawner to Spawner (recruits per spawner)	M&E 12	Stream surveys	Spawner-recruit	Y	Y	M&E 12	Stream surveys / Trap returns	Spawner-recruit	Y	Y	TBD	Y	Y
	Freshwater survival	NA*	Smolt trap / Stream surveys	Spawner-to-smolt	-	-	NA*	Stream surveys / Screw Trap / Fish Surface Collector	Spawner-to-smolt	-	-	NA*	-	-
	Ocean survival	M&E 12	Stream surveys / Trap returns / Screw Trap	Smolt-to-adult (SAR)/ Ocean Recruit	Y	Y	M&E 12	Stream surveys / Trap returns / Screw Trap / Fish Surface Collector	Smolt-to-adult (SAR)/ Ocean Recruit	Y	Y	TBD	Y	Y
Spatial Structure	Redd Distribution	H&S 14	Stream surveys	Redd count/mapping	Y	-	M&E 15	Stream surveys	Redd count/mapping	Y	-	TBD	Y	-
	Reach Occupancy	H&S 14	Stream surveys	GRTS	Y	Y	M&E 15	Stream surveys	GRTS/TBD	Y	Y	TBD	Y	-
	Redds and/or fish per mile	H&S 14	Stream surveys	Survey data expansion	Y	Y	M&E 15	Stream surveys	Survey data expansion	Y	Y	TBD	-	-
Diversity	Age Structure	H&S 13	Stream surveys / Trap returns	Age Ratios	Y	Y	M&E 11&15	Stream surveys / Trap returns	Age Ratios	Y	Y	TBD	Y	Y
	Sex Ratios	H&S 13	Stream surveys / Trap returns	Sex Ratios	Y	Y	M&E 11&15	Stream surveys / Trap returns	Sex Ratios	Y	Y	TBD	Y	Y
	Jack Ratio	H&S 13	Stream surveys / Trap returns	Age Ratios	Y	Y	M&E 11&15	Stream surveys / Trap returns	Age Ratios	Y	Y	TBD	Y	Y
	Stock composition	H&S 13	Stream surveys / Trap returns	CWT analysis	Y	-	M&E 11&15	Stream surveys / Trap returns	CWT analysis	Y	-	TBD	Y	-
	Genetic Diversity	NA	-	-	-	-	NA	-	-	-	-	NA	-	-
	Genetic Effective Population Size	NA	-	-	-	-	NA	-	-	-	-	NA	-	-
	Run and/or Spawn Timing	H&S 14	Stream surveys	Cumulative spawner proportion	Y	-	M&E 11&15	Stream surveys / Trap returns	Cumulative Arrival/ spawner proportion	Y	-	TBD	Y	-

NA - The parameter/metric is not applicable.
NA* - There are no PacifiCorp related objectives pertaining to this metric, but WDFW may either collect data or conduct the analysis for this metric.
[1] Analytical methods to estimate population level metrics have not been fully developed
TBD - To Be Determined.

Table 2.22.3: Lewis River winter steelhead cross-walk table that summarizes the monitoring activities in the lower Lewis River (downstream of Merwin Trap), and upper Lewis River (upstream of Swift Reservoir) as they pertain to individual viable salmonid population (VSP) parameter metrics and the corresponding objectives, data collection, and analytical methods, which are detailed in the Lewis River Hatchery & Supplementation (H&S) Plan and the Lewis River Monitoring & Evaluation (M&E) Plan. Metrics for which estimates and precision levels will be calculated according to M&E and H&S objectives are indicated with a "Y" (Yes).

		Lower River					Upper River					Total Population		
VSP Parameter	**Metric**	**ve**	**Data Collection**	**Analysis**	**Estimate**	**Precision**	**Objective**	**Data Collection**	**Analysis**	**Estimate**	**Precision**	**Analysis**	**Estimate**	**Precision**
Abundance	Total Escapement (adults and jacks)	NA	-	-	-	-	M&E 11	Trap returns	Census	Y	Y	NA	-	-
	Spawner Abundance (Adults)	H&S 13	Stream surveys	Redd Expansion	Y	-	M&E 15	Stream surveys/PIT Tag	TBD	Y	Y	TBD	Y	TBD
	pHOS	H&S 2	Stream surveys	TBD	Y	Y	M&E 15	Stream surveys/PIT Tag	TBD	Y	Y	TBD	Y	Y
	Juvenile Abundance (migrants)	H&S 13	Screw Trap	Petersen M-R	Y	Y	M&E 6&7	Screw Trap / Fish Surface Collector	Petersen M-R	Y	Y	TBD	Y	Y
Productivity	Spawner to Spawner (recruits per spawner)	M&E 12	Stream surveys	Spawner-recruit	Y	Y	M&E 12	Stream surveys / Trap returns	Spawner-recruit	Y	Y	TBD	Y	Y
	Freshwater survival	NA*	Smolt trap / Stream surveys	Spawner-to-smolt	-	-	NA*	Stream surveys / Screw Trap / Fish Surface Collector	Spawner-to-smolt	-	-	NA*	-	-
	Ocean survival	M&E 12	Stream surveys / Trap returns / Screw Trap	Smolt-to-adult (SAR)/ Ocean Recruit	Y	Y	M&E 12	Stream surveys / Trap returns / Screw Trap / Fish Surface Collector	Smolt-to-adult (SAR)/ Ocean Recruit	Y	Y	TBD	Y	Y
Spatial Structure	Redd Distribution	H&S 14	Stream surveys	Redd count/mapping	Y	-	M&E 15	Aerial Radio Tracking	Radio detection mapping	Y	-	TBD	Y	-
	Reach Occupancy	NA	-	-	-	-	M&E 15	Stream surveys	GRTS/TBD	Y	Y	NA	-	-
	Redds and/or fish per mile	H&S 14	Stream surveys	Survey data expansion	Y	Y	M&E 15	Stream surveys	Survey data expansion	Y	Y	TBD	-	-
Diversity	Age Structure	H&S 13	Trap	Age Ratios	Y	Y	M&E 11	Trap returns	Age Ratios	Y	Y	TBD	Y	Y
	Sex Ratios	H&S 13	Trap	Sex Ratios	Y	Y	M&E 11	Trap returns	Sex Ratios	Y	Y	TBD	Y	Y
	Jack Ratio	NA	-	-	-	-	NA	-	-	-	-	NA	-	-
	Stock composition	NA	-	-	-	-	NA	-	-	-	-	NA	-	-
	Genetic Diversity	H&S 11	Trap	Genetic Analysis	Y	Y	NA	-	-	-	-	NA	-	-
	Genetic Effective Population Size	H&S 11	Trap returns/Seining	Genetic Analysis	Y	Y	NA	-	-	-	-	NA	-	-
	Run and/or Spawn Timing	H&S 14	Stream surveys / Trap returns	Cumulative Arrival redd proportions	Y	-	M&E 11&15	Stream surveys/PIT Tag/Trap Returns	TBD	Y	-	TBD	Y	-

NA - The parameter/metric is not applicable.
NA* - There are no PacifiCorp related objectives pertaining to this metric, but WDFW may either collect data or conduct the analysis for this metric.
[1] Analytical methods to estimate population level metrics have not been fully developed
TBD - To Be Determined.

Table 2.22.4: Lewis River fall (Tule) Chinook salmon cross-walk table that summarizes the monitoring activities in the lower (downstream of Merwin Trap), upper Lewis River (upstream of Swift Reservoir), and East Fork Lewis River as they pertain to individual viable salmonid population (VSP) parameter metrics and the corresponding objectives, data collection, and analytical methods, which are detailed in the Lewis River Hatchery & Supplementation (H&S) Plan and the Lewis River Monitoring & Evaluation (M&E) Plan. Estimates and the associated level of precision that will be calculated for each metric are indicated with a "Y" (Yes). Estimates to be collected, analyzed and reported that are to be completed by WDFW are indicated as such.

		Lower River											Upper River		Total Population[1]		
VSP Parameter	Metric	Objective	Data Collection	Analysis	Estimate	Precision	Objective	Estimate	Precision	Objective	Data Collection	Analysis	Estimate	Precision	Analysis[2]	Estimate	Precision
Abundance	Total Escapement (adults and jacks)	**NA**	-	-	WDFW	WDFW	**NA**	-	-	NA	-	-	WDFW	WDFW	**NA**	-	-
	Spawner Abundance (Adults)	H&S 1, M&E 16	Stream surveys	Jolly-Seber	WDFW	WDFW	**NA**	-	-	NA*	Stream surveys	Jolly-Seber, AUC, Redd Expansion	WDFW	WDFW	TBD	Y	Y
	pHOS	H&S 1, M&E 16	Stream surveys	Spawning Ground Ratios	WDFW	WDFW	**NA**	-	-	NA*	Stream surveys	Spawning Ground Ratios	WDFW	WDFW	TBD	Y	Y
	Juvenile Abundance (migrants)	H&S 1, M&E 16	Smolt trap	Petersen M-R	WDFW	WDFW	**NA**	-	-	NA	-	-	WDFW	WDFW	**NA**	-	-
Productivity	Spawner to Spawner (recruits per spawner)	**NA**	Stream surveys	Spawner-recruit	WDFW	WDFW	**NA**	-	-	NA*	Stream surveys	Spawner-recruit	WDFW	WDFW	TBD	-	-
	Freshwater survival	**NA**	Smolt trap / Stream surveys	Spawner-to-smolt	WDFW	WDFW	**NA**	-	-	NA	-	-	WDFW	WDFW	**NA**	-	-
	Ocean survival	**NA**	Smolt trap / Stream surveys / Trap returns	Smolt-to-adult (SAR)	WDFW	WDFW	**NA**	-	-	NA	-	-	WDFW	WDFW	**NA**	-	-
Spatial Structure	Redd Distribution	H&S 1, M&E 16	Stream surveys	Peak Redd count/mapping	WDFW	WDFW	**NA**	-	-	NA*	Stream surveys	Redd count/mapping	WDFW	WDFW	TBD	Y	-
	Reach Occupancy	**NA**	-	-	WDFW	WDFW	**NA**	-	-	NA	-	-	WDFW	WDFW	**NA**	-	-
	Redds and/or fish per mile	**NA**	-	-	WDFW	WDFW	**NA**	-	-	NA	-	-	WDFW	WDFW	**NA**	-	-
Diversity	Age Structure	H&S 1, M&E 16	Stream surveys / Trap returns	Age Ratios	WDFW	WDFW	**NA**	-	-	NA*	Stream surveys	Age Ratios	WDFW	WDFW	TBD	Y	Y
	Sex Ratios	H&S 1, M&E 16	Stream surveys / Trap returns	Sex Ratios	WDFW	WDFW	**NA**	-	-	NA*	Stream surveys	Sex Ratios	WDFW	WDFW	TBD	Y	Y
	Jack Ratio	H&S 1, M&E 16	Stream surveys / Trap returns	Age Ratios	WDFW	WDFW	**NA**	-	-	NA	-	-	WDFW	WDFW	**NA**	-	-
	Stock composition	H&S 1, M&E 16	Stream surveys / Trap returns	CWT analysis	WDFW	WDFW	**NA**	-	-	NA*	Stream surveys	CWT analysis	WDFW	WDFW	TBD	Y	Y
	Genetic Diversity	**NA**	Stream surveys / Trap returns	Genetic Structure	WDFW	WDFW	**NA**	-	-	NA*	Stream surveys	Genetic Structure	WDFW	WDFW	TBD	-	-
	Genetic Effective Population Size	**NA**	-	-	WDFW	WDFW	**NA**	-	-	NA	-	-	WDFW	WDFW	**NA**	-	-
	Run and/or Spawn Timing	H&S 1, M&E 16	Stream surveys / Trap returns	Cumulative spawner proportion	WDFW	WDFW	**NA**	-	-	NA*	Stream surveys	Cumulative spawner proportion	WDFW	WDFW	TBD	Y	-

NA* - There are no PacifiCorp related objectives pertaining to this metric, but WDFW may either collect data or conduct the analysis for this metric.

Analysis or estimates related to East Fork Lewis River monitoring and total population metrics are not required as part of the Utilities annual reporting to FERC. Therefore, these columns will not be included in the annual report.

Analytical methods to estimate population level metrics have not been fully developed by WDFW

Table 2.22.5: Lewis River fall (Bright) Chinook salmon cross-walk table that summarizes the monitoring activities in the lower Lewis River (downstream of Merwin Trap), and upper Lewis River (upstream of Swift Reservoir), as they pertain to individual viable salmonid population (VSP) parameter metrics and the corresponding objectives, data collection, and analytical methods, which are detailed in the Lewis River Hatchery & Supplementation (H&S) Plan and the Lewis River Monitoring & Evaluation (M&E) Plan. Metrics for which estimates and precision levels will be calculated according to M&E and H&S objectives are indicated with a "Y" (Yes).

		Lower River					Upper River			Total Population		
VSP Parameter	**Metric**	**Objective**	**Data Collection**	**Analysis**	**Estimate**	**Precision**	**Objective**	**Estimate**	**Precision**	**Analysis**	**Estimate**	**Precision**
Abundance	Total Escapement (adults and jacks)	NA	-	-	-	-	NA	-	-	NA	-	-
	Spawner Abundance (Adults)	H&S 1, M&E 16	Stream surveys	Jolly-Seber	Y	Y	NA	-	-	Same	Y	Y
	pHOS	H&S 1, M&E 16	Stream surveys	Spawning Ground Ratios	Y	Y	NA	-	-	Same	Y	Y
	Juvenile Abundance (migrants)	H&S 1, M&E 16	Smolt trap	Petersen M-R	Y	Y	NA	-	-	Same	Y	Y
Productivity	Spawner to Spawner (recruits per spawner)	NA*	Stream surveys	Spawner-recruit	-	-	NA	-	-	Same	-	-
	Freshwater survival	NA*	Smolt trap / Stream surveys	Spawner-to-smolt	-	-	NA	-	-	Same	-	-
	Ocean survival	NA*	Smolt trap / Stream surveys / Trap returns	Smolt-to-adult (SAR)	-	-	NA	-	-	Same	-	-
Spatial Structure	Redd Distribution	H&S 1, M&E 16	Stream surveys	Peak Redd count/mapping	Y	-	NA	-	-	Same	Y	-
	Reach Occupancy	NA	-	-	-	-	NA	-	-	NA	-	-
	Redds and/or fish per mile	NA	-	-	-	-	NA	-	-	NA	-	-
Diversity	Age Structure	H&S 1, M&E 16	Stream surveys / Trap returns	Age Ratios	Y	Y	NA	-	-	Same	Y	Y
	Sex Ratios	H&S 1, M&E 16	Stream surveys / Trap returns	Sex Ratios	Y	Y	NA	-	-	Same	Y	Y
	Jack Ratio	H&S 1, M&E 16	Stream surveys / Trap returns	Age Ratios	Y	Y	NA	-	-	Same	Y	Y
	Stock composition	H&S 1, M&E 16	Stream surveys / Trap returns	CWT analysis	Y	-	NA	-	-	Same	Y	-
	Genetic Diversity	NA*	Stream surveys / Trap returns	Genetic Structure	-	-	NA	-	-	Same	-	-
	Genetic Effective Population Size	NA	-	-	-	-	NA	-	-	NA	-	-
	Run and/or Spawn Timing	H&S 1, M&E 16	Stream surveys / Trap returns	Cumulative spawner proportion	Y	-	NA	-	-	Same	Y	-

NA - The parameter/metric is not applicable.
NA* - There are no PacifiCorp related objectives pertaining to this metric, but WDFW may either collect data or conduct the analysis for this metric.
Same - The "Lower River"segment represents the entire Lewis River fall (bright) Chinook population, therefore the total population analysis is the same as that completed for the "Lower River" segment.

Table 2.22.6: Lewis River chum salmon cross-walk table that summarizes the monitoring activities in the lower Lewis River (downstream of Merwin Trap), upper Lewis River (upstream of Swift Reservoir), and East Fork Lewis River as they pertain to individual viable salmonid population (VSP) parameter metrics and the corresponding objectives, data collection, and analytical methods, which are detailed in the Lewis River Hatchery & Supplementation (H&S) Plan and the Lewis River Monitoring & Evaluation (M&E) Plan. Metrics for which estimates and precision levels will be calculated according to M&E and H&S objectives are indicated with a "Y" (Yes). Metrics for which estimates and precision levels will be calculated by WDFW are indicated with "Y (WDFW)".

		Lower River					Upper River			East Fork Lewis[2]					Total Population[2]		
VSP Parameter	Metric	Objective	Data Collection	Analysis	Estimate	Precision	Objective	Estimate	Precision	Objective	Data Collection	Analysis	Estimate	Precision	Analysis[1]	Estimate	Precision
Abundance	Total Escapement (adults and jacks)	NA	-	-	-	-	NA	-	-	NA	-	-	-	-	NA	-	-
	Spawner Abundance (Adults)	H&S 1, M&E 16	Stream surveys	Presence/Absence, Jolly-Seber, AUC	Y	Y	NA	-	-	NA*	Stream surveys	Presence/Absence, Jolly-Seber, AUC	Y (WDFW)	Y (WDFW)	TBD	Y	Y
	pHOS	H&S 1, M&E 16	Stream surveys	Spawning Ground Ratios (otolith)	Y	Y	NA	-	-	NA*	Stream surveys	Spawning Ground Ratios (otolith)	Y (WDFW)	Y (WDFW)	TBD	Y	Y
	Juvenile Abundance (migrants)	H&S 1, M&E 16	Smolt trap	Petersen M-R	Y	Y	NA	-	-	NA	-	-	-	-	NA	-	-
Productivity	Spawner to Spawner (recruits per spawner)	NA*	Stream surveys	Spawner-recruit	-	-	NA	-	-	NA*	Stream surveys	Spawner-recruit	Y (WDFW)	Y (WDFW)	TBD	-	-
	Freshwater survival	NA*	Smolt trap / Stream surveys	Spawner-to-smolt	-	-	NA	-	-	NA	-	-	-	-	NA	-	-
	Ocean survival	NA*	Smolt trap / Stream surveys / Trap returns	Smolt-to-adult (SAR)	-	-	NA	-	-	NA	-	-	-	-	NA	-	-
Spatial Structure	Redd Distribution	H&S 1, M&E 16	Stream surveys	Peak Redd count/mapping	Y	-	NA	-	-	NA	Stream surveys	Redd count/mapping	Y (WDFW)	-	TBD	Y	-
	Reach Occupancy	NA	-	-	-	-	NA	-	-	NA	-	-	-	-	NA	-	-
	Redds and/or fish per mile	NA	-	-	-	-	NA	-	-	NA	-	-	-	-	NA	-	-
Diversity	Age Structure	H&S 1, M&E 16	Stream surveys / Trap returns	Age Ratios	Y	Y	NA	-	-	NA*	Stream surveys	Age Ratios	Y (WDFW)	Y (WDFW)	TBD	Y	Y
	Sex Ratios	H&S 1, M&E 16	Stream surveys / Trap returns	Sex Ratios	Y	Y	NA	-	-	NA*	Stream surveys	Sex Ratios	Y (WDFW)	Y (WDFW)	TBD	Y	Y
	Jack Ratio	NA	-	-	-	-	NA	-	-	NA	-	-	-	-	NA	-	-
	Stock composition	H&S 1, M&E 16	Stream surveys / Trap returns	CWT/otolith/PBT analysis	Y	-	NA	-	-	NA*	Stream surveys	CWT/otolith/PBT analysis	Y (WDFW)	-	TBD	Y	Y
	Genetic Diversity	NA*	Stream surveys / Trap returns	Genetic Structure	-	-	NA	-	-	NA*	Stream surveys	Genetic Structure	Y (WDFW)	-	TBD	-	-
	Genetic Effective Population Size	NA	-	-	-	-	NA	-	-	NA	-	-	-	-	NA	-	-
	Run and/or Spawn Timing	H&S 1, M&E 16	Stream surveys / Trap returns	Cumulative spawner proportion	Y	-	NA	-	-	NA*	Stream surveys	Cumulative spawner proportion	Y (WDFW)	-	TBD	Y	-

NA - The parameter/metric is not applicable.

NA* - There are no PacifiCorp related objectives pertaining to this metric, but WDFW may either collect data or conduct the analysis for this metric.

[1] Analytical methods to estimate population level metrics have not been fully developed

[2] Analysis or estimates related to East Fork Lewis River monitoring and total population metrics are not required as part of the Utilities annual reporting to FERC. Therefore, these columns will not be included in the annual report.

TBD - To Be Determined.

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Appendix A

Incidental Take Statement Report Form

Appendix A- Incidental Take Statement Report Form

Post-Season Monitoring and Evaluation Form
Scientific Research Plan
Annual Report

Date: __________

Plan Name: ___________ **Evaluator's Name:** ___________________________________

Contact Name: ________________ **Contact Email:** ______________________ **Contact Phone #:** ________________
(Contact = person submitting report)

Study Number and Title (if applicable): ____
Provide separate tables for each study.

Part I: This is an example of how to fill out the table. **Replace all red text with the information in the plan. Replace all blue text with the actual results of your activities.**

ESU/Species and population group if specified in your permit	Life Stage	Origin	Take Activity	Number of Fish Authorized for Take	Actual Number of Listed Fish Taken	Authorized Unintentional Mortality	Actual Unintentional Mortality	Evaluation Location	Evaluation Period
Lower Columbia River (LCR) Chinook	Juvenile	Naturally Produced	Capture, mark, release	100	90	5/100	4/90	Columbia River, Oregon	January – February
LCR Chinook	Adult	Artificially Propagated	Capture, handle, release	10	9	1/10	0/9	Bonneville Dam	June
LCR Chinook	Adult	Naturally Produced	Intentional mortality	20	15	N/A	N/A	Bonneville Dam	June
Oregon Coast Coho	Juvenile	Naturally Produced	Observe / Harass	500	400	N/A	N/ A	Nehalem River	October

Instructions:

ESU/Species: Enter the ESU and Species you were permitted to take. Enter by population, if your permit specifies that.

Life Stage: Enter life stage(s) specified in your plan.

Origin: Enter the origins specified in your plan.

Take Activity: Indicate the type of take activity as it is shown in your plan: ACapture, handle release,@[1] ACapture, tag [or mark], release,@ AIntentional mortality,@ or other Take Activities listed in your plan. Intentional mortality (i.e., direct mortality, sacrifice) must be accounted for on a separate line (see above). You must account for all Take Activities in your plan. If you did not take any fish or did not conduct the activities, enter zeros in the Actual Take and Actual Mortality columns.

Number of Fish Authorized for Take: State the number of fish authorized for take under each Take Activity (must be the same as the plan).

Actual Number of Listed Fish Taken: State the actual number of fish taken.

Authorized Unintentional Mortality: State the number of fish authorized for unintentional mortality. Enter it as a number OUT OF the Number of Fish Authorized for Take.

Actual Unintentional Mortality: State the actual number of fish you unintentionally killed. Enter it as a number OUT OF the Actual Number of Listed Fish Taken.

Evaluation Location: State where you conducted the activities. Enter hydrologic unit codes (HUC) if available.

Evaluation Period: State when you conducted the activities.

NOTE: If you conducted activities or took listed fish for which you were not authorized, you must enter them on separate lines of the report and explain exactly what happened (see Part II below).

Part II: Briefly Provide the Following Information

1. Measures taken to minimize effects on listed fish and the effectiveness of these measures.

2. The condition of listed fish taken and used for the research.

3. General effects research activities have on fish, including any unforeseen effects.

4. How listed fish were injured or killed and how were they disposed of.

5. How all take estimates were derived.

6. Steps taken to coordinate the research with other researchers.

7. Any problems that were encountered during the activities.

8. Summary of any preliminary findings (provide an attachment if needed).

Submit the report electronically to the appropriate NMFS staff person (listed in the plan). If you do not have an electronic version of your electrofishing logbook, please submit a hard copy to the following address attention the NMFS staff person listed in the plan or send it to the following fax number (please include your permit number on cover page):

Appropriate NMFS staff person
National Marine Fisheries Service
HydroPower Division
FERC and Water Diversions Branch
1201 NE Lloyd Blvd., Suite 1100
Portland, OR 97232-1274
(503) 231-2318 (FAX)

Appendix B

Active tag Release-Recapture Design at Swift Dam

APPENDIX B – ACTIVE TAG RELEASE-RECAPTURE DESIGN AT SWIFT DAM

Prepared By:

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11804 – 8TH AVENUE NW
SEATTLE, WA 98177

11 JULY 2007

APPENDIX B

TABLE OF CONTENTS

1.0 INTRODUCTION

This report describes the design and analysis of the 2008 tag release-recapture study at Swift Dam No. 1. Mark-recapture models will be used to estimate survival through the Swift Reservoir and Project. This report describes the release and detection locations used in the proposed study along with the recommended data analyses. Specific objectives of the tagging study include the following:

1. Estimate the joint probability of smolt surviving through the reservoir and entering the surface collector.
2. Estimate entrance efficiency and retention efficiency of the surface collector.
3. Estimate smolt survival through the transport system.

These goals will be accomplished using one or more groups of tagged fish.

2.0 RELEASE-RECAPTURE DESIGN

Releases of the tagged fish at the top of the Swift Reservoir will be used to estimate passage survival through the project. Survival through the Swift No. 1 Project can currently be conceptualized by the equation

$$S_{PROJ} = S_{RES}\left[P_{COL} \cdot S_{COL} \cdot S_{TRAN} + P_{TIT} \cdot S_{TIT} + \left(1 - P_{COL} - P_{TIT}\right) S_{SP}\right] \quad (1)$$

where

S_{RES} = survival probability through reservoir,

S_{PROJ} = total Project passage survival,

P_{COL} = proportion of fish arriving at Swift Dam that enter the surface collector,

P_{TIT} = proportion of fish arriving at Swift Dam that enter the turbine intake tower,

S_{COL} = survival probability through the collector,

S_{TIT} = survival probability through the turbine intake tower,

S_{SP} = survival probability through the spillway,

S_{TRAN} = survival probability through the smolt transport system.

Currently it is assumed that $S_{TIT} = S_{SP} = 0$, in which case

$$S_{PROJ} = S_{RES} \cdot P_{COL} \cdot S_{COL} \cdot S_{TRAN}. \quad (2)$$

A single release-recapture model will be used to estimate joint probability

$$S_{RES} \cdot P_{COL} = S_1 \quad (3)$$

Independent sampling of fish known to have entered the collector in will be used to estimate the probability of surviving through the collector and the transport system, i.e.,

$S_{COL} \cdot S_{TRAN} = S_2$. The product $\hat{S}_1 \cdot \hat{S}_2$ will therefore provide an estimate of overall Project passage survival with associated variance

$$\text{Var}\left(\hat{S}_1 \cdot \hat{S}_2\right) = S_1^2 \cdot \text{Var}\left(\hat{S}_2\right) + S_2^2 \cdot \text{Var}\left(\hat{S}_1\right) + \text{Var}\left(\hat{S}_1\right) \cdot \widehat{\text{Var}}\left(\hat{S}_2\right)$$

and estimated variance

$$\widehat{\text{Var}}\left(\hat{S}_1 \cdot \hat{S}_2\right) = \hat{S}_1^2 \cdot \widehat{\text{Var}}\left(\hat{S}_2\right) + \hat{S}_2^2 \cdot \widehat{\text{Var}}\left(\hat{S}_1\right) - \widehat{\text{Var}}\left(\hat{S}_1\right) \cdot \widehat{\text{Var}}\left(\hat{S}_2\right).$$

2.1 Estimating Survival through the Reservoir to the Surface Collector

Fish known to be active migrants will be collected in the surface collector and subsequently used in estimating project passage survival. Fish gathered from the surface collector, tagged, and transported back to the top of the Swift Reservoir will be released to estimate reservoir survival and entry into the surface collector (S_1, Fig. B-1).

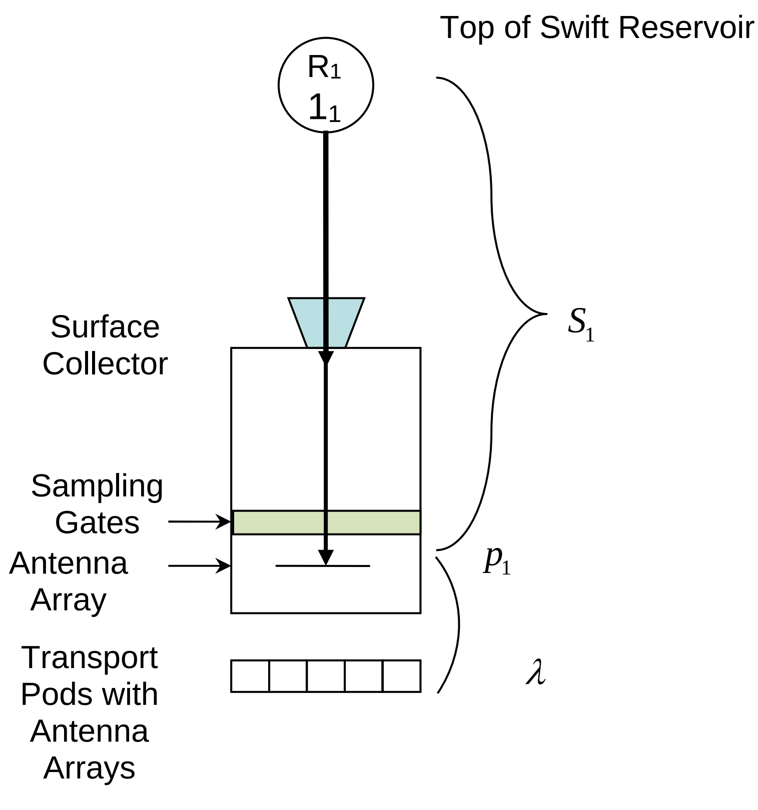

Figure B-1. Schematic of release-recapture design used in estimating survival through the reservoir and into the surface collector (S_1).

The single release-recapture model will be used to estimate the joint probability of surviving the reservoir and entering the surface collector to the point of the sampling gates. Two detection arrays, one in the collector just below the "point of no return" and another set in the collection pods will be used to generate the capture histories necessary to estimate the survival parameter S_1.

With 2 detection arrays, there are $2^2 = 4$ possible capture histories, and the following

likelihood model:

$$L = \binom{R_1}{\underset{\sim}{n}} \left(S_1 p_1 \lambda_1\right)^{n_{11}} \left(S_1 p_1 \left(1-\lambda_1\right)\right)^{n_{10}} \left(S_1\left(1-p_1\right)\lambda_1\right)^{n_{01}}$$

$$\cdot\left(\left(1-S_1\right)+S_1\left(1-p_1\right)\left(1-\lambda_1\right)\right)^{R-n_{11}-n_{10}-n_{01}}, \qquad (4)$$

where

R_1 = number of tagged fish released above Swift Reservoir;
n_{ij} = number of fish with capture history *i* (0,1 detected or not at first array) and *j* (0,1 detected or not at second array);
S_1 = joint probability $S_{RES} \cdot P_{COL}$;
p_1 = probability of being detected at first collection array;
λ = joint probability of surviving between arrays 1 and 2 and being detected at second array.

Survival is then estimated by the quantity

$$\hat{S}_1 = \frac{\left(n_{10}+n_{11}\right)\left(n_{01}+n_{11}\right)}{R_1 n_{11}} \qquad (5)$$

with associated variance

$$\text{Var}\left(\hat{S}_1\right) = S_1^2\left[\frac{(1-\lambda)\left(1-p_1\right)^2}{R_1 \lambda S_1 p_1} + \frac{(1-\lambda)^2 p_1\left(1-p_1\right)}{R_1 \lambda\left(1-\chi_1\right)} + \frac{\chi_1}{R_1\left(1-\chi_1\right)}\right] \qquad (6)$$

where

$$\chi_1 = \left(1-S_1\right)+S_1\left(1-p_1\right)(1-\lambda).$$

The other model parameters are estimated by

$$\hat{p}_1 = \frac{n_{11}}{n_{01}+n_{11}}, \qquad (7)$$

$$\hat{\lambda} = \frac{n_{11}}{n_{10} + n_{11}}. \qquad (8)$$

Assumptions associated with the single release-recapture model include the following:

1. All fish act independently.
2. Release size is known without error.
3. There is no post-release handling mortality or tag loss.
4. Downstream detection is conditionally independent of detection upstream.
5. Tagged fish are uniquely identifiable at all detection sites.
6. Fish that residualize are considered mortalities.

2.2 Estimating Collector and Transport Survival

Survival through the surface collector and subsequent transport process to re-release will be estimated using a conceptual release group of fish that were known to have entered and were retained in the collector. Antenna at the sampling gate (Figure B-1) will identify fish known to have entered the collector (i.e., both alive and dead). These collected fish will then enter the transport system and eventually be transported to the Release Ponds prior to re-release. Two antenna arrays in the release channel will monitor fish as they exit the holding facilities. All visual mortalities in the recovery pond will be collected to compare against known fish entering the transport system. A single release-recapture model analogous to Equation (1) will be used to estimate smolt survival from the vicinity of the sampling gate to the release channel (Figure B-2).

To assure all dead tagged fish are properly identified and adjusted for in the statistical model, a known release of 50 dead tagged fish will be monitored through the system from the sampling gate to the antenna array in the release channel. If all known tagged fish are identified and recovered before the release channel, no adjustments to the release-recapture model would be necessary. If, on the other hand, some of the known dead tagged fish are detected at the recovery channel antenna, the likelihood model will need to be adjusted for the observed rate of false positives. In which case, the likelihood can be rewritten as follows:

$$L = \binom{R_2}{\underset{\sim}{m}} \left[\left(S_2 + (1 - S_2)(1 - p_d) \right) p_2 \lambda_2 \right]^{m_{11}}$$

$$\cdot \left[\left(S_2 + (1 - S_2)(1 - p_d) \right) p_2 (1 - \lambda_2) \right]^{m_{10}}$$

$$\cdot \left[\left(S_2 + (1 - S_2)(1 - p_d) \right) (1 - p_2) \lambda_2 \right]^{m_{01}}$$

$$\cdot \left[\left(S_2 + (1 - S_2)(1 - p_d) \right) \left(\lambda_2 + p_2 (1 - \lambda_2) \right) \right]^{R_2 - m_{11} - m_{10} - m_{01}}$$

$$\cdot \binom{D}{d} (p_d)^d (1 - p_d)^{D-d}, \qquad (9)$$

where

D = number of dead tagged fish released into collector system,
d_2 = number of dead tagged fish retrieved before exiting Release Ponds,
p_d = probability a dead fish is recovered in the transport/handling facilities.

In a similar vein, a tag-life study will be performed to construct a tag-failure curve to adjust perceived survival rates (S_1 and S_2) for rates of tag failure during outmigration. This adjustment will be based on the methods in Townsend et al. (2006) to account for any negative bias due to tag failure during the course of the release-recapture study.

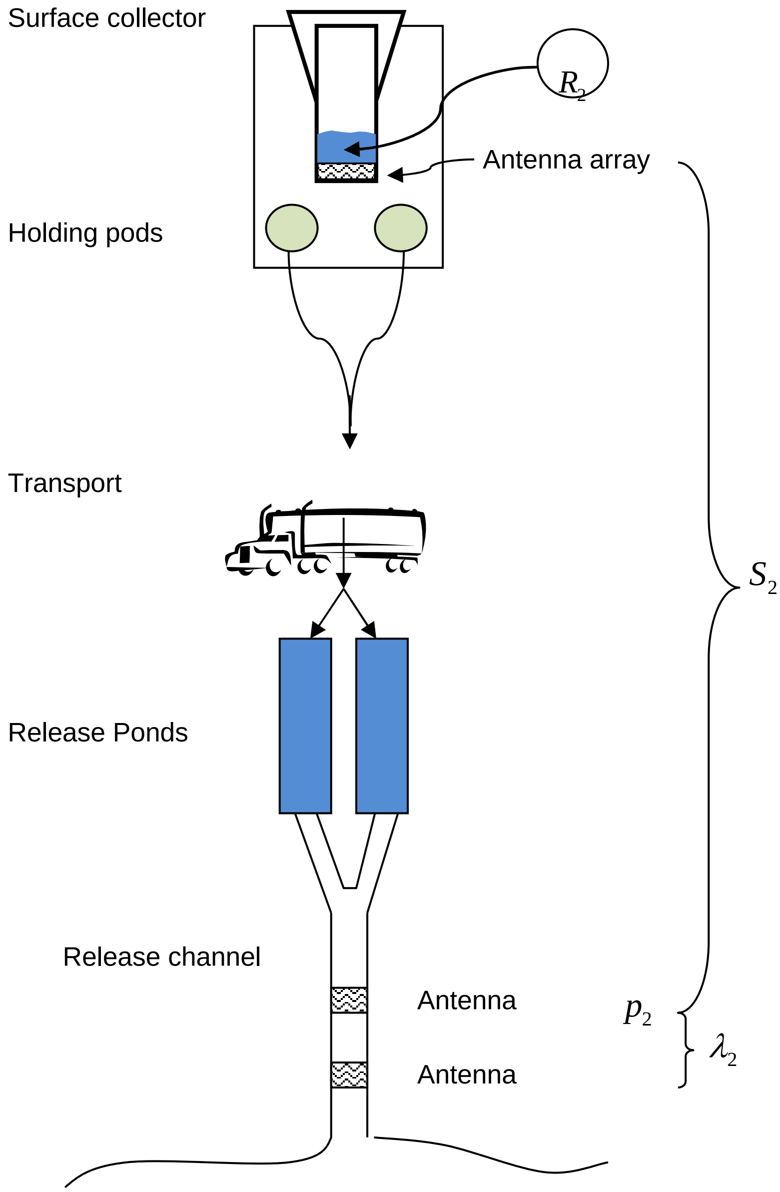

Figure B-2. Schematic of release-recapture design used in estimating survival through collector, transport system, and Release Ponds (S_2). Release group (R_2) composed to tagged fish known to have arrived at the sampling gates in the surface collector.

2.3 Test of Seasonal Performance

Overall dam survival $\left(S_1 \cdot S_2\right)$ will be compared to a desired project goal of 0.80 or greater using an asymptotic Z-test of the form

$$Z = \frac{\hat{S}_1 \cdot \hat{S}_2 - 0.80}{\sqrt{\widehat{\text{Var}}\left(\hat{S}_1 \cdot \hat{S}_2\right)}},$$

testing the null hypotheses

$$\text{H}_\text{o}\!: S_1 S_2 \geq 0.80$$

vs.

$$\text{H}_\text{a}\!: S_1 S_2 < 0.80$$

(at an α = 0.10)

Should the estimate of $S_1 S_2$ be significantly less than 0.80, H_o will be rejected, and it will be concluded survival goals have not been achieved. The estimate of $\hat{S}_1 \hat{S}_2$ will be based on pooling the release-recapture data over the season. Should weekly estimates of $\hat{S}_1 \hat{S}_2$ prove to be heterogeneous, then a weighted average, weighted by an index of smolt migration, will be used to construct an annual estimate.

2.4 Estimating Collector Efficiency

Two sets of antennas will be used to estimate collector efficiency $\left(P_{CE}\right)$ at the surface collector (Figure B-3).

The first antenna array will be in front of the collector, identifying tagged fish within the vicinity of the entrance. The second antenna array will be in the holding pods, assumed to have a 100 % detection efficiency. Then the overall collector will be estimated by the fraction

$$\hat{P}_{CE} = \frac{a_2}{a_1} \qquad (10)$$

with associated variance estimator

$$\widehat{\text{Var}}\left(\hat{P}_{CE}\right) = \frac{\hat{P}_{CE}\left(1 - \hat{P}_{CE}\right)}{a_1}, \qquad (11)$$

where

a_1 = number of unique tagged fish identified in the vicinity of the surface collector,

a_2 = number of unique tagged fish identified in the fish collection pods.

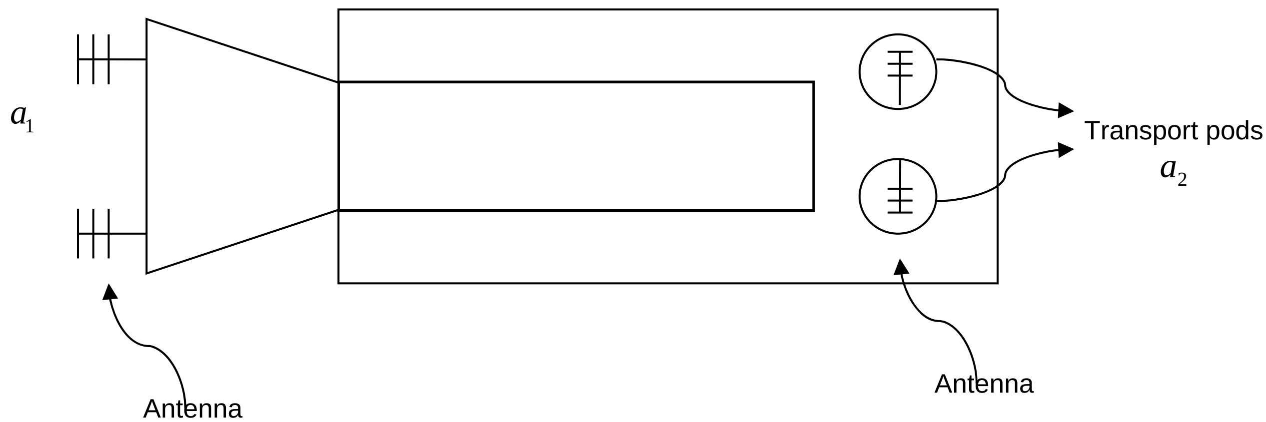

Figure B-2. Schematic of detection data used in estimating collector efficiency.

2.5 Release Schedule

Values of overall Project survival and transport mortality might be expected to vary over the outmigration season due to changes in smoltification and ambient conditions. For these reasons, tag releases need to be distributed across the season in order to more accurately reflect intra-annual trends. Releases will be conducted weekly in order to represent average migration conditions. Efforts will be coordinated to assure estimates of S_1 and S_2 will be paired over the same time frames in order to estimate overall project survival (i.e., $S_1 \cdot S_2$).

2.6 Sample Size Calculations

Using the single release-recapture model, sample size calculations were performed for precision defined as

$$P\left(\left|\hat{S}_1 - S_1\right| < \varepsilon\right) = 1 - \alpha \;;$$

In other words, the absolute error in estimation $\left(\text{i.e.}\left|\hat{S}_1 - S_1\right|\right)$ is less than $\varepsilon, (1-\alpha)100\%$ of the time. For example,

$$P\left(\left|\hat{S}_1 - S_1\right| < 0.05\right) = 0.90$$

specifies that the absolute error in estimating *S* should be less than .05, 95% of the time. Here ε is equivalent to the half-width of a 90% confidence interval.

Required release sizes were calculated under alternative combinations of:

a. S_1 = 0.50, 0.60, 0.70, 0.80, 0.90

b. p_1 = 0.85, 0.90, 0.95, 0.98

c. λ = 1

d. ε = 0.025

e. $1-\alpha$ = 0.95

Required release sizes are summarized in Table B-1. For example, to be within 0.025 of the true survival value (S_1), 95% of the time when S_1 = 0.80, p_1 = 0.95, a total of 996 tagged fish need to be released.

Table B-1. Release sizes to estimate $S_1 = S_{RES}*P_{COL}$ at the Swift Reservoir for alternative values of survival and collection S_1, and detection probability (p_1) at the slide gates for a precision of ε = 0.025, 1 – α = 0.95 when λ = 1 at the holding pods.

S_1	P_1	$\varepsilon = 0.025$	S_1	P_1	$\varepsilon = 0.025$
0.50	**0.85**	**1618**	**0.80**	**0.85**	**1114**
	0.90	**1571**		**0.90**	**1038**
	0.95	**1545**		**0.95**	**996**
	0.98	**1538**		**0.98**	**986**
0.60	**0.85**	**1573**	**0.90**	**0.85**	**700**
	0.90	**1516**		**0.90**	**615**
	0.95	**1485**		**0.95**	**568**
	0.98	**1477**		**0.98**	**556**
0.70	**0.85**	**1405**	**0.95**	**0.85**	**447**
	0.90	**1339**		**0.90**	**357**
	0.95	**1302**		**0.95**	**308**
	0.98	**1293**		**0.98**	**295**

Required release sizes are summarized in Table B-2 for precision values of 0.05 and 0.10, when $1-\alpha$ = 0.90. For example, to be within ± 0.05 of the true survival value (S_1), 90% of the time when S_1 = 0.95, p_1 = 0.95, a total of 55 tagged fish need to be released.

Table B-2. Release sizes to estimate $S_1 = S_{RES} \cdot P_{COL}$ at the Swift Reservoir for alternative values of survival and collection S_1, and detection probability (p_1) at the slide gates for a precision of ε = 0.05 or 0.10, $1-\alpha$ = 0.90 when λ = 1 at the holding pods.

		ε				ε	
S_1	p_1	0.05	0.10	S_1	p_1	0.05	0.10
0.50	0.85	285	72	0.80	0.85	197	51
	0.90	277	70		0.90	183	46
	0.95	272	69		0.95	176	44
	0.98	271	69		0.98	174	44
0.60	0.85	277	70	0.90	0.85	124	31
	0.90	267	67		0.90	109	28
	0.95	262	66		0.95	100	25
	0.98	261	65		0.98	98	25
0.70	0.85	248	62	0.95	0.85	79	20
	0.90	236	59		0.90	63	16
	0.95	230	58		0.95	55	14
	0.98	228	57		0.98	52	13

3.0 REFERENCES

Townsend, R.L., Skalski, J.R., Dillingham, P., and Steig, T.W. 2006. Correcting bias in survival estimation resulting from tag failure in acoustic and radiotelemetry studies. Journal of Agricultural Biology and Environmental Statistics **11**(2): 183-196.

Appendix C

Merwin Upstream Adult Trap Efficiency Study Plan

Appendix C - Merwin Upstream Adult Trap Efficiency Study Plan

INTRODUCTION

Section 4.3 of the Final Settlement Agreement (SA) for the Lewis River Hydroelectric Projects called for the construction and future operation of an adult trap and transport facility at the Merwin Project. Table 4.1.4 of the SA defines Adult Trap Efficiency (ATE) as "The percentage of adult Chinook, coho, steelhead, bull trout, and sea-run cutthroat that are actively migrating to a location above the trap and that are collected by the trap." 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
- Phase III would add a second trap entrance.
- Phase IV would add a second penstock tap with 200 cfs pressure reducing valve increasing fishway flow capacity to 800 cfs.
- If ATE standards are not achieved with Phases I through IV, the additional fishway adjustments will be required.

Performance standards for the new trap were determined by the ACC. These standards are included in Attachment A.

Construction of the Phase I trap is expected to be completed 4.5 years after issuance of license. The license date for the projects is June 26, 2008, which would indicate a trap on-line date of December 26, 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 ATE goals, the study would also inform PacifiCorp and the Aquatics Coordination Committee(ACC) regarding fish behavior in the tailrace as it pertains to adjustments that would occur during Phases 2 through 4 of 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 improvements, and 4) the initial data for SA trap monitoring needs. Specific study objectives follow.

1) Determine trap effectiveness based on Adult Trap Efficiency (ATE) and compare that to the ATE performance standard for efficient passage.
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 and compare that to ATE performance standard for timely passage.
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 injury and mortality rate of fish collected in the trap and compare to ATE performance standard for safe passage.

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 at least three separate days across each 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 five distinct locations downstream in the Lewis River. Approximately 26 fixed antennae will be used in this study to create 16 distinct detection zones. The actual number of antennae set up in the field may vary slightly as more, or fewer, antennae are needed to achieve adequate coverage of the 16 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 coaxial 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). In addition, approximately eight underwater antennas, 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 evaluate successful trap capture an underwater dipole antenna (#18) will be placed within fish trap. The antenna should be placed upstream of the v-trap as once fish pass this location they cannot move freely back into the ladder or out of the trap. Based on design drawings, the best location for the antenna appears to be attached to the downstream wall behind the moving sorting screen. The data collected in his detection zone (Zone 11) will be used for calculating the ATE of the collection facility for both timely and efficient passage.

Five fixed detection zones will be established downstream of the Merwin tailrace (Figures 2, 3). Zone 12 will be generated by two parallel fixed aerial antennas (# 19 and 20) 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 (#21) will be placed downstream of the release location at the Merwin Boat ramp near the Aerial gage (Zone 13) to detect fish moving downstream after release. To monitor fish that are aggregating at the hatchery, two fixed antennas will be located there (Zone 14). One aerial antenna (#22) will be located near the entrance of the Lewis River hatchery ladder, while an underwater antenna (#23) will be placed in the hatchery ladder to detect any fish moving into the hatchery holding ponds. An aerial antenna (#24) will be placed across lower Cedar Creek (Zone 15) to detect and fish moving upstream in Cedar Creek to spawn. Finally as part of a separate study an aerial antenna (Zone 16) 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 (#25) 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: upstream of ladder	18	11
Lewis River Downstream: holding pool	19& 20	12
Lewis River Downstream: below Merwin boat ramp	21	13
Lewis River Downstream: Lewis River Hatchery	22 & 23	14
Cedar Creek	24	15
Lewis River Downstream at the smolt Release Pond.	25	16

Analyses

Within the release groups, the behavior of individual tagged fish moving through the 10 detection zones in the tailrace will be analyzed. The analysis will be completed using individual tagged fish as the unit of replication, instead of tag groups, 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 Adult Trap Efficiency (ATE) and compare that to the ATE performance standard for efficient passage. The Lewis River Settlement Agreement (SA) defined ATE as the percentage of adults that are actively migrating above Merwin Dam and are collected by the Merwin fish trap. The ATE for test fish, ATE_{test} will be calculated by dividing the number of actively migrating tagged fish that enter Merwin tailrace, *M*, by the number of tagged fish that are passed upstream successfully, *C*. *C* will be determined based on unique detections from Zone 12 plus any additional tags collected manually from the collection facility or during fish sorting. Any tagged fish that are found dead or mortally wounded in the trap and those captured after a predetermined time period (as described in Objective 4) will be excluded in determining the value of *C*. Detections from Zone 10 will be combined with any unique first detections from other tailrace zones (1-9) to derive *M*. The appropriate statistical test to apply to determine if ATE_{test} is statistically different than expected ATE will be selected based on the value of *C*. If *C* is large, greater than 100, a One-sample t test can be applied. Whereas, if *C* is considerably smaller than 100, a non-parametric test such as a binomial or Chi-sqare test will be applied to the data to address this objective.

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. Data on fish movements within the tailrace provide information regarding what tailrace zones, if any, are more or less attractive to fish and will be useful for informing post-Phase 1 decisions about holding and alterative trap entrances.

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.

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. Data on time spent in tailrace zones will be useful for informing post-Phase 1 decisions about holding and alterative trap entrances.

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 attraction of the new trap to fish and will be used to assess the potential for fish delay at Merwin Dam (Section 4.1.4c of the SA). We will attempt to calculate total time in the tailrace as the temporal difference between the initial time into Zone 10 and the time of first detection in the ladder or trap. However, in the 2005 study documented a good amount of fish milling in the pool below the tailrace. If this milling behavior is found to extend to the area below the bridge it would result in fish moving in and out of Zone 10 repeatedly, thus complicating the time of initial entry. In that event, an alternative calculation for total time will be used based on the total time fish spend in each of the ten tailrace zones. We will determine the median and ranges for total time in the tailrace to compare with the ATE standard of a median of 24 h with fewer than 5% of fish passing after 168 h. A non-parametric analysis for the median

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 tracks for fish that move downstream based on detections in fixed telemetry location within the Lewis River. In addition to potential strays discussed, tagged fish may also include those that are destined for Lewis River Hatchery, for spawning in Cedar Creek, and coho or Chinook salmon that are destined to spawn downstream of the dam (i.e. are progeny of spawning in this area). Thus, a proportion of tagged fish should be expected to move downstream from the tailrace after release. We do not have a good way to estimate what the total proportion of fish with other Lewis River destinations might be. This task will provide data regarding the disposition of those fish within distinct sections of the lower Lewis River or beyond. Furthermore, the data will be used to generate information on the proportion of fish that leave the tailrace with no documented destination.

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 sorting. In addition a random sample of approximately 100 run of the river fish from each species should be anesthetized and examined for descaling and injury to correlate levels seen in test fish with the overall migratory population.

Schedule

This study will be conducted over a two year timeframe. 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 of Year 1. 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 used 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 (e.g. 100 year flood event) prevent us from completing a successful evaluation of the trap for all three species in two years. Any contingence would move forward with ACC consultation and approval from NMFS. 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 (1-18) 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.

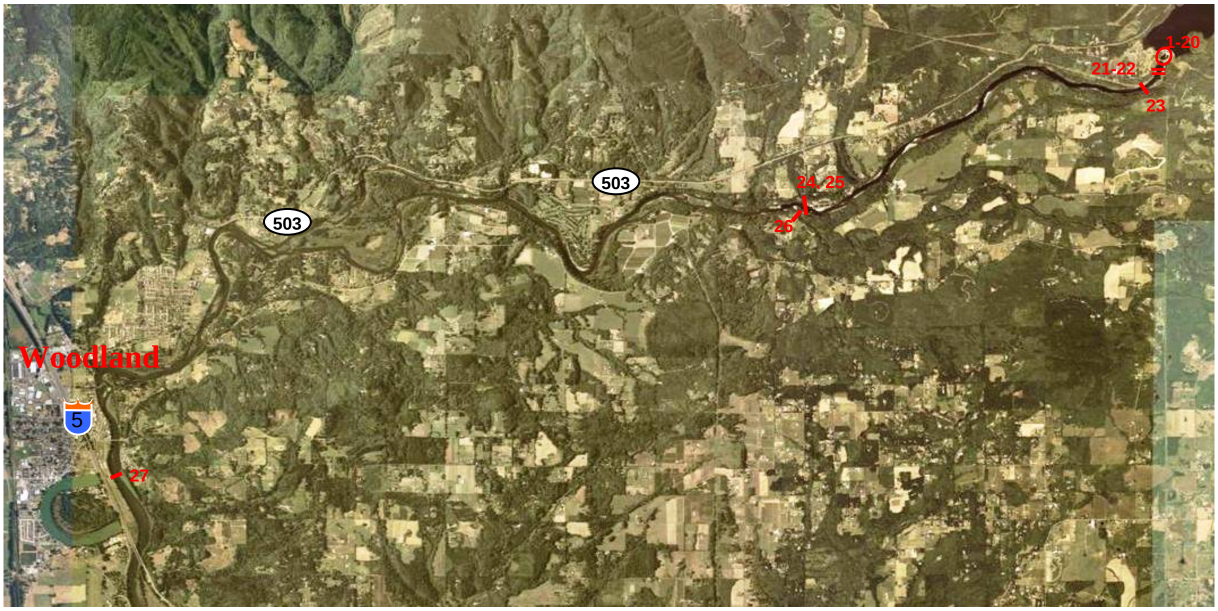

Figure 5. Location of the proposed fixed telemetry array providing coverage from Merwin Tailrace to the juvenile release facility in Woodland WA.

Note that some of the antenna placements will be modified from these original photographs from year to year with ACC approval.

ATTACHMENT A

ATE PERFORMANCE STANDARD

Section 4.1.4c of the SA requires the ACC to "… develop an ATE performance standard for the term of each New License to ensure the safe, timely and efficient passage of adult salmonids."

The ACC agrees that for ATE performance standard evaluation purposes at Merwin Dam, the following conditions apply:

a) ATE is calculated by taking the number of actively migrating test fish that are passed upstream in a safe, timely and efficient manner, divided by the number of actively migrating test fish entering the Merwin tailrace.

b) Actively migrating is defined as fish that enter the Merwin tailrace and are migrating to a location above the trap.

c) The Merwin tailrace is defined as the river between Merwin Dam and the Project access bridge.

d) Test fish are fish that are tagged for the ATE tracking study, after capture from the Merwin Trap or locations downstream, and are considered to be active migrants subject to the conditions below.

e) Dropbacks are test fish that do not enter the Merwin tailrace. Dropbacks are considered to be either fish that have strayed into the Lewis River system, or fish that spawn in the Lewis River below the Merwin tailrace. Dropbacks are not considered to be active migrants for purposes of calculating ATE.

f) Fallbacks are test fish that require multiple attempts to pass Merwin Dam, and may re-enter the Merwin tailrace multiple times. Fallbacks are considered to be active migrants for purposes of calculating ATE.

g) Tag loss and tagging mortality will be identified by methods to be described in the tracking study plan. Test fish that lose their tags or are tagging mortalities are not considered to be active migrants for purposes of calculating ATE.

h) Test fish that enter the Lewis River Hatchery are not considered to be active migrants for purposes of calculating ATE.

i) Test fish that are captured by the sport or commercial fisheries are not considered to be active migrants for purposes of calculating ATE.

j) Delay time is defined to be the total time it takes for a test fish to locate and enter the Merwin Trap, calculated as the time period between initial tailrace entry and final trap capture.

To achieve the ATE performance standard, the ACC agrees that:

a) Safe passage means that active migrants must be re-captured and passed upstream of Merwin Dam with facility-induced injury less than 2% and mortality rates less than 0.5% as defined in Section 4.1.4 of the SA. Adult injury rate (AIR) will be calculated as follows:

AIR = IAC/TAC

Where:

IAC = Number of injured actively migrating adults collected in the Merwin Trap

TAC = Total number of actively migrating adults collected in Merwin Trap

Adult mortality rate (AMR) will be calculated as follows:

AMR= AM/TAC

Where:

AM = Number of actively migrating adults killed through Merwin adult trapping operations, as measured at point of release

TAC = Total number of actively migrating adults collected in the Merwin Adult Trap

b) Timely passage means that the median delay time for active migrants must be measured at less than or equal to 24 hours, with no more than 5% of the active migrants taking longer than one week to pass, and migrants must be transported upstream of Merwin Dam within 24 hours of trap capture. If study results show the median delay is less than 30 hours and all other upstream fish passage SA performance standards at Merwin Dam are met, the 30-hour median delay may be acceptable based on consensus of the ACC. Median delay times of less than 24 hours have been demonstrated to be achievable for multiple adult salmonid species at other hydro projects (see April 10, 2008 ACC meeting minutes: simple median and percent exceedence calculations).

c) Efficient passage means that at least 98% of the active adult migrants must be passed upstream of Merwin Dam. Passage success has been measured at greater than 98% for multiple adult salmonid species at other hydro projects (see July 10, 2008 ACC meeting minutes). Adult passage efficiency (APE) will be calculated as follows:

APE= TAC/AMA

Where:
TAC = Total number of actively migrating adults collected in the Merwin Adult Trap
AMA = Number of actively migrating adults

The ATE criteria would be when the four adult passage sub-criteria are achieved:

1. Adult Injury Rate (AIR) is less than 2%.
2. Adult Mortality Rate (AMR) is less than 0.5%.
3. Adult Timely Passage (ATP) is less than or equal to 24 hours (median value) and no more than 5% of the active migrants take longer than 1 week to pass.
4. Adult Passage Efficiency (APE) is equal or greater than 98%.

If median delay time is less than 30 hours, and all other criteria are achieved, then the ATE criteria may be met with a consensus vote of the ACC.

Until ATE performance standards are achieved, the Merwin Trap will be adjusted or modified per Settlement Agreement Section 4.1.6 and in consultation with the ACC. After ATE performance standards are achieved, no further adjustments or modifications to the Merwin upstream passage facility will be required.

Appendix D

Ocean Recruits Analysis and Formulas

Appendix D - Ocean Recruits Analysis and Formulas

There are three possible options for calculating Ocean Recruits for the H&S Plan:

1. Catch Plus Escapement (CPE)
2. Adult Equivalent Run Size (AER)
3. Age 2 recruitment

The calculations used for completing each of the three analyses are performed as follows:

1. Catch plus escapement, $(C+E)_Y$, for brood year Y is computed as:

$(C+E)_Y = Xesc_Y + Xterm_Y + Xcol_Y + Xocean_Y$, where

$Xesc_Y, Xterm_Y, Xcol_Y, and\_Xocean_Y$ are brood year escapement; terminal, mainstem, and ocean harvest based on expanded CWT recoveries.

2. Adult equivalent return, $(AER)_Y$ for brood year Y is computed as:

$$(AER)_Y = \sum_{age=1}^{NN} R_{Y,age}\text{, where}$$

$$R_N = C_N + Xocean_N(1+oi_N)(1-n_N)^{(na_N-1)}\text{, and}$$

$$C_N = R_{N+1} + B_N/(1-mm_N) + Xcol_N(1+ci_N)\text{, and}$$

$$B_N = A_N + Xterm_N(1+ti_N)\text{, and}$$

$$A_N = Xesc_N/(1-ps_N)\text{, and } R_{NN+1} = 0$$

Symbols are defined in Figure D-1 below.

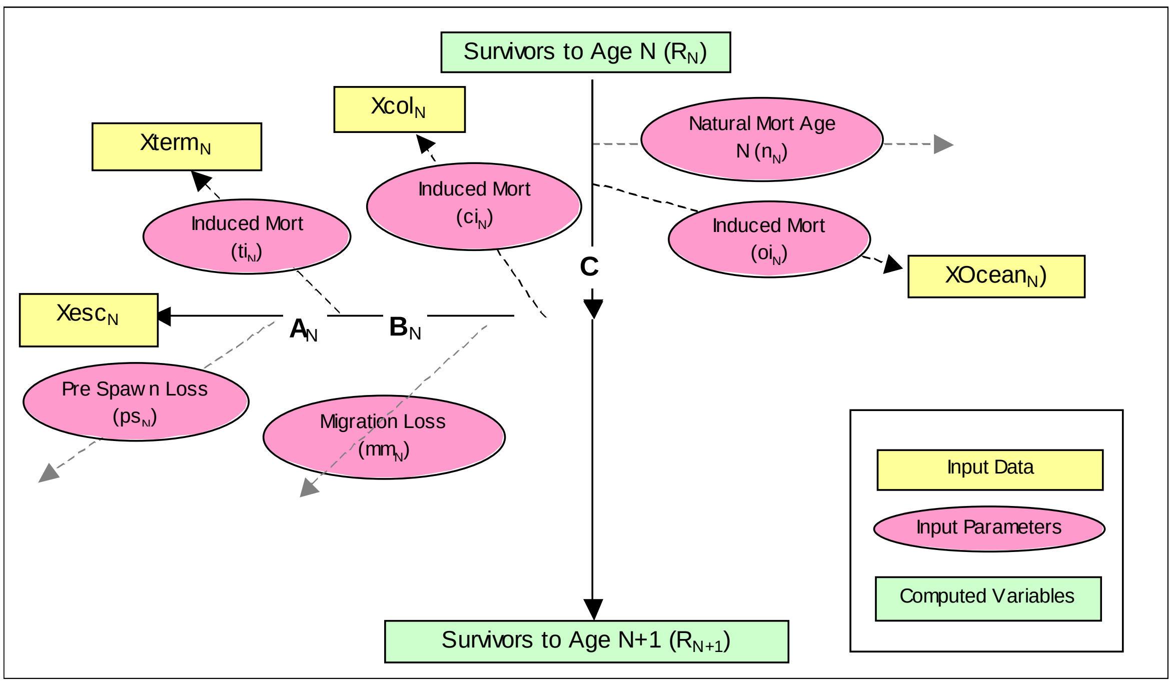

Figure D-1. Age 2 recruitment, A2R, is computed as R_2 in AER equation above.

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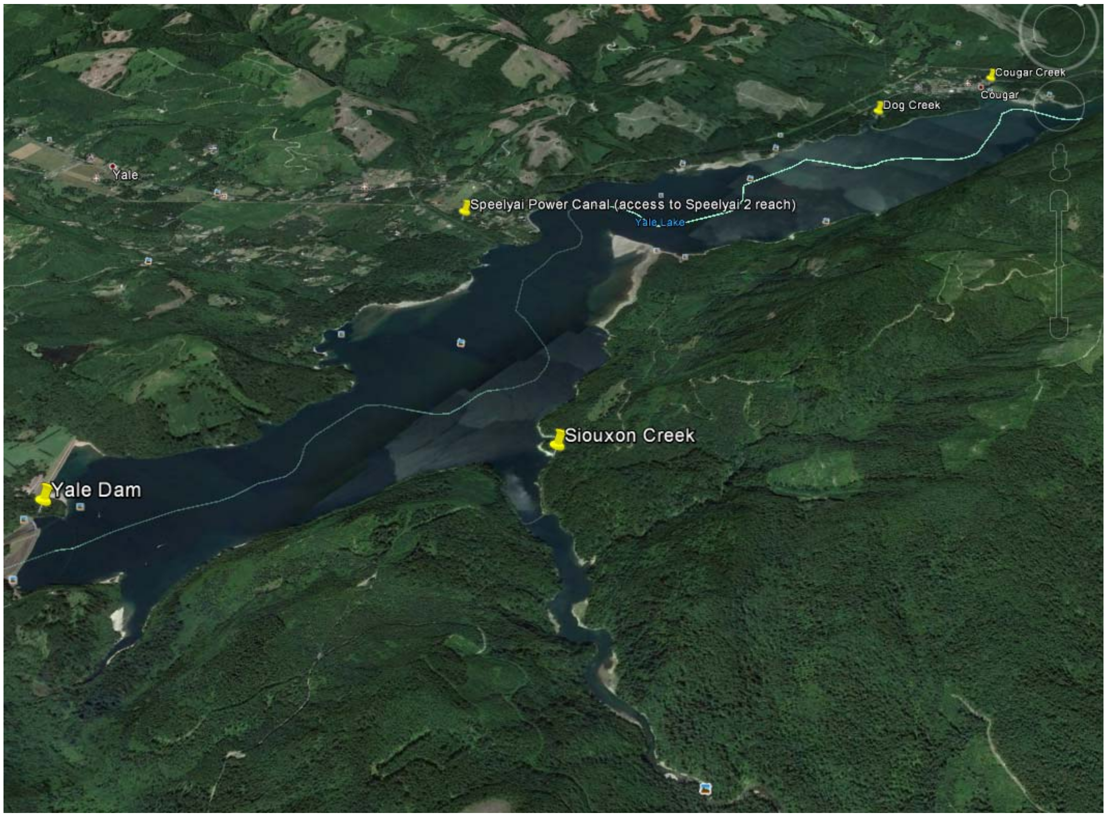
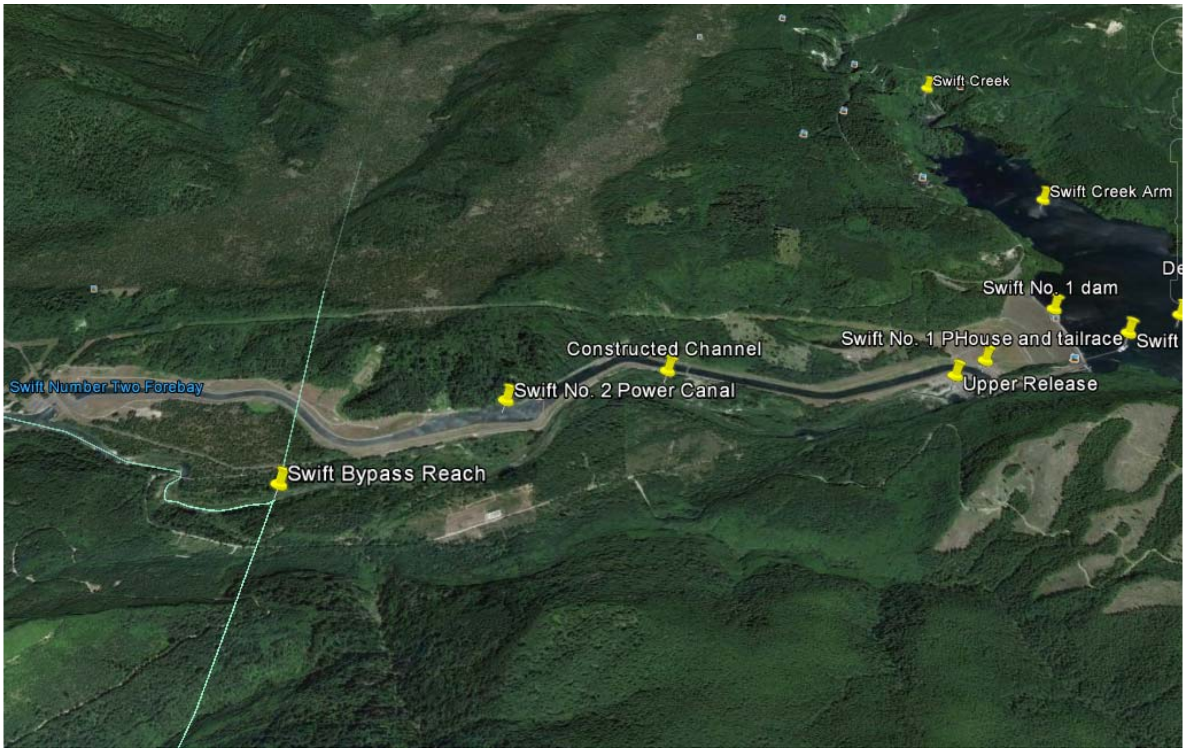
Appendix E Area Reference Maps

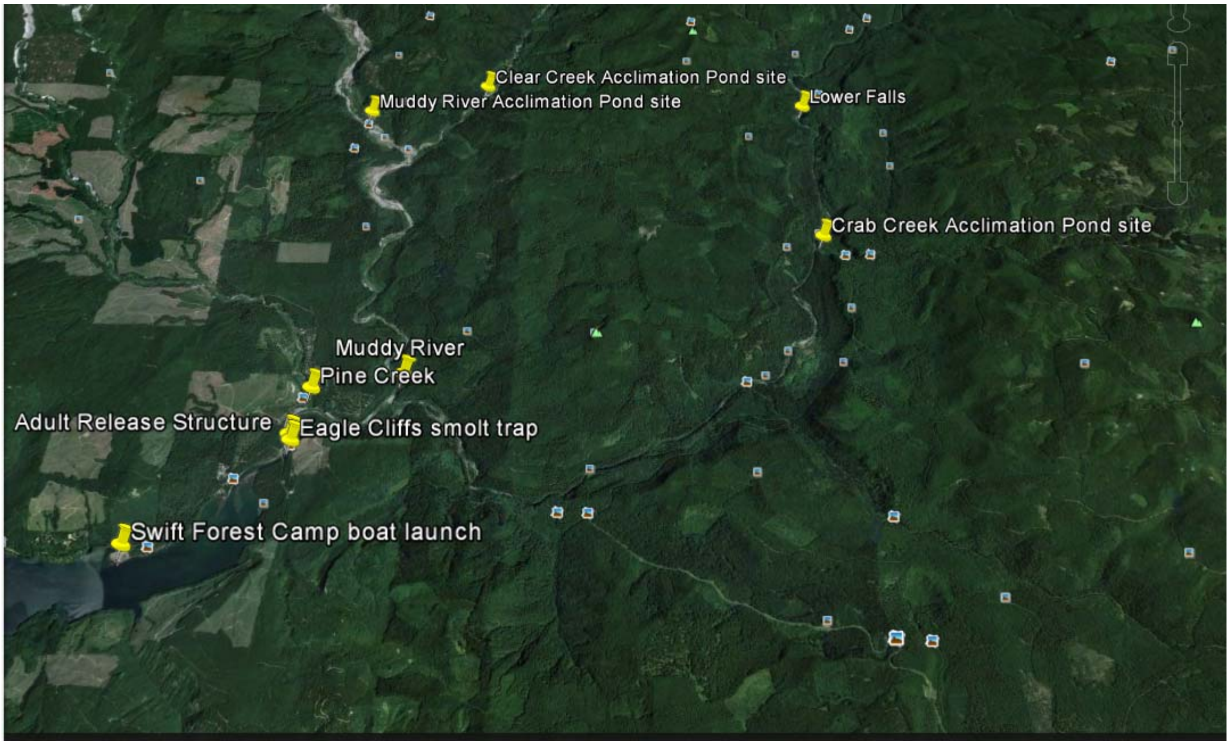

alama
Merwin Dam
Ariel
Woodland
Release Ponds


Cougar Cre
Cougar
Dog Creek
Speelyai Power
Speelyai Bay
Yale
Merwin Dam
Chelatchie


Cougar Creek
Cougar
Dog Creek
Yale
Speelyai Power Canal (access to Speelyai 2 reach)
Yale Lake
Siouxon Creek
Yale Dam


Swift Creek
Swift Creek Arm
Swift No. 1 dam
Constructed Channel
Swift No. 1 PHouse and tailrace
Swift Number Two Forebay
Swift No. 2 Power Canal
Upper Release
Swift Bypass Reach


Swift Creek
Swift Creek Arm
Diamond Creek
Swift No. 1 dam
Swift Forebay
Release
Swift FSC
PHouse and tailrace
Swift Reservoir
Range Creek
Drift Creek


Clear Creek Acclimation Pond site
Muddy River Acclimation Pond site
Lower Falls
Crab Creek Acclimation Pond site
Muddy River
Pine Creek
Adult Release Structure
Eagle Cliffs smolt trap
Swift Forest Camp boat launch

Appendix F

PacifiCorp Response to Draft M&E Plan Comments

Pat Frazier (WDFW) comments received February 16, 2017

Section 2-22, first paragraph, fifth sentence: remove extra period after '…used to analyze data, ….'

Utilities' response: deleted period

Section 2-22, fourth paragraph, second line: replace 'that are aligned with the M&E Objectives and H&S Objectives.' with 'and how these parameters are aligned with metrics measured as part of the M&E and H&S Plan objectives.'

Utilities' response: replaced language.

Michelle Day and Rich Turner (NMFS) comments received March 24, 2017

Rich's comment: Do have the results of the Bouchamp bio-energetics study? Would like to see if you could apply some if it to tributary and reservoir interactions between wild and hatchery fish/

Utilities' response: The results of the Univ. of Washington bioenergetics study are discussed in Section 2.18 and next steps are outlined at the end of that section.

How does this SA section apply here? Section 8.2.6 doesn't seem to relate to the M&E (page 4, second paragraph)

Utilities' response: You are correct, reference to section 8.2.6 is a carry-over from the previous M&E version. Reference deleted.

SA section 9.1 M&E requires NMFS approval (Page 4, second paragraph)

Utilities' response: added In addition, the Services shall have final approval of changes to the M&E Plan with respect to fish passage or species listed under the ESA.

The following needs to be included:

There may be a need to change some of the monitoring and evaluation measures if it is determined that the current measure is not meeting the overall intended purpose.(Page 4, second paragraph)

Utilities' response: Statement added to end of paragraph.

I do not see this in 4.1.4. Please direct me to the language in the SA (Page 6, end of first paragraph)

Utilities' response: The language about ground-truthing is not found in the SA. Rather, this was included in the 2010 version of the M&E Plan.

How will these fish numbers be determined? (page 7, beginning of 3rd paragraph)

Where is there allowance to consider this

Utilities' response: It is difficult, if not nearly impossible to determine the actual numbers so the ACC agreed to ignore these numbers toward the ODS standard.

Where is there allowance to consider this (page 7, end of 3rd paragraph)

Utilities' response: SA 9.2.1(g) states, "Turbine Survival, i.e., the percentage of juvenile anadromous fish of each of the species designated in Section 4.1.7 that are entrained in turbines and that survive through the turbines; provided that such monitoring shall only be performed if and when fish passing through Project turbines may contribute materially to ODS; provided further that prior to performing Turbine Survival studies, the Licensees shall assume Turbine Survival equals zero"

How will favorable water conditions be met? (page 12, middle of first paragraph)

Utilities' response: A flow-through tank will be supplied with water from the FSC fish-handling pumped water supply which is taken from the reservoir at a depth of about 40 feet to insure good temperature and oxygen conditions.

What if we can't get enough fish from here or by this method? (page 12 First paragraph under Section 2.2)

Utilities' response: The next paragraph addresses where additional fish will be collected for this analysis. This was added because of previous difficulties in gathering enough fish at the Eagle Cliffs trap to conduct the analysis.

This is not appropriate to include in a M&E plan.

Plus, I'm not ready to conclude this. (Page 13, end of paragraph under PENC)
Utilities' response: Sentence deleted.

Again, this is about solutions and not appropriate for the M&E plan (Page 13, last sentence under PENT)

Utilities' response: Sentence deleted

Same comment as above (Page 13, last sentence under PRET)

Utilities' response: Sentence deleted

I thought we originally had 95% (Page 13, next-to-last sentence)

Utilities' response: This language is unchanged from the 2010 M&E Plan and refers to the 90% CI around the estimate. Not to be confused with the FSC Collection Efficiency which remains 95%.

This is 18 years old. Is this the lastest data? If so, there should be a statement here that as tags get smaller, this will be review (Page 15, third bullet)

Utilities' response: Even though this is old, fish size for active tag studies remains at 90mm or greater. The next sentence states that until tech improvements are made smaller fish will not be used (which insinuates that the Utilities will continue to monitor available technologies and alter the standards when new technology becomes available)

Where is this language in the settlement agreement? This is not appropriate if it's not in the SA (Page 16, last sentence under 2.2.1.2)

Utilities' response: This language is not specifically called out for in the SA but was lifted from the approved 2010 M&E Plan and carried over in the 2017 version.

Where is this in the SA (Page 17, under Section 2.2.2.2)

Utilities' response: While this language is not in the SA, nor the 2010 M&E Plan, it was added because it conforms with determination of Capture Efficiency (previous comment) and is an integral part of the equation to determine CE. In other words, if CE has the stated caveat regarding the ability to improve CE, as agreed to by the ACC and the Services in the 2010 version, then the components of the CE equation should have the same caveat.

Not sure what is meant here. [From Rich] - Michelle: I think this relates to the figure above

Utilities' response: Rich's statement is correct – Array A is shown in Figure 2.1.3

Why can't this be quantified with the antenna located downstream? Can there also be a PIT antenna istalled below to identify the PIT tagged fish? Gives a higher number of possible detected fish. (Page 18, first sentence under Section 2.3)

Utilities' response: This language was also included in the 2010 M&E Plan. The paragraph does state that turbine entrainment at Yale and Merwin dams will be addressed once downstream collectors are installed at those projects. Until that occurs, the fish are considered lost to the system. Especially since those fish numbers cannot be determined without the aid of a downstream collector.

Are these NORs? (Page 36, second paragraph/second sentence)

Utilities' response: The sentence about transported adults includes NOR's but is primarily HOR coho and Chinook (when available) used to reintroduce these species upstream of the dams. These two HOR species have a greater affinity for the Lewis River trap since that was their final rearing point before their release to the Lower Lewis as smolts.

Is this defined somewhere? (Page 42, last sentence)

Utilities' response: this statement about adequate numbers of spring Chinook is referring to numbers used in the H&S Plan where it states that about 1,000 HOR adults and 60 NOR adults are needed for the hatchery program, and about 2,560 spring Chinook (NOR and HOR) are needed for the reintroduction program. So that implies that if greater than 3,620 spring Chinook adults return consistently to the Lewis River Hatchery and the Merwin Adult trap facility, then that would trigger a creel effort to support the Ocean Recruit estimate.

??? (Page 44, beginning of first sentence under Section 2.13.2)

Utilities' response: delete '9' from the end of the word recruitment

Where is this defined? (Page 44, end of second sentence under section 2.13.2)

Utilities' response: This is referred to as 'Proportionate Natural Influence' in the HSRG 2014 reference.

Any screw traps in the lower river that could be used to estimate survival of different ages and sizes collected upstream? (Page 45, First full paragraph)

Utilities' response: The Utilities are operating screw traps in the Lower Lewis River where size and age class information is collected. While this information could be applied to the upper watershed, it is not likely there would be god correlation between the upper and lower watershed due to the differences in rearing conditions – especially the presence of reservoirs which could yield larger individuals than the lower river.

What is this? Could also use Sandy Hatchery spring Chinook salmon – now an integrated program. (Page 45, Table 2.13.1)

Utilities' response: the Sandy R. wild SPC was added by WDFW staff. The integrated SPC was added into the table.

Would these be ad-clipped? (Page 46, under Solution for Issue 1)

Utilities' response: No since the goal is to estimate natural origin recruits that are not from the Upper Lewis.

You still would not know how many of the unclipped untagged coho are from outside the basin. All you would know is how many CWT fish with an adipose fin and one without that are passed upstream. You would have to kill those fish sampled to recovery tags to know if the fish is a Lewis fish or one from outside the basin. (Page 46, Second paragraph)

Utilities' response: Recommend some discussion on this issue to clarify

Any results? (Page 81, beginning of second paragraph)

Utilities' response: The results are available in the 2016 annual ACC/TCC report

This should also include investigation to the impact to fish if event had possible impacts. Or as requested from FERC, WDOE, or an ACC member (Page 76, 2nd paragraph under Swift Bypass Reach Canal Drain)

Utilities' response: Added 'a description of impacts to the fish present'

This should also include investigation to the impact to fish if event had possible impacts. Or as requested from FERC, WDOE, or an ACC member (Page 78, last sentence)

Utilities' response: Added 'a description of impacts to the fish present'

Add this at the end of the paragraph: Monitoring and evaluation will likely require more than just what is currently included in the Monitoring and evaluation plan. PacifiCorp must monitor at level that is necessary to measure the VSP parameters consistent the NOAA guidance. The Monitoring and evaluation program and results with be reviewed annually by the ACC with NOAA Fisheries approval. This is the comment I provided in December (Page 82, end of second paragraph)

Utilities' response: Recommend some discussion on this issue to clarify