Pacific Lamprey Upstream Passage Modifications Literature Review and Analysis and Recommendations for Passage Improvements in the Rocky Reach Fishway

Rocky Reach Hydroelectric Project (FERC No. 2145)

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Executive Summary

Pursuant to the Rocky Reach Hydroelectric Project (Rocky Reach Project or Project) Pacific Lamprey Management Plan (Chelan PUD 2006), Public Utility District No. 1 of Chelan County (Chelan PUD) is required to complete, in consultation with the Rocky Reach Fish Forum (RRFF), a literature review of the effectiveness of upstream lamprey passage measures implemented at other hydroelectric projects in the Columbia and Snake rivers, and to evaluate implementation of similar measures at the Project. The RRFF selected a team of consultants (Long View Associates, LGL Limited, Blue Leaf, and S. P. Cramer and Associates) to perform this work.

The Pacific Lamprey Upstream Passage Modifications Literature Review and Analysis and Recommendations for Passage Improvements in the Rocky Reach Fishway (Literature Review Document) summarizes the results of upstream lamprey passage measures implemented and evaluated at other hydroelectric projects in the Columbia River basin. In addition, this document describes site-specific assessments regarding the fishway facility at Rocky Reach Dam, including observations gathered during a site visit to the facilities in February 2010. Based upon review of this information, a list of potential modifications for the Rocky Reach fishway and a prioritization of that list were developed. The recommendations are intended to provide a basis for future RRFF discussions regarding identification of additional information needs, and the selection of the initial set of modifications to evaluate for the purposes of improving adult lamprey passage at the Rocky Reach Project.

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1.0 Introduction

1.1 General Description of the Rocky Reach Hydroelectric Project

The Rocky Reach Hydroelectric Project (Rocky Reach Project or Project), the largest of the Public Utility District No. 1 of Chelan County's (Chelan PUD) three hydroelectric projects licensed by the Federal Energy Regulatory Commission (FERC), is located on the Columbia River in Chelan County, Washington, approximately seven miles upstream of the city of Wenatchee, Washington. The Project utilizes the waters of the Columbia River, whose drainage basin extends over substantial portions of northern Washington, Idaho, Montana and into Canada.

The Project impounds 43 river miles and has a surface area of 8,235 acres at the normal maximum pool elevation of 707 feet above mean sea level (MSL).[1] The Project consists of a dam, which incorporates a spillway, powerhouse and non-overflow structures, as well as power transmission, fish passage and visitor facilities. The spillway consists of 12 spillway gates with a combined hydraulic capacity of 980 kcfs. The powerhouse contains eleven generating units. The Project's total installed capacity is 865.76 MW.

1.2 Purpose of the Report

As set forth in the Pacific Lamprey Management Plan (PLMP; dated February 3, 2006) and consistent with the Project License Order (issued by the FERC on February 19, 2009):

> *Chelan PUD shall, within one year of the effective date of the New License, complete a literature review of the effectiveness of upstream lamprey passage measures implemented at other hydroelectric projects in the Columbia and Snake rivers, such as plating over grates, improvement in orifices for passage, rounding sharp edges, constructing rest areas in front of submerged orifices, and reducing diffuser grating spacings. Chelan PUD shall, in consultation with the Rocky Reach Fish Forum (RRFF), evaluate whether it would be appropriate and reasonable to implement similar measures at Rocky Reach Dam.*

To fulfill these requirements, this document is structured as follows:

1. Section 2.0: General information regarding upstream passage at dams and efforts to implement and evaluate structural and operational modifications in the Columbia River Basin as well as information regarding Pacific lamprey-related research and improvement activities at the Project.

2. Section 3.0: Information resulting from the literature review of the effectiveness of upstream lamprey passage measures and studies implemented at other hydroelectric projects in the Columbia River basin.

3. Section 4.0: A summary of observations made during the February 25, 2010 tour of the Project's existing fishway facilities.

[1] All elevations in this document are referenced to the National Geodetic Vertical Datum of 1929.

4. Section 5.0: A recommendation list of potential modifications in the Project fishway to improve upstream passage and the supporting rationale for each modification. The list of potential modifications to be considered are based upon an evaluation of upstream passage improvement measures listed in Section 3.0, the available site specific information, and a qualitative evaluation of a modifications applicability at the Project.

5. Section 6.0: Prioritization of the list developed in Section 5. The ranking of potential modifications considered the available site-specific information in combination with a modification's relative cost and location in the fishway, its probability of improving lamprey passage performance and the magnitude of a modification's improvement on the overall population passing Rocky Reach dam (e.g., the higher the probability of improving passage performance for a larger proportion of fish, the higher the prioritization ranking).

1.3 Consultation

The consultant team (Long View Associates, LGL Limited, Blue Leaf, and S. P. Cramer and Associates; Team) provided a draft outline of contents for the Pacific Lamprey Upstream Passage Modifications Literature Review and Analysis and Recommendations for Passage Improvements in the Rocky Reach Fishway (Literature Review Document) to the RRFF on March 18, 2010. The draft outline was discussed at the March 25, 2010 RRFF meeting and written comments were provided by the RRFF March 29, 2010, to which, the Team provided preliminary written responses to the RRFF on April 19, 2010. The Team's responses were discussed at the April 29, 2010 RRFF meeting, with additional follow-up via an email exchange between the RRFF and Bao Le (Long View Associates) on May 5, 2010. Subsequently, the Team gave a presentation of the Literature Review Document at the May 24, 2010 RRFF meeting and provided a complete draft to the RRFF on May 28, 2010 for review. The draft Literature Review Document was discussed at the June 14, 2010 RRFF meeting and written comments were provided by the RRFF June16, 2010. On June 22, 2010, several RRFF members requested that the Team prioritize the list of recommended modifications in the Literature Review Document. In response to the request, the Team added a Section 6.0 that prioritizes the list of recommended modifications in Section 5.0.

A summary of comments by the RRFF as received by the Team on the outline and draft Literature Review Document have been summarized along with the Team's responses in Appendix A. All documentation of the relevant communications (including the summaries from the relevant RRFF meetings[2]) is included in Appendix B.

2.0 Background

The Pacific lamprey (*Entosphenus tridentatus*) is an anadromous member of the jawless fish family (Petromyzontidae) that inhabits marine and freshwater systems in western North America and eastern Asia. The fish are indigenous to the Columbia River basin. In general, their historic distribution coincides with that of Pacific salmon. The current distribution of Pacific lamprey in the Columbia River extends as far upstream as Chief Joseph Dam, and in the Snake River as far

[2] The summary for the June 14, 2010 RRFF meeting was not yet available at the time of issuance of the final Literature Review Document.

upstream as Hells Canyon Dam. The Pacific lamprey is parasitic on various ocean fishes for one to two years. After maturing in the ocean, they return to the Columbia River in the summer and fall, migrating upstream before overwintering. The following spring, lamprey spawn over gravel substrate, constructing a nest in shallow water up to two feet in diameter, and die soon after spawning. Juveniles live in the high sediment and slow water habitats of streams for five to six years, filter feeding on detritus, algae and micro-organisms before entering the ocean where they become parasitic. They appear to have little impact on marine fish populations and do not feed when they move into streams to spawn.

Adult lamprey counts have decreased at all Columbia and Snake river dams as compared with historical estimates, with the greatest declines occurring at the upper Columbia and Snake river projects. Annual lamprey counts at Bonneville Dam prior to the 1970's often exceeded 250,000 fish. In 2009, only 8,622 were counted at Bonneville Dam (DART 2010). Causes of population decline may include: 1) passage problems for adult and juvenile lamprey migrating past dams; 2) declining conditions of spawning and rearing habitat in freshwater; 3) a decline of prey available in the marine environment; 4) industrial and agricultural pollution; 5) urbanization; 6) dewatering of streams; and 7) adult losses at sea (Close 2002; Moser and Close 2003). Based on the decreasing trend of adult Pacific lamprey, conservation groups filed a lawsuit against the U.S. Fish and Wildlife Service (USFWS) in May 2004 to compel the USFWS to act on their January 27, 2003 petition to list four species of lamprey, including Pacific lamprey. On December 22, 2004, the USFWS announced that a petition to list four species of lamprey did not contain sufficient information to warrant further review at that time.

In the Columbia River basin, recent planning efforts to develop Pacific lamprey management and recovery strategies by the USFWS, Northwest tribes, and public and private hydroelectric operators reflect the growing need to begin actively addressing decreasing lamprey population trends. Based upon the recognition that dam passage is a major contributing factor to the species' decline, a significant amount of lamprey research over the past decade has been focused on identifying potential impediments to adult passage at hydroelectric facilities. Results of this research coupled with regional planning efforts and an increase in activity focused on implementing and evaluating the efficacy of project specific fishway modifications towards improving passage have provided a beginning framework for lamprey recovery and conservation.

Specific to the Project, in 2004, a radio-telemetry study was conducted at Rocky Reach Dam to assess passage proportions and passage times of adult lamprey (Stevenson et al. 2005) through various sections of the fishway in order to better understand potential Project impacts to lamprey migration (Figure 1). Analysis of the data determined that:

1. Forty-five percent (n=50) of lamprey entering the fishway (n=110) dropped back out of the fishway[3] or were last detected residing in the fishway. Further, 25% (n=6) of lamprey released in the Upper Ladder (n=25) did not exit. Results for the points of furthest migration in the fishway were not provided in the report;

[3] Drop back is defined by a lamprey that has entered the fishway but is detected moving downstream (volitionally or non-volitionally) back through the fishway and out into the tailrace.

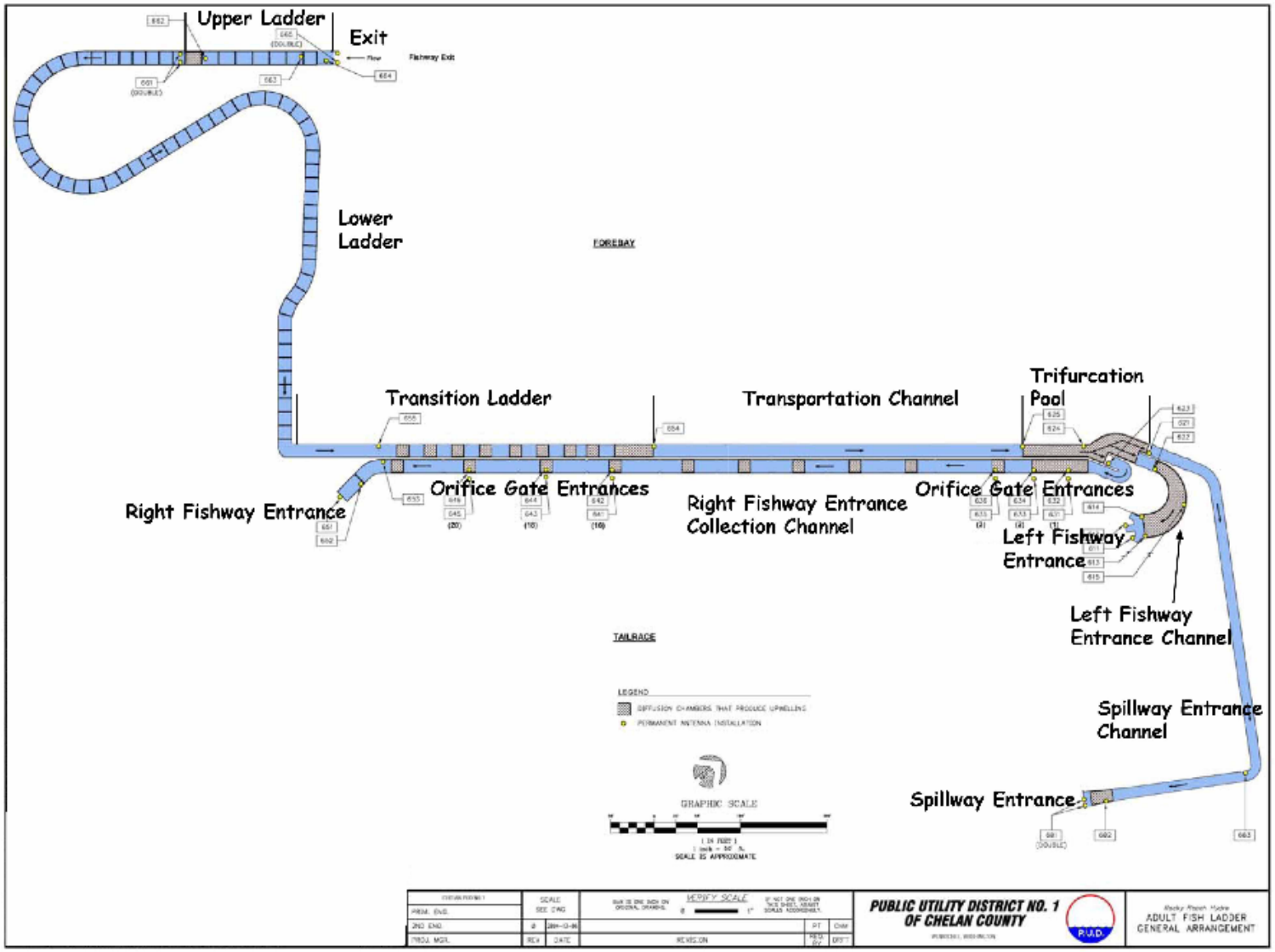
2. Twenty-two percent (n=17) of lamprey exiting the fishway into the forebay fell back[4] or moved downstream through the dam. Some of these fish reascended the fishway resulting in a net fallback rate of 13% (n=10);

3. Six percent (n=7) of lamprey arriving at the Project (n=117) did not enter a fishway (i.e., 94% approaching do enter); and

4. Migration rate was slowest in the Upper Ladder (between the diffuser in the control weir section and the Fishway Exit), and was progressively faster for the lower fishway (between the end of Transition Ladder and the Upper Ladder), the Transportation Channel, and the entrance channels (between entrances and the Trifurcation Pool).

[4] Fallback is defined by a lamprey that has successfully ascended the fishway and exited into the forebay, but is later detected in the tailrace downstream of the Project presumably due to non-volitional downstream movements.

Figure 1. Rocky Reach Dam fishway.



Although a single year of data does not typically provide an adequate foundation to develop rigorous conclusions, the study results did provide some clear trends. Drop-out from the fishway combined with residualization of tagged lamprey that entered the fishway was the largest "loss" from successful passage. Fallback accounted for the second largest "loss" from successful passage, followed by fish detected in the tailrace that did not enter the fishway. In general, the results of the 2004 passage assessment indicate that there are areas in the fishway where modifications may be appropriate to improve adult lamprey passage success.

Golder (2006) investigated issues and potential solutions regarding adult and juvenile lamprey passage at hydro facilities in the lower Columbia River by conducting interviews with researchers. As applied to the Rocky Reach fishway, several potential issues were identified: 90 degree corners on bulk-head/stop-log slots and orifice openings, standard diffusion grating (incongruent attachment surfaces), and potentially high water velocities at the Right Fishway Entrance. Possible structural solutions considered include: lamprey passage system (LPS) if an area of lamprey congregation area exists, plating on diffuser grates, and filling bulk-head/stop-log slots to provide flat surfaces. Possible operational solutions included: slow dewatering of fishway for servicing to promote voluntary drop-out, configuring orifice gate openings on the collection channel to minimize water current differentials, and the use of multiple openings at the Left Fishway Entrance to maintain flow but decrease velocity.

Chelan PUD's PLMP summarized information from Stevenson et al. (2005) and concluded that the 2004 study "suggests that adult passage impediments may exist within the Rocky Reach fishway". However, it did not define any specific locations or structures.

3.0 Literature Review

This section provides a summarization of activities occurring in the Columbia River basin related to Pacific lamprey upstream passage improvement measures and research. Activities identified in Table 1 include those that have been implemented, planned and/or evaluated at a Columbia River basin hydroelectric facility. Details include the project(s) where the activity has or will occur, river of each project, lead entity, a description of the measure and if applicable, the evaluation results. In addition, for each improvement measure, the intended "Adult Lamprey Metric" (as being developed by the Columbia Basin Fish and Wildlife Authority [CBFWA] Technical Workgroup) is indicated (CBFWA Technical Workgroup 2010). The three potential passage categories include:

1. Entrance efficiency;
2. Ladder passage (passage efficiency within the fishway and ability to count); and
3. Fallback from forebay back to tailrace.

Table 1 Upstream lamprey passage improvement measures and studies implemented at hydroelectric projects in the Columbia River basin.

	Hydroelectric Project (River)	Project Owner (Study Lead(s))	Measure Planned (P), Implemented (I), and/or Evaluated (E)	Measure Description and Evaluation Results (if applicable)
	Structural Modifications			
1.	**Measure:** Install Lamprey Passage Structures (LPS) **Intended Metric Category:** Ladder Passage			
1a	Bonneville (Columbia), Bradford Island auxiliary water supply (AWS)	Army Corps of Engineers (ACOE) (National Marine Fisheries Service [NMFS], Pacific States Marine Fisheries Commission, and the University of Idaho)	I, E	In 2004-2005, a prototype LPS was operated in the Bradford Island AWS channel. In 2005, 8,889 untagged lamprey were counted as they exited the AWS LPS, and estimated that this represented 29% of the lamprey at the top of the Bradford Island fishway in 2005. Of the PIT-tagged lamprey released into the AWS, 42% were detected in the LPS. Median time required to pass through the LPS was 1.5 h, and of fish detected in the AWS LPS, 94% successfully exited. There was no evidence that lower flow through the LPS resulted in either significantly higher counts of lamprey, more rapid passage rates, or higher passage success. (Moser et al. 2008a) In 2006, the LPS was bolted to the walls of the AWS channel, and its original configuration was changed to include dual ramps for improved lamprey collection. In the 2006 evaluation, 38% of the lamprey that reached the top of the Bradford Island fishway were estimated to have used the AWS LPS. Seven percent of the PIT-tagged lamprey were detected in the LPS. In addition, 14% of the fish detected at The Dalles Dam were known to have used the LPS at Bradford Island. The median time lamprey required to pass through the LPS was 45 min, and 99% of the fish successfully exited the AWS LPS. Based on the 2005 and 2006 results, it was clear that the structural modifications made in 2006 improved lamprey collection, rate of passage, and passage success through this structure. (Moser et al. 2009) The 2007 and 2008 data is currently being evaluated; however, preliminary results indicate that, in 2007, 464 untagged lamprey and 12 with PIT-tags were caught and in 2008, 490 untagged lamprey and 17 with PIT-tags were caught. (personal communication with M. Moser, NMFS Northwest Fisheries Science Center, 4/19/10)

Table 1, continued…

	Hydroelectric Project (River)	Project Owner (Study Lead(s))	Measure Planned (P), Implemented (I), and/or Evaluated (E)	Measure Description and Evaluation Results (if applicable)
1b	Bonneville, Washington-shore AWS	ACOE (University of Idaho and NMFS)	I, E	In 2009, lamprey use of the Washington-shore AWS channel proved difficult to evaluate using radiotelemetry because the close proximity of antennas in the ladder and AWS allowed transmitters to be detected at both locations simultaneously. The lampreys that had clear evidence of AWS use either entered laterally from the serpentine weir section of the ladder or entered through the picketed lead at the downstream end of the AWS. Collection efficiency of the LPS located inside the AWS was 7% for all double-tagged (radio and half-duplex PIT) fish in the study area (5 of 74) and 87% (7 of 8) for fish known to be in the upstream end of the AWS channel. A better understanding of the inter-related effects of water temperature, forebay elevation, and water transfers between the AWS and serpentine weirs is needed. There was strong evidence that forebay elevation plays a role in lamprey passage through this area. Increased monitoring of depth, water temperature, current direction and velocity is needed to help resolve these or other causal mechanisms. (Keefer et al. 2010a)
1c	Bonneville, Washington-shore fishway entrance	ACOE (NMFS, Pacific States Marine Fisheries Commission, and the University of Idaho)	I, E	The first iteration of a lamprey collector at a fishway entrance was fabricated and installed at Bonneville Dam in 2005. During its first full year of operation, 135 lamprey used the LPS collector at the downstream north entrance to the Washington-Shore fishway. This collector was modified in 2006 to provide less turbulent flows on the collector ramp. However, lamprey use of this structure was still low, indicating that further modification or better siting is needed. There was some evidence that fewer lamprey entered the collector during periods of high flow emanating from the Washington-shore fishway entrance. (Moser et al. 2009) In 2008, the Washington-shore fishway entrance collector captured 490 lamprey and 16 of these had a PIT tag (3%). Both the efficiency and collection rate for this structure were higher than in any other year of operation (2005-08). (ACOE 2008)

Table 1, continued…

	Hydroelectric Project (River)	Project Owner (Study Lead(s))	Measure Planned (P), Implemented (I), and/or Evaluated (E)	Measure Description and Evaluation Results (if applicable)
1d	Bonneville, Cascade Island fishway entrance	ACOE (University of Idaho and NMFS)	I, E	As part of modifications made to the entrance of the Cascade Island fishway during the 2008-2009 winter work period, a LPS was installed inside the fishway opening that allowed volitional passage to the elevation of the dam forebay. Although lampreys were collected at the top of the new LPS, none of the HD-PIT tagged lampreys were recorded using this structure in 2009. It was not clear whether the relatively limited use was due to siting, the distribution of attraction flows inside the fishway and near the LPS, or other factors. In other LPS's at Bonneville Dam, lamprey use of the structures was relatively lower in the installation year compared to subsequent years. A possible explanation is that the newly-installed metal is unattractive to some lamprey for olfactory or other reasons. If this is the case with the Cascade Island LPS, then it is possible that collection efficiency will improve at this site in future years (Clabough et al. 2010). An additional detailed evaluation of the new LPS will be presented in a companion report (Moser et al. *in prep*).
1e	Three Mile Dam (Umatilla)	Confederated Tribes of the Umatilla Indian Reservation (CTUIR)	I	In late summer 2009, a LPS was installed at Three Mile Dam. A few adult lamprey have been observed using the structure but most of the migration had occurred prior to the installation. Effectiveness testing is planned for 2010. (personal communication with Aaron Jackson, CTUIR 10/19/09)

Table 1, continued…

	Hydroelectric Project (River)	Project Owner (Study Lead(s))	Measure Planned (P), Implemented (I), and/or Evaluated (E)	Measure Description and Evaluation Results (if applicable)
2.	**Measure:** Modifications at entrance **Intended Metric Category:** Entrance Efficiency			
2a	Priest Rapids and Wanapum (Columbia)	Grant Public Utility District (PUD) (LGL Limited)	I, E	During construction of Wanapum Dam, keyhole entrances were installed at several locations. During the 1996-1997 fish ladder outage period and during the 2004-2005 construction of the Future Unit Fish Bypass, keyhole entrances were installed at remaining locations. During the 1998-1999 fish ladder outage period, keyhole entrances were installed at Priest Rapids Dam. (personal communication with Mike Nichols, Grant PUD 5/17/10) In 2001-2001, Grant PUD conducted a comprehensive passage evaluation at both dams. Entrance efficiencies ranged between 53% and 100% for Priest Rapids Dam and 54% and 100% for Wanapum Dam for the two years of study. Small sample size in 2001 confounded interpretation between years. The largest differences were found between different types of entrances; more specifically, the entrance efficiency of orifice entrances were significantly lower compared to the larger main entrances (which contained key hole entrances) on the powerhouse and spillway. (Nass et al. 2003)
2b	Bonneville (Columbia), Cascade Island fishway entrance	ACOE (University of Idaho and NMFS)	I, E	As part of modifications made to the entrance of the Cascade Island fishway during the 2008-2009 winter work period, a variable width entrance weir (keyhole entrance) was constructed. Lamprey entrance efficiency at the Cascade Island fishway (58.8%) was higher in 2009 than 2008 (33.3%; P =0.002), suggesting some post-modification benefit for lampreys. Entrance efficiency was also higher in 2007 (50.0%) than 2008, though this difference was not significant, possibly due to lower sample size. Entrance efficiency at the unmodified Bradford Island fishway did not differ significantly among years, supporting the hypothesis that the increase at Cascades Island in 2009 was related to the modification. Overall, the analyses indicated that the Cascade Island modifications may have improved entrance efficiency for adult Pacific lamprey and did not have strong positive or negative effects on other passage metrics. (Clabough et al. 2010)
2c	Willamette Falls (Willamette)	PGE	I, E	In the summer of 2008, bulkhead slot modifications were made at the project's "Leg 1" ladder entrance to allow for operation over the full range of tailrace operating conditions. The 2009 passage evaluation is still ongoing; however, preliminary data suggest that combined entrance efficiency (all 3 entrances) is approximately 82%. The role the modifications play in this result are unclear since past radio-telemetry studies were not designed at the scope necessary for pre and post modification comparisons. (personal communication with Tim Shibahara, PGE 4/7/10)

Table 1, continued…

	Hydroelectric Project (River)	Project Owner (Study Lead(s))	Measure Planned (P), Implemented (I), and/or Evaluated (E)	Measure Description and Evaluation Results (if applicable)
3.	**Measure:** Round sharp edges (entrances, bulkheads, orifices, tops of overflow weir walls, etc.) **Intended Metric Category:** Ladder Passage			
3a	Willamette Falls (Willamette)	Portland General Electric (PGE)	I, E	In the summer of 2008, footings were rounded to not have 90 degree angles for slot. The 2009 passage evaluation is still ongoing; however, preliminary data suggests that combined entrance efficiency (all 3 entrances) is approximately 82%. The role the modifications play in this result are unclear since past radio-telemetry studies were not designed at the scope necessary for pre and post modification comparisons. (personal communication with Tim Shibahara, PGE 4/7/10)
3b	Bonneville (Columbia), Bradford B-Branch entrance	ACOE (prepared by NMFS, Pacific States Marine Fisheries Commission, and the University of Idaho)	I, E	In 2000, bulkheads adjacent to the Bradford B-Branch entrance were rounded to provide more attachment areas for lamprey. Evaluations indicated that entrance efficiency at this entrance was higher in 2000 than in 1998 or 1999. (Moser et. al. 2000)
3c	Dalles (Columbia)	ACOE	I	During the 2009-2010 winter work period, at the 3 locations in the east and north ladders, corners were rounded from 90 degrees to 2-in radius. No evaluation is planned. (personal communication with Sean Tackley, ACOE 4/12/10)
3d	McNary (Columbia)	ACOE	I	During the 2009-2010 winter work period, the edges of the 26 inch by 26 inch salmon orifices located at the Oregon shore fish ladder exit were smoothed/rounded through the installation of additional metal plating to increase attachment area for Pacific lamprey. Future evaluations of this modification are not currently planned. (personal communication with Derek Fryer, ACOE 5/6/10)

Table 1, continued…

	Hydroelectric Project (River)	Project Owner (Study Lead(s))	Measure Planned (P), Implemented (I), and/or Evaluated (E)	Measure Description and Evaluation Results (if applicable)
4.	**Measure:** Replace diffuser grating with reduced gap spacing or modify/maintain in some manner **Intended Metric Category:** Ladder Passage			
4a	John Day (Columbia)	ACOE	P	During the 2010-2011 winter work period, gratings at the north and south ladders will be replaced (1-inch to ¾- inch). (personal communication with Sean Tackley, ACOE 4/12/10) The reduction from 1-inch to ¾-inch grate spacing is based upon an assessment of the bar spacing needed to exclude lamprey that enter the fishways at Bonneville Dam (Moser et al. 2008b). During dewatering simulations, all lamprey tested were able to pass through the traditional 2.5cm (1 inch) grate spacing whereas none of the lamprey tested were able to pass through a 1.9 cm (¾-inch) grate spacing. An initial field test of the 1.9 grating at John Day Dam confirmed these results. The study concluded that the very smallest end of the Pacific lamprey size frequency distribution may have been missed during testing because lamprey shrink during freshwater residence. The smallest lamprey in the study was 53 cm long, weighed 282 g, and was 9.2 cm in girth.
4b	Wells (Columbia)	Douglas PUD	P	If additional passage improvement measures are deemed necessary by work group members during implementation of the Wells Project Pacific Lamprey Management Plan, such measures may include modification, maintenance, or replacement of diffuser grating that adversely affect passage of adult Pacific lamprey (Douglas PUD 2010).

Table 1, continued…

	Hydroelectric Project (River)	Project Owner (Study Lead(s))	Measure Planned (P), Implemented (I), and/or Evaluated (E)	Measure Description and Evaluation Results (if applicable)
5.	**Measure:** Install plating over diffuser grating along base of walls and weirs, and through orifices **Intended Metric Category:** Ladder Passage			
5a	Rocky Reach (Columbia)	Chelan PUD	I	Installation of plating around the perimeter of diffuser grating to eliminate gaps between the grating and concrete started during the 2007-2008 fishway overhaul and has been ongoing during subsequent overhauls. No evaluation is planned. (personal communication with Lowell Rainey, Chelan PUD, 4/29/10)
5b	Priest Rapids (Columbia)	Grant PUD	I	During the 2009-2010 winter work period, aluminum plating over the diffuser grates was installed. An evaluation will be conducted in summer 2010. (Nass et al. 2009)
5c	McNary (Columbia)	ACOE	I	During the 2009-2010 winter work period, steel plating was installed over a portion of the fish ladder diffuser grating. The plating was installed around the perimeter of three main sections (at the bottom of the fish ladder grating and up one side) at the Oregon shore fish ladder. Future evaluations of this modification are not currently planned. (personal communication with Derek Fryer, ACOE, 5/6/10)
5d	Ice Harbor (Snake)	ACOE	I	During the 2009-2010 winter work period, a total of 8 diffuser grating sections in the fish ladder were plated. Diffuser sections 8-11 were no longer operational and were fully plated (entire section covered) and diffuser sections 4-7 received partial plating (perimeter). Future evaluations of this modification are not currently planned. (personal communication with Derek Fryer, ACOE, 5/6/10)
5e	John Day (Columbia)	ACOE	P	In 2010-2011, at the north ladder, a 12-inch-wide metal strip will be installed over the south side of floor diffuser 16. (ACOE 2009a)
6.	**Measure:** Install ramps at sills and perched orifices **Intended Metric Category:** Ladder Passage			
6a	Willamette Falls (Willamette)	PGE	I, E	In the summer of 2008, a sill located at the base of the entrance was ramped. The 2009 passage evaluation is still ongoing; however, preliminary data suggests that combined entrance efficiency (all 3 entrances) is approximately 82%. The role the modifications play in this result are unclear since past radio-telemetry studies were not designed at the scope necessary for pre and post modification comparisons. (personal communication with Tim Shibahara, PGE 4/7/10)
6b	Priest Rapids (Columbia)	Grant PUD	I	During the winter of 2009-2010, aluminum ramps at elevated sills and lips were installed. An evaluation will be conducted in summer 2010. (Nass et al. 2009)

Table 1, continued…

	Hydroelectric Project (River)	Project Owner (Study Lead(s))	Measure Planned (P), Implemented (I), and/or Evaluated (E)	Measure Description and Evaluation Results (if applicable)
7.	**Measure:** Modify fishway count stations **Intended Metric:** Ladder Passage			
7a	Priest Rapids and Wanapum (Columbia)	Grant PUD	I	During the winter of 2009-2010, lamprey-specific fish crowder structures were installed at the count stations. An evaluation is planned for summer 2010. (Nass et al. 2009)
7b	Rocky Reach (Columbia)	Chelan PUD	I	During the 2008-2009 fishway overhaul (December 2008 through the first week of March 2009), brush strips were added to the counting backboard and the upstream picket barrier trashrack edges to prevent lamprey from evading the counting window. Also during the 2008-2009 overhaul, a bulkhead seal was added to the downstream end of the counting board to also prevent lamprey from evading the window. Evaluation of these modifications for lamprey has not occurred. (personal communication with Lowell Rainey, Chelan PUD, 4/29/10)
7c	John Day (Columbia)	ACOE	P	In 2010, the following modifications will be made at the north ladder: (ACOE 2009a) - Raise count station floor one foot to match invert at new weir 1 (holey wall site) - Remove 23-inch ramp through count slot and lower viewing window by 11.5 inches - Upgrade count station lighting and add automated brush cleaner for viewing window - Replace antiquated crowder, adding new transition farings and horizontal vanes Video monitoring is planned for summer 2010 to verify that the count station modifications are functioning properly.
7d	Wells (Columbia)	Douglas PUD	P	Per the Wells Project Pacific Lamprey Management Plan (Douglas PUD 2010), Douglas PUD, in consultation with work group members, may modify existing count stations to utilize alternative passage routes as a counting facility for adult Pacific lamprey to improve the accuracy of lamprey counts at the project.

Table 1, continued…

	Hydroelectric Project (River)	Project Owner (Study Lead(s))	Measure Planned (P), Implemented (I), and/or Evaluated (E)	Measure Description and Evaluation Results (if applicable)
8.	**Measure:** Install flow reduction structures **Intended Metric:** Ladder Passage			
8a	Bonneville (Columbia), Cascade Island entrance	ACOE	I, E	As part of modifications made to the entrance of the Cascade Island fishway during the winter of 2008-2009, bollards (a.k.a. "artificial rocks") were installed in the lower fishway inside the fishway entrance. Overall, the Cascade Island entrance modifications did not appear to have had a substantive negative or positive effect on adult lamprey passage at the dam because there were not large and consistent changes in the measured passage metrics between pre- and post-modification years nor large increases in the metrics at Cascade Island compared to the Bradford Island entrance. (Clabough et al. 2010)
9.	**Measure:** Weir wall modifications **Intended Metric:** Ladder Passage			
9a	McNary (Columbia)	ACOE	I	During the 2009-2010 winter work period, 3-inch high by 18-inch wide lamprey orifice openings were constructed flush with the fishway floor at 10 tilting weirs (with perched orifices) in the Oregon shore fish ladder. Evaluation of any potential impacts to migrating adult salmon is currently being conducted. Preliminary observations using underwater video have observed no interactions by migrating adult salmon/steelhead with the one open lamprey orifice. To date, approximately 19,000 salmon/steelhead have passed McNary Dam. (personal communication with Derek Fryer, ACOE, 5/6/10)
9b	John Day (Columbia)	ACOE	P	The following modifications at the north ladder are planned for 2010-2011: (ACOE 2009a) - Remove all 18 serpentine weirs + holey wall and replace with 23 lamprey-improved, JDAS-type w/ 15- to 18-inch vertical slots and 18- by 18-inch orifices - Add electrically powered sill actuators and support structure for 22 new weirs

Table 1, continued…

	Hydroelectric Project (River)	Project Owner (Study Lead(s))	Measure Planned (P), Implemented (I), and/or Evaluated (E)	Measure Description and Evaluation Results (if applicable)
10.	**Measure:** Other ladder modifications **Intended Metric:** Ladder Passage			
10a	John Day (Columbia)	ACOE	P	The following modifications at the north ladder are planned for 2010-2011: (ACOE 2009a) - Remove 1st vertical slot and sill baffle in forebay transition area - Modify 2nd baffle in forebay transition
10b	Willamette Falls (Willamette)	PGE	P	Activities to restore portions of the existing "old fishway" to operability are planned for 2010. Current information indicated that lamprey congregate in an area of this fishway early in the migration season. Operations of this fishway will allow lamprey, including salmon and steelhead that are currently salvaged as necessary from this area, volitional passage to the forebay of the project. There is not a license commitment but there will likely either be enumeration effort or funding to an existing research project (Warm Springs Tribe) that is utilizing half duplex tags to the falls to evaluate lamprey. (personal communication with Tim Shibahara, PGE 4/7/10)

Table 1, continued…

	Hydroelectric Project (River)	Project Owner (Study Lead(s))	Measure Planned (P), Implemented (I), and/or Evaluated (E)	Measure Description and Evaluation Results (if applicable)
	Operational Modifications			
11.	**Measure:** Reduce water velocities during the night / improvement in hydraulic conditions at entrance **Intended Metric:** Entrance Efficiency			
11a	Bonneville (Columbia), spillway entrance	ACOE	I, E	In 2000, tests to determine whether lowering water velocity at the Bonneville Dam spillway entrance would improve lamprey entrance success were conducted. Velocity at entrances was decreased from approximately 2.4 m/s to 1.2 m/s at night (2100 to 0400 h) at alternating spillway entrances during the period from July 25 to October 1. Fifty eight lamprey approached the spillway entrances during this period and 36 of these fish made their approach during the velocity test period. Entrance efficiency was actually higher during the high velocity treatment than during the low velocity treatment for these fish, indicating that reducing the velocity at these entrances did not improve lamprey entrance performance. (Moser et al. 2002)
11b	Bonneville, Powerhouse 2 (PH2)	ACOE	I, E	In 2007 and 2008, ladder flows at PH2 fishway were placed on standby at night. The combined 2007 and 2008 results suggest that some reduction in entrance velocity is beneficial for lamprey passage, but that these benefits are velocity-dependent and that zero attraction flow is probably a deterrent. Entrances with higher velocities under normal operation (capable of a larger net reduction in velocity) may provide relatively more benefit from velocity reductions than entrances with lower velocities. (Johnson et al. 2009a and 2009b) The 2009 evaluation revealed that overall dam passage metrics in 2009 were similar to estimates observed in prior years. Of the 596 lamprey tagged and released, 471 (79%) approached the dam, 383 (64%) entered, 177 (29%) passed the dam thru September 30. Fifty-four percent of the tagged lamprey made their first approach at PH2 (two-thirds of these did so at one of the north openings). The greatest proportion first entered PH2 fishway openings (32%) followed by the spillway (20%) and PH1 openings (14%). Thirty-four percent of the entrances at Bonneville Dam had unknown locations or times and we presume that most of these were associated with entries at unmonitored floating orifice gates. Dam passage times were similar to previous years for all passage segments (e.g., median release-to-dam passage time = 8.7 d, range 1.7-57.8 d). In addition, comparison of treatment vs. control nights at PH2 entrances indicated that there was a benefit of the lower velocity treatment to entrance efficiency (entrance: approach ratio) for tagged lamprey. (ACOE 2009b)

Table 1, continued…

	Hydroelectric Project (River)	Project Owner (Study Lead(s))	Measure Planned (P), Implemented (I), and/or Evaluated (E)	Measure Description and Evaluation Results (if applicable)
11d	McNary (Columbia)	ACOE	I, E	In an effort to increase fishway entrance efficiency at McNary Dam, water velocities were manipulated in 2009 by lowering the telescoping entrance weirs in a randomized block design between the hours of 2100 and 0400 daily, July 2 – October 10. In 2009, relatively high percentages of radio-tagged lampreys were recorded approaching McNary Dam after release (68%), entering McNary Dam fishways (63%), and passing the dam (56%) compared to the previous four years of research. In the 2005–2008 studies, the rate of approach after release was 23–76%, rate of entrance was 17–56% and the rate of dam passage was 12–41%. Return to the dam and passage efficiency metrics in 2009 were the highest recorded with the exception of the rate of approach in 2008. Entrance efficiency (proportion that approached that subsequently entered the fishway) in 2009 was 93%, substantially higher than all years other than 2006. Consistent with a priori statistical power analyses, preliminary results of the first year of the two-year experiment suggest that the reduction of velocity during night did not have an extreme positive or negative effect on lamprey passage behavior. (Boggs et al. 2010) During the 2009-2010 winter work period, modifications of the gate were made to allow for better operational control. In 2010, a second year of alternative gate operations of the fishway entrance gates are planned. The gates will be lowered by 5-6 feet at nighttime (9pm-4am) to enlarge the opening that will send the same volume of water through the larger space resulting in lowered water velocities. (personal communication with Derek Fryer, ACOE, 5/6/10)
11e	Wells (Columbia)	Douglas PUD	I, E	In 2009, Dual-frequency Identification Sonar (DIDSON) was used to passively assess adult Pacific lamprey passage behavior in response to operational modifications at the Wells Dam fishway entrances. The 2009 lamprey run resulted in few fish observed at Wells Dam, precluding statistically significant evaluation of these results. Nonetheless, operational modifications implemented in 2009 suggest strong potential for increasing entrance efficiency. Pooling observations that occurred during reduced velocity treatments shows a 67% (2 of 3) entrance efficiency compared to 50% (1 of 2) under normal conditions. (Johnson et al. 2010) An additional DIDSON evaluation is planned for summer 2010.
11f	Ice Harbor (Snake)	ACOE	I	In 2009, the ACOE conducted a flow reduction study at fishway entrances at the project during the lamprey migration season. The change in fishway operations was not evaluated and implementation in 2010 is not planned. (personal communication with Derek Fryer, ACOE, 5/6/10)

Table 1, continued…

	Hydroelectric Project (River)	Project Owner (Study Lead(s))	Measure Planned (P), Implemented (I), and/or Evaluated (E)	Measure Description and Evaluation Results (if applicable)
12.	**Measure:** Turn off lights in fishway at night **Intended Metric:** Ladder Passage			
12a	John Day (Columbia)	ACOE	P	In 2010-2011, at the north ladder, a 7-ft wide walkway over the exit weir section will be installed to provide access to all sill actuators and the top of the sidewalls in the exit section will be raised 3 feet to block light into the fishway. (ACOE 2009a)

4.0 Rocky Reach Fishway Tour/Observations

Rocky Reach Dam has one fish ladder to aid the migration of adult fish around the Project. The fishway operates at all times of the year except when closed for annual maintenance which occurs for approximately eight weeks in the winter (See Figure 1 for terminology used for various fishway sections). The fishway consists of entrances, channels, a fish ladder, and an attraction water system (AWS). The Right Fishway Entrance Collection Channel runs from the right powerhouse entrance along the length of the powerhouse (Figure 1). From the Spillway Entrance, a tunnel runs under the west end of the spillway and towards the middle dam area. The tunnel connects first with the left powerhouse entrance at the bifurcation pool and then meets with the Right Fishway Entrance Collection Channel at the Trifurcation Pool. From the Trifurcation Pool, a Transportation Channel runs parallel to the collection channel where it connects to the Transition Ladder section of the fishway. Moving upstream, the Transition Ladder becomes the Lower Ladder and then the Upper Ladder as it winds around the south end of the powerhouse and exits on the west end of the south forebay parapet wall. A fish counting room is located in the Upper Ladder section, as well as a public fish viewing room. The AWS maintains proper attraction flow within the fishway and at the fishway entrances to aid adult fish in locating the entrances and to provide favorable hydraulic conditions for rapid passage through the facility.

On February 25, 2010, the Team met with participants of the RRFF to tour the fishway facilities at Rocky Reach Dam. Chelan PUD representatives guided the group to multiple locations along the fishway to discuss structural and operational characteristics relative to adult lamprey passage. During the tour, participants were briefed on the layout of the fishway and its general operational conditions. Previously documented information on water velocity at specific locations (Chelan PUD as presented in Stevenson et al. [2005]) was described.

The fishway was not in operation at the time of the tour so the portion of the fishway from the Lower Ladder section of the fishway to the Fishway Exit was dewatered. The entrances, Right Fishway Entrance Collection Channel, Trifurcation Pool, and Transportation Channel were partially inundated (i.e., bulkhead not installed) so the fishway floor in these areas could not be seen. The primary observation points of the tour included (Figure 1):

- Upper Ladder/Fishway Exit: (from single diffusion chamber to the exit, including a series of control weirs and the adult trapping facility and count station);
- Transition Ladder (from end of Transportation Channel to the start of the Lower Ladder);
- Transportation Channel (from upper end of Trifurcation Pool to the Transition Ladder where pool and weirs start);
- Right and Left Fishway entrances;
- Right Fishway Entrance Collection Channel (from Right Fishway Entrance to Trifurcation Pool including orifice gates); and

- Trifurcation Pool (convergence area of Spillway Entrance Channel, Left Fishway Entrance Channel, and Right Fishway Entrance Collection Channel).

The Upper Ladder/Fishway Exit section includes the count station and a series of control weirs located immediately downstream. The adult salmon trapping facility and count station use a trash rack and vertical weir structure to route upstream moving fish past the video chamber and gated trap. The Chelan PUD representative explained that the structure was "fish tight" due to the small gap size (3/4 inch nominal) on the trash rack and the rubber gaskets sealing the panels to the fishway stem walls. All fish, including lamprey, must pass through the video chamber to exit into the forebay. Below the trapping/counting facility are a series of control weirs. These control weirs provide a 1 foot incremental increase in elevation within the Upper Ladder. Although orifice corners at these weirs have beveled edges, the orifice openings are perched. The top edges of the weirs in this section are beveled on the downstream side and have a 90 degree angle on the upstream side. The start of this fishway section (downstream end) contains a single AWS chamber and diffuser grating that spans the width of the fishway floor. All diffuser grating in the fishway has a 1-inch nominal gap. Adult lamprey trapping also occurs at this diffuser location.

The Lower Ladder section of the fishway is defined as the portion of the fishway between the Upper Ladder/Fishway Exit and the Transition Ladder. This section of the fishway is composed of pools separated by weir walls with orifice openings to facilitate passage. Edges at the tops of weirs and at the edges of orifices openings are apparently similar to weir and orifice edges in the Upper Ladder section.

The Transition Ladder section lies between the Lower Ladder and Transportation Channel. Unlike the control weirs in the Upper Ladder/Fishway Exit section, the orifice openings in this section are flush with the fishway floor. There are eight pools at the downstream end of this section that have diffuser grating that span the width of the floor. During previous fishway maintenance activities, some plating was added around the edges of diffusers.

The Transportation Channel is defined as the area of the fishway between the Trifurcation Pool and the Transition Ladder area that begins the ladder section of the fishway. This area of the fishway is simple in structure (no weir walls and is linear).

The Right Fishway Entrance Collection Channel connects the Right Fishway Entrance with the Trifurcation Pool. Also within this fishway section are a series of orifice gates evenly divided between the left and right bank ends of the channel. Six of these gates (gates 16, 18, 20 on the right bank and gates 1, 2, 3 on the left bank) are typically in operation for fish passage. Similar to the Transportation Channel, this section of the fishway is linear and simple in structure. However, diffuser grating is located at each of the areas where orifice gate openings are present. Staff at the Project did express an interest in closing these gates as previous assessment data indicate little use.

The Trifurcation Pool is the area where all three entrances (left, right, and spillway) converge and connect to the Transportation Channel. Diffuser grating spans the entire width of the fishway floor throughout this area. This section of the fishway was partially inundated and

observations about the conditions of the grating and whether any plating exists could not be confirmed.

The Left Fishway, Right Fishway and Spillway entrances are designed as rectangular slots that can accept bulkheads to provide complete or partial gating. The entrances were inundated, which limited observations; however, drawings indicate that floor diffuser grating that spans the width of the floor exists at the Left Fishway, Right Fishway and Spillway entrances.

During the fishway tour, issues of concern raised by participants relative to adult lamprey passage included the potential for water velocities that may impede entrance to the fishway, areas of the fishway with diffuser grating, and the perched orifices in the Upper Ladder.

5.0 Recommendations for Consideration

Based upon a review of existing site specific assessments (Section 2.0) and fishway design drawings, results of modifications that have been implemented and/or evaluated at other Columbia River basin projects (Section 3.0), observations gathered during the February 25, 2010 fishway tour (Section 4.0), and the Team's best professional judgment, a list of potential modifications for the Rocky Reach fishway are provided below. The recommendations presented in this section are not exhaustive, but reflect a collective evaluation of the body of existing information while qualitatively evaluating a measure's relative cost magnitude and potential benefit, probability of success, and applicability to site. The recommendations are intended to provide a basis for future RRFF discussions regarding identification of additional information needs, and the selection of the first phase of modifications to be evaluated. These recommendations, considered collectively, are intended to represent a step-wise, iterative, and scientifically rigorous approach to improving adult lamprey passage at the Project.

1. **Entrance Synopsis:** Based upon the results of the 2004 study (Stevenson et al. 2005), a fishway entrance efficiency of 94% (n=110) of fish detected in the tailrace is higher than at other projects in the basin which ranged from 14% to 85%[5]. During the fishway tour, fishway entrances were partially inundated so an evaluation of entrance structures (bulkhead slots, presence of sill, and other transition structures) was not possible.

   Recommendation: In evaluating the literature related to lamprey fishway entrance efficiency, relatively high water velocities at and inside fishway entrances have been identified as a major impediment to lamprey passage. Based upon a review of the available site-specific information, hydraulic barriers at or inside the fishway entrance do not appear to impede lampreys' ability to enter the Rocky Reach fishway. The 2004 study results indicate that entrance efficiency into the Rocky Reach fishway is high. The Team recommends continued monitoring during the next evaluation. The Team also recommends that during the next winter fishway outage when the entrance area is accessible, that a structural assessment of each entrance floor and walls for lamprey-friendly transitions, be conducted. If future monitoring of the fishway entrance identify significant decreases in performance, the RRFF may consider structural (e.g., rounding corners) or operational (e.g., nighttime reduction of water velocities) measures at that time.

[5] Range of entrance efficiencies reported are based upon studies conducted at Bonneville, The Dalles, Priest Rapids, Wanapum, and Wells dams.

2. **Collection Channel / Entrance Channels / Trifurcation Pool Synopsis:** Travel rates were relatively high from the Right Fishway Entrance and Orifice Gate (O.G.) Entrances 18-20, but substantially lower from O.G. Entrances 1-3 and the Left Fishway Entrance (Stevenson et al. 2005). The 2004 study notes that downstream movement within the collection channel was detected after entrance to the channel from O.G. Entrances 1-3. Fishway design drawings show large areas of diffuser grating that span the width of the fishway floor immediately inside the Spillway Entrance, Left Fishway Entrance, and O.G. Entrance. Further, travel rates through the Trifurcation Pool were "somewhat surprising" (i.e., relatively fast) given the continuous expanse of diffuser grating in this location (Stevenson et al. 2005). Although a visual evaluation of the fishway floor at the Trifurcation Pool was not possible during the tour, Project schematics confirm that the floor in this area consists entirely of diffusion grating.

   Of the 110 tagged lamprey entering the fishway, all of them progressed upstream and were detected at the Trifurcation Pool. Therefore, these fish traveled the entire segment from a respective entrance to the start of the Trifurcation Pool. They also displayed the highest travel rates (m/min) for a monitored segment of the fishway (Table 5, Stevenson et al. 2005). However, 45% of these lamprey dropped back out of the fishway (n=30) or were last detected residing in the fishway or AWS system (n=20). It is important to note that typical operational life of transmitters used during the study averaged 45 days. Therefore, the final fate of fish last detected residing in the fishway or AWS system is unclear (i.e., they may still have passed the Project after tag expiration).

   Data regarding the extent of progression past the Trifurcation Pool was not reported on; however, these data indicate that after lamprey arrive at the Trifurcation Pool, structural and/or hydraulic impediments exist that reduce continued upstream migration or causes them to drop-out from the fishway into the tailrace.

   Using their oral disks, Pacific lamprey exhibit a burst and attach behavior to negotiate areas of difficult passage and high water velocity. In fishways, this type of behavior can be ineffective, particularly where suitable attachment surfaces are unavailable (Keefer et al. 2010b). Diffuser grating serves as the structural interface between the AWS and fishways. These structures have been identified as potential problem areas for lamprey because of their lack of solid continuous surfaces. Within the Right and Left Fishway Entrance channels, Trifurcation Pool, and Transition Ladder, a high frequency of diffuser grating was identified.

   Recommendation: Conduct additional analyses of the 2004 data to determine the number of unique lamprey detected by detection zone, and more specifically, determine the extent of upstream movement in the fishway for each individual. This analysis would demonstrate the progression of some individuals and the attrition of others. If the segment of the fishway where the majority of the "losses" can be identified, then site specific measures may be developed.

   Provide solid continuous aluminum plating (18-inch wide) around the entire perimeter of each diffuser grate (along walls and across end points) through the Right and Left Fishway Entrance channels, Trifurcation Pool, and Transition Ladder (Table 1, Measure 5). Installing plating to the diffuser grating perimeter at these locations will provide migrating lamprey a continuous, solid surface in which to exhibit burst and attach swimming behavior, thus

improving passage times, reducing entrance into the AWS system, and reducing frequency of drop back into the tailrace after entering the fishway.

Consider the closure of O.G. Entrances 1-3. These gates had relatively low (12% of fish entering used these locations) use during the 2004 study and lamprey were reported as having a high frequency of downstream movement after entrance. Further, these gates provide entrance directly into areas with diffusion plating. It is likely overall entrance efficiency would not be impacted at the Project due to the other numerous options for entering the fishway.

3. **Transportation Channel Synopsis:** This section of the fishway is completely concrete without any weirs or diffusion chambers. There is no indication that lamprey migration may be impeded through this section by structural or operational conditions.

   Recommendation: None.

4. **Transition Ladder and Lower Ladder Synopsis:** The Transition Ladder area contains a set of 9 diffuser grates in pool and weir structures. All orifices in these pools are flush with the fishway floor, and corners of orifice openings are beveled. The Lower Ladder section of the fishway appears to be similar to the Transition Ladder section; however, no diffuser grating is present. During the tour, the Team was unable to access the Lower Ladder section of the fishway to confirm that orifice openings were flush with the fishway floor and that the corners of orifice openings were beveled.

   Recommendation: The Team recommends 18-inch wide perimeter aluminum plating around all diffuser grating in the Transition Ladder section (Table 1, Measure 5). This should allow migrating lamprey a continuous, solid surface along the perimeter of each pool to bypass upwelling flows created by diffusers and should improve passage times, reduce entrance into the AWS system, and may reduce the frequency of drop back after entering the fishway. The Team also recommends confirming that all other orifice openings in this Lower Ladder section are flush with the fishway floor and at that corners of orifice openings are beveled.

5. **Upper Ladder Synopsis:** This area contains one large diffuser grating that begins the Upper Ladder section of the ladder. This area also served as the location where lamprey were trapped for the 2004 study. Upstream of the lamprey trapping area are a series of control weirs that contain perched orifices (i.e., orifice has sill and is not flush to fishway floor). Although the corners of the orifice opening are beveled, perched orifices have been identified as potential passage impediments at other basin projects. Generally, velocity differentials between the areas below the sill (below the main orifice flows and lower then flows directly in orifice opening) and over the sill (within the orifice where flows are at a maximum) create hydraulic barriers that may be problematic to migrating lamprey. Burst and attach behavior is not well adapted to transition areas with high differentials in velocities. Allowing for more gradual changes both structurally and hydraulically at perched orifices is more complimentary to lamprey swimming behavior.

   Recommendation: The Team recommends 18-inch wide perimeter aluminum plating around the diffuser grating (Table 1, Measure 5). Allowing lamprey a continuous, solid surface along the perimeter of this area to bypass upwelling flows should improve passage

times, reduce entrance into the AWS system, and may reduce the frequency of drop back after entering the fishway. The Team also recommends constructing ramps upstream and downstream of all perched orifices in this Fishway Exit section to ensure a gradual structural and hydraulic transition through the orifice (Table 1, Measure 6) more complimentary to lamprey swimming behavior.

6. **Count Window Synopsis:** Historically, the potential for lamprey to bypass the count station existed due to gaps in the associated structures of the fish count window. However, Chelan PUD implemented the following during the 2008-2009 winter fishway outage to prevent lamprey from evading the counting window (Table 1, Measure 7):

   a. Three-quarter inch nominal mesh trash rack was installed.

   b. Brush strips were added to the counting backboard and the trash rack edges.

   c. A rubber seal was added to the downstream end of the counting board.

   Recommendation: The Team recommends continued monitoring during the next evaluation and reporting of higher resolution tag detection data to assess whether passage delays due to hydraulic barriers exist at the count station or whether lamprey are bypassing the count window.

7. **Fallback after Ladder Exit Synopsis:** The 2004 study indicated a conditional fallback rate of 21.5% and a net fallback (after considering re-ascension) rate of 14.5% (slightly higher than other facilities in the basin). The results of the 2004 study indicated fallback through powerhouse units 1-4 with the highest frequency through unit 1 (8 fish).

   Recommendation: Since all potential modifications to address fallback have a relatively high cost with uncertain benefit, the Team recommends evaluating frequency of fallback during the next adult lamprey passage evaluation to increase sample size toward validating the 2004 study conclusions. Toward consideration of having to address fallback at the Project in the future, it is recommended that the next passage evaluation consider three additional study design elements: 1) Identify a location in the Upper Ladder/Fishway Exit section where lamprey may be collected. As an example, it may be possible to open a small section of the picketed lead downstream of the count window and provide a ramp to a trap box similar to LPS structures at other facilities in the Lower Columbia River; 2) Tag and release an appropriate number of lamprey at pre-determined distances upstream of the Fishway Exit along the right bank to determine alternative locations upstream of the fishway where lamprey may be less prone to fallback; 3) If hydraulic data of the Rocky Reach forebay exist, utilize the information to assess the potential for lamprey entrainment as based on bulk flow patterns, water velocities and bathymetry.

   If future study results identify fallback as substantial, data collected from these additional study components will help to inform the design and location of collection systems (e.g., LPS system) where fish can access this alternative passage system at an Upper Ladder location (e.g., exit pool, at count station, trapping location) and migrate volitionally upstream (distance to be determined by study data) along the right bank shoreline to an exit location outside of the influence of entrainment flows. Another alternative modification may include

a modified LPS to a trap box (Table 1, Measure 1) where fish would then be transported upstream to an area upstream of the influence of entrainment flows.

6.0 Prioritization of Recommendations

The ranking of potential modifications (Section 5.0) considered existing site-specific information in combination with a modification's relative cost, location in the fishway (lower fishway modifications were generally prioritized higher), its probability of improving lamprey passage performance and the magnitude of a modification's improvement on the overall population passing Rocky Reach dam (e.g., the higher the probability of improving passage performance for a larger proportion of fish, the higher the prioritization ranking). Recommendations of "continued monitoring" from Section 5.0 were not considered in the prioritization exercise because unlike specific modifications, these will not directly improve passage performance at the Project, will have no significant costs associated with them above traditional study evaluation costs, and should automatically be implemented during the next evaluation period in order to conserve passage metrics for comparison between studies.

Similar to Section 5.0, these prioritized recommendations represent the Team's best professional judgment and are intended to provide the RRFF a basis for future discussions toward the selection of the first phase of fishway modifications to be evaluated. During the selection process, it may be necessary for the RRFF to collect additional information or conduct additional analysis to evaluate the feasibility of implementing recommended modifications (as described in this section) in the Rocky Reach fishway.

The potential modifications identified in Section 5.0 are ranked below beginning with highest priority modifications:

1. *18-inch wide aluminum plating around the perimeter of each diffuser grating in the Entrance Channels, Collection Channels and Trifurcation Pool Section*. Although travel times were relatively high in these lower sections of the fishway, the data indicate that 45% of lamprey entering the fishway either dropped back or were last detected residing in these areas. Plating around diffuser grating in these lower sections of the fishway is a relatively low cost, high benefit modification that may reduce drop back and facilitate successful passage further upstream in the fishway for a relatively large number of fish passing the Project.

2. *18-inch wide aluminum plating around the perimeter of each diffuser grating in the Transition Ladder Section.* Median travel times through the Transition Ladder were generally slower than in the Entrance and Collection Channels and Trifurcation Pool Area (with the exception of fish that entered through Orifice Gates 1-3). Plating around the perimeter of diffuser grating in this area of the fishway is a relatively low cost, high benefit modification that may reduce drop back and increase travel times in this section of the fishway.

3. *Confirm all orifice openings are flush with the fishway floor and that corners of orifice openings are beveled in the Lower Ladder Section.* From discussions with staff at the Project, this section of the fishway has orifice openings flush with the floor and beveled corners at orifice openings. On-site confirmation that this section of the fishway

compliments lamprey behavior would be critical to improving fishway passage performance and ensuring the efficacy of modifications conducted in the lower fishway. This is a simple activity, free of significant costs and is considered a high priority.

4. *18-inch wide aluminum plating around the perimeter of the diffuser grate at the start of the Upper Ladder Section.* Median travel times of tagged fish were lowest in this section of the ladder. Plating should increase travel times, reduce the possibility of residualization in the ladder, drop back and the likelihood of entrance into the AWS system.

4. *Tied with #4 above (plating) - Ramp all perched orifices in the Upper Ladder Section.* This modification should be implemented concurrent with plating the diffuser grate in this fishway section to increase the likelihood of improving travel times and reducing residualization or drop back.

5. *Fallback – tag and release fish at various distances upstream of fishway exit.* Tagging and releasing fish at various locations upstream of the fishway exit may provide additional information related to the scope of future modifications if results from continued monitoring indicate that Project fallback rates are a concern.

6. *Review of Existing Hydraulic Information in forebay to inform fallback*. If available, this information would inform the release locations of tagged fish identified in #5.

7. *Closure of Orifice Gates 1-3*. Plating around the perimeter of diffuser grating located immediately inside of Orifice Gates 1-3 (as described in #1) may increase passage times and reduce drop back in this section of the fishway and reduce the need for closure of these gates, especially if these gates are critical in the passage of other species. During the 2004 study, only a relatively small number of fish entering the Rocky Reach fishway entered through these gates (N=13). If these gates are not critical to the passage of other species (i.e., HCP species are not impacted), this activity could be prioritized higher.

8. *Fallback – identify alternative location in the Upper Fishway Section where lamprey may be collected.* This is a low priority given the existing lamprey trap located at the start of the Upper Fishway Section. If in the future, a more permanent location for lamprey collection were needed for alternative volitional passage or transport, the current location could be used.

9. *Assess fishway entrance for lamprey-friendly transitions.* Entrance efficiency at Rocky Reach Dam is high with 94% of fish detected in the tailrace entering the fishway during the 2004 study. These results suggest that fishway operations and structures at the entrance are conducive to successful entry into the fishway. When evaluating the entrance in consideration of other areas within the fishway where data indicates impediments to passage may exist, this action was determined to be a low priority.

10. *Analysis of the 2004 data set.* If modifications #1-#4 are implemented, the analysis of the 2004 dataset may not provide significant insight into additional "sight-specific measures." However, specific queries of the 2004 data set may still provide insight into locations where alternative technology may be used to evaluate the efficacy of fishway

modifications (e.g., the use of an underwater video camera at a modified location that analysis has determined may be problematic).

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Appendix A
Summary of RRFF Comments on Outline and Draft Literature Review, Analysis, and Recommendations for Pacific Lamprey Upstream Passage Improvements and Consultant Team's Responses

Summary table of RRFF comments on the Pacific Lamprey Upstream Passage Modifications Literature Review and Analysis and Recommendations for Passage Improvements in the Rocky Reach Fishway and consultant team's responses [6]

Comment Number	Comment Date/Source	RRFF Comment	Consultant Team's Response to Comment
1	3/29/10 RRFF red-line of Literature Review Document outline	Section 1.3 Consultation: Move this section to an appendix.	The section was retained within the main body of the document to provide a summary of the consultation that occurred between the RRFF and the consultant team throughout the development of the Literature Review Document but the comment/response table and the consultation documentation are contained in appendices.
2	3/29/10 RRFF red-line of Literature Review Document outline	Section 3.0 Literature Review: This section should identify what existing structures work and which ones do not. Also identify what modifications work and which ones do not. In addition, describe why successful structures work. For example, describe the velocity and hydraulic characteristics associated with the different structures.	*Pursuant to 4/19/10 memo from the consultant team to the RRFF:* Section 3.0 consists of a table that includes all information relevant to adult upstream passage improvements (planned, implemented, and evaluated) in the Columbia River basin. The Team intends to use peer-reviewed literature, reports and management plans, and personal communications with researchers as the primary sources for reporting information. Any conclusions about the efficacy of modifications and additional supporting information that may explain why a modification may be effective will be reported only if they are communicated within the reports or by the researchers. Typically, results of evaluations of a modification are reported as statistics as opposed to definitive conclusions of a modification's effectiveness. For the purposes of the literature review, Team members shall only report the available information.
3	3/29/10 RRFF red-line of Literature Review Document outline	Section 3.0 Literature Review: Although the RFP indicated that the literature review is to focus on the Columbia River Basin, if you have time, please consider including information on lamprey passage at other projects outside the Columbia River Basin.	Pursuant to the requirement set forth in the Pacific Lamprey Management Plan and consistent with the FERC license order: "*Chelan PUD shall, within one year of the effective date of the New License, complete a literature review of the effectiveness of upstream lamprey passage measures implemented at other hydroelectric projects in the Columbia and Snake rivers….*"

[6] Comments provided in the RRFF's March 29 and June 16 document red-lines that were editorial or organizational in nature were accepted and/or changed in the document and are not identified in this table.

Comment Number	Comment Date/Source	RRFF Comment	Consultant Team's Response to Comment
4	3/29/10 RRFF red-line of Literature Review Document outline	Section 4.0 Rocky Reach Fishway Tour/Observations: This section should focus on describing the Rocky Reach fishway and how it compares with fishways at other dams. In terms of lamprey passage efficiency, describe how the Rocky Reach fishway design compares with other fishway designs.	*Pursuant to 4/19/10 memo from the consultant team to the RRFF:* The purpose of the fishway tour was to provide a brief summary of observations of the fishway elements relevant to lamprey passage at Rocky Reach Dam. Section 4.0 Rocky Reach Fishway Tour/Observations will include a brief description of the Project fishway's architecture as an introduction to the fishway tour and observations of fishway elements relevant to improving lamprey passage. Additional comparisons with fishways at other dams are considered outside the scope of the review. With regard to including additional information related to passage efficiency, results of Rocky Reach lamprey passage assessments can be found in Section 2.0 and other project passage efficiency evaluations that have occurred post-modification can be found in Section 3.0. In Section 5.0 Recommendations for Consideration, any fishway elements that are recommended for modification will include supporting information (e.g., other locations where implemented and improvement observed) as to why these potential modifications may be appropriate at Rocky Reach.
5	3/29/10 email from Bob Rose (Yakama Nation) with additional comments	With regards to the Adult Lamprey Metrics being developed by the Columbia Basin Fish and Wildlife Authority (CBFWA) Tech Work Group, I think each of the metrics can be pigeon-holed into three general slots: 1) Entrance Efficiency 2) Ladder Passage (efficiency and ability to count) 3) Fallback from forebay back to tail race. Maybe there is better way to organize these metrics - but I'd like to see the document organized accordingly.	Recommendation adopted by the consultant team. The respective metric was identified for each measure in Section 3.0/Table 1 of Literature Review Document.

Comment Number	Comment Date/Source	RRFF Comment	Consultant Team's Response to Comment
6	3/29/10 email from Bob Rose (Yakama Nation) with additional comments	Suggests reserving a section for a discussion of study design characteristics / potential issues for each of these major passage components.	*Pursuant to 4/19/10 memo from the consultant team to the RRFF:* The request for statement of qualifications and the subsequent contract were developed around 3 elements: 1) complete a literature review of the effectiveness of upstream lamprey passage measures and studies implemented at other hydroelectric projects in the Columbia and Snake rivers; 2) review pertinent documents to Pacific lamprey studies conducted at Rocky Reach Dam; and 3) provide recommendations regarding passage improvement measures, either structural or operational, that are deemed technically feasible to implement at Rocky Reach Dam. Although the [Consultant] Team agrees that a discussion of study design characteristics and potential issues related to major passage elements is necessary prior to moving forward with any potential modifications to improve adult lamprey passage at Rocky Reach Dam, this additional analysis is outside of the scope of the current contracted work. The literature review document is intended to serve as the basis for the step described in the comment above. Despite not being included as part of the current scope of work, this additional step could be integrated into the existing scope of work (with contract modifications) or it could be identified as a separate scope of work to be conducted in the future.
7	6/16/10 RRFF red-line of draft Literature Review Document	Section 2.0 Background: [In #1 and #2 of numbered list] Please define "drop out" and "fall back".	Definitions have been added.
8	6/16/10 RRFF red-line of draft Literature Review Document	Section 2.0 Background: Related to the statement, *"Forty-five percent (n=50) of lamprey entering the fishway (n=110) dropped out of the fishway or were last detected residing in the fishway (did not pass)"*, tag life may have expired when the fish were in the ladder or in the tailrace. Therefore, is it correct that they "did not pass?" Recommend deleting "did not pass.	The consultant team agrees. "Did not pass" has been deleted.

Comment Number	Comment Date/Source	RRFF Comment	Consultant Team's Response to Comment
9	6/16/10 RRFF red-line of draft Literature Review Document	Section 3.0 Literature Review: In the table, add discussion on grating size.	Paragraph added to item #4a in Table 1.
10	6/16/10 RRFF red-line of draft Literature Review Document	Section 5.0 Recommendations and Conclusions: [In recommendation #1] Please add a range of entrance efficiencies at these other projects.	Done.
11	6/16/10 RRFF red-line of draft Literature Review Document	Section 5.0 Recommendations and Conclusions: [In recommendation #2] Need to address the tag life issue.	Done.
12	6/16/10 RRFF red-line of draft Literature Review Document	Section 5.0 Recommendations and Conclusions: [In recommendation #5] Related to the statement, "*Note that during evaluations, plating in this area of the fishway may reduce trapping efficiency",* fish already miss the trap by the time they reach the grating; therefore, the plating would have no effect on trapping efficiency. Recommend deleting sentence.	Sentence deleted.
13	6/16/10 RRFF red-line of draft Literature Review Document	Section 5.0 Recommendations and Conclusions: [In recommendation #7] This [first] paragraph should focus on what is known. Currently, too many assumptions and speculation.	The consultant team agrees; the paragraph has been modified accordingly.
14	6/16/10 RRFF red-line of draft Literature Review Document	Section 5.0 Recommendations and Conclusions: [In recommendation #7] Related to the statement, "*fish already miss the trap by the time they reach the grating; therefore, the plating would have no effect on trapping efficiency",* recommend deleting sentence as the flow is not perpendicular to the exit.	Sentence deleted.

Comment Number	Comment Date/Source	RRFF Comment	Consultant Team's Response to Comment
15	6/16/10 RRFF red-line of draft Literature Review Document	Section 5.0 Recommendations and Conclusions: [In recommendation #7] Related to the statements, "*lamprey exiting into the forebay upstream of the powerhouse will have a tendency to sound to greater depths due to their demersal behavior. Since lamprey are relatively poor swimmers as compared to salmonids, they are more likely to be entrained in powerhouse flows"*, entrainment is not an issue at the exit (it may be an issue upstream from the exit); recommend deleting these two sentences because they are inaccurate.	Sentences deleted.
16	6/22/10 and 6/25/10 emails from RRFF	Request for consultant team to prioritize the list of recommendations in the Literature Review Document.	Consultant team added a Section 6.0 to the Literature Review Document that prioritizes the list of recommendations in Section 5.0

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Appendix B
Consultation on Outline and Draft Literature Review, Analysis, and Recommendations for Pacific Lamprey Upstream Passage Improvements

From: Bao Le
Sent: Thursday, March 18, 2010 2:55 PM
To: Tracy Hillman
Cc: Osborn, Jeff; Bryan Nass; Emily Andersen
Subject: RRH Pacific Lamprey passage modifications lit review and recommendations: draft outline
Attachments: PLMP lit review outline 03-18-10 to RRFF.doc

Hi Tracy. Please find attached a draft outline of the RRH Pacific lamprey passage modifications literature review and recommendations document to be provided to the RRFF for approval. Please note a couple of things:

1. Our team has three tasks:
    a. Literature review
    b. Rocky Reach fishway tour/summary memo
    c. Recommendations for potential passage modifications that can be implemented and then evaluated at Rocky Reach Dam in the near term

    We thought it would be much more efficient and user-friendly to structure the document in a comprehensive manner so that includes all three of the above tasks since they are all inter-related to one another and support the same objective.

2. Per discussions with Bryan, I understand that this document could go directly to you for distribution to the RRFF and for discussion at the next RRFF meeting. However, since this is a little bit different then how we have done things for other clients, I have cc'd Jeff here so that if he would like to review this document and comment, we could address those comments prior to you sending this out. This is obviously a critical component of the communication/work flow so I find it better to get clear guidance on this assumption. Jeff, please weigh-in here as to whether you desire a review or not and whether in the future, you'd like us to communicate directly with Tracy on the development of the next phases of the document.

Please let me know if you have any questions. Thanks, Bao

Bao Le
Long View Associates, Inc.
p-503-719-7355
c-503-309-9423

Rocky Reach Fish Forum Meeting Minutes

Date: March 25, 2010
Time: 10:00 am – 3:00 pm
Location: Chelan PUD Headquarters, Wenatchee, WA
Second Floor Conference Room

Call in number: (509)661-4844, Password is 4000.

Meeting called by:	Jeff Osborn, Chelan PUD	Type of meeting:	RRFF Meeting
		Note taker:	Debby Bitterman

Representatives

Name	Agency	Phone	Email
Glesne, Reed	NPS	(360) 856-5700 x369	Reed_Glesne@nps.gov
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Huber, Bob	Alcoa	(509) 664-2193	bob.huber@alcoa.com
Irle, Pat	Ecology	(509) 454-7864	pirl461@ecy.wa.gov
Lewis, Steve	USFWS	(509) 665-3508 x14	stephen_lewis@fws.gov
Marco, Jerry	CCT	(509) 634-2114	jerry.marco@colvilletribes.com
Osborn, Jeff	Chelan PUD	(509) 661-4176	jeff.osborn@chelanpud.org
Rose, Bob	YN	(509) 865-5121	brose@yakama.com
Viola, Art	WDFW	(509) 665-3337	violaaev@dfw.wa.gov
Vradenburg, Keith	City of Entiat	(509) 784-1500	kvradenburg.city@entiat.org

Participants

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Hillman, Tracy	BioAnalysts	(208) 321-0363	tracy.hillman@bioanalysts.net
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James, Brad	WDFW	(360) 906-6716	jamesbwj@dfw.wa.gov
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Miller, Joe	Chelan PUD	(509) 661-4473	joseph.miller@chelanpud.org
Nordlund, Bryan	NOAA	(360) 534-9338	bryan.nordlund@noaa.gov
Rosebrough, Susan	NPS	(206) 220-4121	susan_rosebrough@nps.gov
Verhey, Patrick	WDFW	(509) 754-4624	Patrick.Verhey@dfw.wa.gov

Attendees in BOLD

Meeting Purpose: Meeting of the Rocky Reach Fish Forum to continue Rocky Reach license implementation

Minutes

Tracy Hillman welcomed everyone to the Rocky Reach Fish Forum (RRFF) meeting and made known that voice recording of the meeting was initiated.

Tracy reviewed the agenda with the Forum and asked if the Forum was okay with reshuffling agenda items to accommodate Bob Rose, who would be available by phone from 1:00 to 2:00 pm. The Forum approved the reorganization of the agenda items. The Forum also agreed that any agenda items requiring a decision must be made

known to the Forum at least five business days before the scheduled meeting. Any agenda items added after the five-day period and requiring a decision would be considered by the Forum during the following scheduled meeting.

Pat Irle asked that the Forum develop a one- or two-page document that lists the Forum's protocols (rules). Tracy Hillman and Debbie Bitterman will begin development of the list.

February 25 meeting minutes were reviewed and approved with edit changes.

White Sturgeon

Bob Rose invited RRFF members to participate on a tour of the Yakama Nation (YN) sturgeon facilities at Toppenish on Wednesday, April 7, 2010. Members are to respond to Bob if they want to attend the tour.

Joe Miller reported that Chelan PUD was moving forward in finalizing a contract with the YN for sturgeon rearing at their Marion Drain facility. The scope of work includes mating, early life history, grow-out, and planting. Joe also noted that Chelan PUD, YN, and WDFW coordination of brood stock collection activities in McNary, Wanapum, and Priest Rapids reservoirs are moving forward.

Steve Lewis confirmed that Rocky Reach White Sturgeon Management Plan activities, specifically the collection of 12 sturgeon (six males and six females) for broodstock, is covered for bull trout take under the USFWS Rocky Reach relicensing Biological Opinion.

Tony Eldred asked if Brad James had a chance to review and comment on the White Sturgeon Plan. Joe Miller indicated that Brad did not provide any comments during the discussion. Tracy Hillman will check with Brad to see if Brad had any concerns or comments on the White Sturgeon broodstock plan.

Action item:

- ✓ Tracy will email the Rocky Reach Fish Forum Sturgeon Update, 1-28-10, to Brad James to see if he has any concerns or comments.

Resident Fish

The Forum reviewed and commented on the draft Rocky Reach Resident Fish Study Plan. Art Viola recorded in his document the many comments made by members. Members also agreed to send Art comments in track changes (due to Art on April 23). The Forum identified the following schedule for completing the revised draft study plan:

- April 23 – RRFF members provide red line comments to Art Viola and Dave Burgess (cc to Tracy Hillman)
- May 21 – Art Viola and Dave Burgess send revised draft to Tracy
- May 21/24 – Tracy will distribute revised draft to RRFF
- May meeting – RRFF will discuss the revised draft

Bob Huber suggested that Chelan PUD prepare a press release to alert the public when the proposed night surveys will occur. This should reduce the number of calls the Sheriff's Office receives during the nights of the surveys.

Action item:

- ✓ Waikele Hampton and Steve Hays will develop a water quality sampling plan to present to the RRFF at the May meeting, portions of which could be included in the Resident Fish Study.
- ✓ Chelan PUD (Jeff Osborn and Steve Hays) will review the study plan to ensure that statements, goals, and objectives are consistent with the Rocky Reach Settlement Agreement.

Pacific Lamprey Artificial Propagation RFQ

The Forum reviewed and commented on the artificial propagation Request for Qualifications (RFQ). The forum agreed to all edits and recommended that the RFQ be sent to consultants for their reply. The Forum also supported the need to

include a cover letter that would state that the consultant/entity could submit their Statement of Qualifications (SOQ) for Tasks 1, 2 or both. The following timeline was approved by the Forum:

- March 26 – Bob Rose will send the final RFQ to Tracy
- March 30 – Jeff Osborn will send a draft cover letter to Tracy
- March 30/31 – Tracy will package the cover letter and RFQ and send them to the Pacific lamprey subcommittee (Steve Lewis, Bob Rose, Pat Irle, Molly Hallock, and Jeff Osborn) for review
- April 2 – Subcommittee will send comments to Tracy
- April 2 – RRFF will send potential consultant/entity names to Tracy
- April 5 – Tracy will send final cover letter and RFQ to potential consultants/entities
- May 7 – Consultants/entities will submit their SOQ's to Tracy
- May 10 – Tracy will email consultants/entities SOQ's to the subcommittee for their review

Molly Hallock asked where one would collect lamprey broodstock. Bob Rose thought that fishways would be a good starting place.

It was noted that Chelan PUD has an active accounting process that tracks all out-going costs that occur during the Literature Review and Recommendations for the Pacific lamprey Upstream Passage Improvements and future studies.

Action item:

- ✓ Tracy will begin developing a list of possible consultants/entities and send it to the Forum by March 31. Members will make additional recommendations and send those to Tracy by April 2.
- ✓ Jeff will email a meeting (May 17) request to Pacific lamprey subcommittee to review SOQ's

Pacific Lamprey Update

Jeff reported that he was still working on identifying potential sampling locations for ammocoetes within the Rocky Reach Reservoir. He also noted that he is still in the process of researching GIS mapping of aquatic habitat within the reservoir. Jeff indicated that he will attempt to contact the author of the study (John Blum) to verify the locations of the ammocoetes collected during the Benthic Macroinvertebrate Survey 1999.

Bob Rose stated that there is definitely a regional interest in studying Pacific lamprey. He is investigating other potential sources of funding (e.g., WASCO, FCRPS, PUD, and CRITFC funds) for lamprey studies. Bob also noted that it would be cost effective to join efforts with multiple agencies to rear lamprey.

Steve Lewis indicated that he and Bob Rose talked about how to sample ammocoetes in the reservoir. Because of ESA consulting and permitting, there may be an issue with deep-water shocking. Therefore, they are thinking that a simple approach (e.g., grab samples or shovel samples) may be appropriate. Steve indicated that they will provide more information on this during the next meeting.

Action item:

- ✓ Jeff will provide an update regarding Reservoir investigations for ammocoetes
- ✓ Jeff will continue his mapping investigation
    - o ID sampling locations within Rocky Reach Reservoir
    - o Ability to use GIS for identifying aquatic habitats within the reservoir

Juvenile Lamprey Impingement Monitoring

RRFF provided comments on the draft Juvenile Lamprey Impingement Monitoring proposal. This proposal is to continue juvenile lamprey impingement monitoring at Rocky Reach to satisfy the license condition. Forum attendees approved the proposal.

It was noted that funding for this monitoring is supported by general relicensing funds and not the $700,000 identified in Section 4.2.3 *Measurement of Impacts on Juvenile Downstream Migration* of the Pacific Lamprey Management Plan.

Jeff Osborn noted that this work will cost roughly $4,000-$5,000 per year.

Action item

- ✓ Molly Hallock and Bob Rose will provide comments to Tracy by March 29
- ✓ Jeff will provide a lamprey impingement report to the forum every 2 weeks during the April 15 through June 15 monitoring period.

Literature Review for Pacific lamprey

RRFF reviewed and commented on the draft outline for the Literature Review and Recommendations for Pacific lamprey Upstream Passage Improvements report per the consulting team's request. Pat Irle stated that the report should include what modifications and existing structures work, and that the review should not be entirely Columbia River basin centric. She also asked that the Consultants describe why a certain structure works (i.e., discuss hydraulic and velocity profiles associated with the structures). Steve Hays noted that the report should compare the fishway at Rocky Reach with fishways at other projects (fishway design comparison). The Forum directed Tracy to share these and other comments with the Consultants.

Action item;

- ✓ Tracy will share with Bao Le the recommendations of the RRFF on the draft outline for the Upstream Passage Literature Review report.
- ✓ Tracy will request that a 70-75% complete draft report be submitted to the RRFF by April 20.

Misc

Items to be discussed at the next meeting:

- Update on reservoir investigations for ammocoetes
- Update on sampling ammocoetes in the reservoir
- Update on trapping of upstream-migrating adults in the tailrace of Rocky Reach Dam

Next meeting is April 29, 2010

*Note that there is a proposal to change the May 29th meeting to May 24th.

From: Tracy Hillman [tracy.hillman@bioanalysts.net]
Sent: Monday, March 29, 2010 10:36 AM
To: Bao Le; Emily Andersen; Bryan Nass
Cc: Art Viola; Bob Huber; Bob Rose; Deborah Bitterman; Jeff Osborn; Molly Hallock; Pat Irle; Steve Hays; Steve Lewis; Tony Eldred; Waikele Hampton
Subject: Comments on the Literature Review Outline
Attachments: PLMP lit review outline 03-18-10 to RRFF (RRFF comments).doc

Hello Consultant Team,

Thank you for submitting an outline for the literature review for Pacific lamprey upstream passage improvements. The RRFF had an opportunity to review the outline during the last meeting and provide their edits/comments (see attachment).

The RRFF would appreciate receiving a rough draft (~75% complete) by Tuesday, April 20. The RRFF will review the incomplete draft during the next meeting (Thursday, April 29) and will provide you with their thoughts and suggestions shortly thereafter. Let me know if you have any questions or if you would like to have a conference call with the RRFF to discuss their edits/comments.

RRFF participants—If you have any comments or edits that I missed, please share those with the Consultants and the rest of the RRFF participants.

Thanks,
Tracy

Literature Review, Analysis, and Recommendations for Pacific Lamprey Upstream Passage Improvements

Rocky Reach Hydroelectric Project (FERC No. 2145)

Prepared for:
Public Utility District No. 1 of Chelan County
Wenatchee, Washington

Prepared by:

Emily Andersen and Bao Le
Long View Associates
Portland, Oregon

Bryan Nass
LGL Limited
Ellensburg, Washington

Chris Peery
Cramer Fish Sciences
Gresham, Oregon

___ 2010

[Draft Outline Dated 3/18/10]

Executive Summary

[To be developed.]

Table of Contents

List of Tables

List of Appendices

1.0 Introduction

1.1 General Description of the Rocky Reach Hydroelectric Project

[Utilize existing Rocky Reach licensing documents to briefly describe the project.]

1.2 Purpose of the Report

[Describe the requirements as set forth in the License Order and PLMP.]

1.3 Consultation

[Include any comments (verbal or written) provided by the RRFF on the outline and/or draft report. Include comment letters and/or relevant RRFF meeting summaries in an appendix.]

2.0 Background

[Brief descriptions (1-paragraph each) regarding: 1) general life history; 2) species status; 3) passage at dams and recent effort to begin modifications and evaluation thereof; and 4) Rocky Reach-specific information.]

3.0 Literature Review

[Draft description to introduce the table.]

Scope of literature review:

a) Upstream passage modifications in the Columbia River basin (proposed and implemented) and evaluations of modifications only;
b) No associated timeline (i.e., need to find all past passage improvement work and evaluations thereof); and
c) Will utilize information in Table 3 of Grant PUD's Comprehensive Annual PLMP Report (March 2010), (specifically in the *Adult Passage at Hydroelectric Facilities, Structural and Operational Fishway Modifications* section) as a starting point and then identify additional improvement measures to further explore in terms of the relevance to literature review. For applicable measures, will gather relevant information and documents.

Comment [MSOffice1]: Move this section to an Appendix.

Comment [MSOffice2]: Items 1 and 2 should not make up more than one paragraph. The focus of this section should be on items 3 and 4.

Comment [MSOffice3]: This section should identify what existing structures work and which ones do not. Also identify what modifications work and which ones do not. In addition, describe why successful structures work. For example, describe the velocity and hydraulic characteristics associated with the different structures.

Although the RFP indicated that the literature review is to focus on the Columbia River Basin, if you have time, please consider including information on lamprey passage at other projects outside the Columbia River Basin.

Table 1 **[Title TBD.]**

	Improvement Measure(s)	Hydroelectric Project (River)	Lead Entity	Measure Proposed, Implemented, and/or Evaluated	Evaluation Results (if applicable)	Appropriate/Reasonable ~~Reasonable/Feasible~~ to Implement at Rocky Reach [specify Y/N]
1.	[If more than one instance of "Measure X", will keep all instances together.]					
2.						
3.						
4.						

Comment [MSOffice4]: Throughout the document please use "Appropriate/Reasonable."

4.0 Rocky Reach Fishway Observations~~Tour~~

[Summary of February 25 visit to Rocky Reach.]

Comment [MSOffice5]: This section should focus on describing the RR fishway and how it compares with fishways at other dams. In terms of lamprey passage efficiency, describe how the RR fishway design compares with other fishway designs.

5.0 Recommendations for Consideration

[Based on the information in Sections 3.0 and 4.0, a subset of the measures presented in Table 1 (i.e., those deemed "reasonable/feasible") will be further evaluated as to the potential applicability at Rocky Reach, and based on the evaluation, a recommendation will be made (including the expected impact, rationale for implementation, and location(s) of implementation).]

Literature Cited

[Maintain/update throughout development of the report.]

Appendix A
[TBD]

[TBD]

Appendix B
[TBD]

[TBD]

Appendix C
[TBD]

[TBD]

From: Bob Rose [brose@yakama.com]
Sent: Monday, March 29, 2010 1:21 PM
To: Tracy Hillman
Cc: Bao Le; Emily Andersen; Bryan Nass; Art Viola; Bob Huber; Deborah Bitterman; Jeff Osborn; Molly Hallock; Pat Irle; Steve Hays; Steve Lewis; Tony Eldred; Waikele Hampton
Subject: Re: Comments on the Literature Review Outline

Dear Everyone,
I think the draft is a good start - it is quick to review at this point anyway - and that is good!
With regards to the Adult Lamprey Metrics being developed by the CBFWA Tech Work Group, I think each of the metrics can be pigeon-holed into three general slots:
1) Entrance Efficiency
2) Ladder Passage (efficiency and ability to count)
3) Fallback from forebay back to tail race.

Maybe there is better way to organize these metrics - but I'd like to see the document organized accordingly AND I'd like to reserve a section for a discussion of study design characteristics / potential issues for each of these major passage components.

Hope that is useful.
Thanks - Rose
==========

Tracy Hillman wrote:
>
> Hello Consultant Team,
>
> Thank you for submitting an outline for the literature review for
> Pacific lamprey upstream passage improvements. The RRFF had an
> opportunity to review the outline during the last meeting and provide
> their edits/comments (see attachment).
>
> The RRFF would appreciate receiving a rough draft (~75% complete) by
> Tuesday, April 20. The RRFF will review the incomplete draft during
> the next meeting (Thursday, April 29) and will provide you with their
> thoughts and suggestions shortly thereafter. Let me know if you have
> any questions or if you would like to have a conference call with the
> RRFF to discuss their edits/comments.
>
> RRFF participants—If you have any comments or edits that I missed,
> please share those with the Consultants and the rest of the RRFF
> participants.
>
> Thanks,
>
> Tracy
>

From: Bao Le
Sent: Monday, April 19, 2010 1:21 PM
To: Tracy Hillman
Cc: Osborn, Jeff; Emily Andersen; Bryan Nass
Subject: RRH literature review outline - response to comments
Attachments: MEMO_resp to comments RRH lit review 4_19_10.pdf

Hi Tracy. After review of the comments received from the Rocky Reach Fish Forum (Forum) on the literature review outline and a brief call with Jeff, the Team concluded that several of the comments, if implemented, would require additional work outside of the current agreed to contract scope. We've prepared a memo outlining these specific comments (note that all other comments on the document were accepted) and provided responses to each for discussion at the next Forum meeting. In general, we felt that the comments were very constructive and could be addressed but would require additional effort and a modification of the existing scope of work. We leave it to you and the Forum to decide how you'd like to proceed. Please let us know if you or members of the Forum have any questions.

Best Regards,
Bao

Bao Le
Long View Associates, Inc.
p-503-719-7355
c-503-309-9423

MEMORANDUM

April 19, 2010

To: Rocky Reach Fish Forum

From: Bao Le (Long View Associates), Emily Andersen (Long View Associates) and Bryan Nass (LGL Limited)

Subject: Response to comments – Literature Review, Analysis, and Recommendations for Pacific Lamprey Upstream Passage Improvements, Rocky Reach Hydroelectric Project (FERC No. 2145)

On January 28, 2010, The Rocky Reach Fish Forum (Forum) selected the LGL Limited, Long View, Cramer Fish Sciences, and Blue Leaf Environmental Team (Team) to conduct the Pacific Lamprey Upstream Passage literature review as identified in the Rocky Reach Pacific Lamprey Management Plan. On March 18, 2010, as part of the document development process, the Team submitted a literature review outline to the Forum for review and subsequently received comments via electronic mail on March 29, 2010. Many of the comments received from the Forum were editorial/organizational in nature and were accepted and/or changed in the outline. A subset of comments had implications that could significantly expand the scope of literature review effort. After reviewing these comments (listed below) and discussing each of them as they relate to the scope of work, the Team has provided responses below.

1. Section 3.0: "*This section should identify what existing structures work and which ones do not. Also identify what modifications work and which ones do not. In addition, describe why successful structures work. For example, describe the velocity and hydraulic characteristics associated with the different structures.*"

   Section 3.0 consists of a table that includes all information relevant to adult upstream passage improvements (planned, implemented, and evaluated) in the Columbia River basin. The Team intends to use peer-reviewed literature, reports and management plans, and personal communications with researchers as the primary sources for reporting information. Any conclusions about the efficacy of modifications and additional supporting information that may explain why a modification may be effective will be reported only if they are communicated within the reports or by the researchers. Typically, results of evaluations of a modification are reported as statistics as opposed to definitive conclusions of a modification's effectiveness. For the purposes of the literature review, Team members shall only report the available information.

2. Section 4.0: "*This section should focus on describing the RR fishway and how it compares with fishways at other dams. In terms of lamprey passage efficiency, describe how the RR fishway design compares with other fishway designs.*"

The purpose of the fishway tour was to provide a brief summary of observations of the fishway elements relevant to lamprey passage at Rocky Reach Dam. Section 4.0 Rocky Reach Fishway Tour/Observations will include a brief description of the Project fishway's architecture as an introduction to the fishway tour and observations of fishway elements relevant to improving lamprey passage. Additional comparisons with fishways at other dams are considered outside the scope of the review.

With regard to including additional information related to passage efficiency, results of Rocky Reach lamprey passage assessments can be found in Section 2.0 and other project passage efficiency evaluations that have occurred post-modification can be found in Section 3.0. In Section 5.0 Recommendations for Consideration, any fishway elements that are recommended for modification will include supporting information (e.g., other locations where implemented and improvement observed) as to why these potential modifications may be appropriate at Rocky Reach.

3. Additional Comment: *"I'd like to reserve a section for a discussion of study design characteristics / potential issues for each of these major passage components."*

The request for statement of qualifications and the subsequent contract were developed around 3 elements: 1) complete a literature review of the effectiveness of upstream lamprey passage measures and studies implemented at other hydroelectric projects in the Columbia and Snake rivers; 2) review pertinent documents to Pacific lamprey studies conducted at Rocky Reach Dam; and 3) provide recommendations regarding passage improvement measures, either structural or operational, that are deemed technically feasible to implement at Rocky Reach Dam. Although the Team agrees that a discussion of study design characteristics and potential issues related to major passage elements is necessary prior to moving forward with any potential modifications to improve adult lamprey passage at Rocky Reach Dam, this additional analysis is outside of the scope of the current contracted work. The literature review document is intended to serve as the basis for the step described in the comment above. Despite not being included as part of the current scope of work, this additional step could be integrated into the existing scope of work (with contract modifications) or it could be identified as a separate scope of work to be conducted in the future.

Rocky Reach Fish Forum Meeting Minutes

Date: 29 April 2010
Time: 10:00 am – 2:15 pm
Location: Chelan PUD Headquarters, Wenatchee, WA
Second Floor Conference Room

Call in number: (509)661-4844, Password is 4000.

Meeting called by:	Jeff Osborn, Chelan PUD	Type of meeting:	RRFF Meeting
		Note taker:	Debby Bitterman

Representatives

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Viola, Art	WDFW	(509) 665-3337	violaaev@dfw.wa.gov
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Verhey, Patrick	WDFW	(509) 754-4624	Patrick.Verhey@dfw.wa.gov

Attendees in BOLD

Meeting Purpose: Meeting of the Rocky Reach Fish Forum to continue Rocky Reach license implementation

Minutes

Tracy Hillman welcomed everyone to the Rocky Reach Fish Forum (RRFF) meeting and made known that voice recording of the meeting was initiated.

Tracy reviewed the agenda with the Forum and asked if the Forum had any additions or corrections to the agenda. Members identified two additional agenda items: (1) Review of Meeting Protocols under Review March Draft Meeting

Minutes and (2) Update on Water Quality Plan Development under Resident Fish Update.

March meeting minutes were reviewed and approved with one edit.

Members reviewed the Meeting Protocols with edits proposed by Pat Irle. During the May meeting, members will decide if the protocols should be added as an appendix to the 29 October 2009 Final Protocols. Jeff Osborn noted that the Final Protocols that were posted to the website did not include Section 7, Duration and Amendment. That section has been added to the final protocols and is posted on the website.

Pacific Lamprey Updates

Literature Review

Tracy Hillman reported that the Consultants submitted a written response to the comments provided by the RRFF on the Consultants' proposed outline for the Literature Review, Analysis, and Recommendations for Pacific Lamprey Upstream Passage Improvements report. In general, the Consultants agreed with most of the comments/recommendations offered by the RRFF. However, there were three items that the Consultants identified that they believe are outside the scope of their work. The RRFF reviewed the three items and concluded that it is not necessary under their existing contract to describe the velocity and hydraulic characteristics associated with the different structures. That is more of an engineering assessment that may be conducted at a later time. However, based on the Consultants' review of the literature and their discussions with researchers, the RRFF agreed that the Consultants should identify those structures and operations that may work at Rocky Reach Dam and to provide a brief description of their rationale as to why they believe these structures and operations may be effective. To the degree that the literature provides estimates of velocity profiles and hydraulic conditions, the RRFF would like the Consultants to use those in their evaluations. Finally, the RRFF recommends that the Consultants link the measures (structures and operations) with the adult lamprey metrics being developed by the Columbia Basin Fish and Wildlife Authority Lamprey Technical Workgroup.

Tracy Hillman stated that the Consultants would not be able to provide a 70-75% complete draft document to the RRFF by 20 April. This is because their contract states that the draft report is to be submitted by 28 May. The final report is due on 30 June.

Impingement Monitoring

Jeff Osborn reported that he received feedback from both Bob Rose and Molly Hallock on the Draft Juvenile Lamprey Impingement Monitoring Plan. The final plan will be sent to the RRFF and posted on the website. Jeff noted that the PUD began monitoring juvenile impingement on 15 April. Jeff will provide a brief report every two weeks on the results of the monitoring.

Ammocoete Sampling in the Reservoir

Jeff Osborn reported that he is still working on identifying potential sampling locations for ammocoetes within the Rocky Reach Reservoir. He contacted John Blum, who is trying to verify the locations of where ammocoetes were collected during the Benthic Macroinvertebrate Survey 1999. In addition, Jeff is still in the process of researching GIS mapping of aquatic habitat (substrate and aquatic vegetation layers) within the reservoir.

Bob Rose stated that he and Steve Lewis talked about how to sample ammocoetes in the reservoir. Because of ESA consulting and permitting, there may be an issue with deep-water shocking. Therefore, they are thinking that a simple approach (e.g., backpack shocking, grab samples, or shovel samples) may be appropriate. Bob noted that he recently spoke with Howard Schaller, USFWS, about ammocoete sampling. Howard indicated, based on his work, that there may be no issue with permitting electrofishing surveys for ammocoetes. Sampling during the fall may be best when there are few to no ESA-listed species present. However, there may be an issue with sampling efficiency if ammocoetes bore deeper into the substrates as temperatures decline. Bob noted that he, Steve Lewis, and Molly Hallock will conference with Howard Schaller to discuss sampling in 2010. Jeff noted the Steve Lewis also sent a paper briefly describing sampling within the reservoir. Tracy will distribute the paper to the RRFF.

Hatchery Propagation

Tracy Hillman reported that he sent the RFQ for the Pacific lamprey hatchery propagation tasks to 18 individuals on 6 April. So far only two individuals had responded to the request. Responses to the request are due to Tracy on Friday, 7 May. Tracy will then send the responses to the Lamprey Subcommittee (Steve Lewis, Bob Rose, Pat Irle, Molly Hallock, and Jeff Osborn) on Monday, 10 May. The RFQ was sent to the following individuals:

- Matthew Mesa (USGS)
- Richard Beamish (Pacific Biological Station)
- Jim Hall (OSU)
- Mary Moser (NOAA Science Center)
- Douglas Hatch (CRITFC)
- Abel Brumo (Stillwater Sciences)
- David Close (UBC)
- Camm Swift (ENTRIX)
- Peter Moyle (UC Davis)
- RD Nelle (USFWS)
- Bryan Nass (LGL)
- Bao Le (Longview)
- Chris Caudill (UI)
- Chris Peery (Cramer)
- Carl Schreck (OSU)
- Ken Ostrand (USFWS)
- Mark Timko (Blue Leaf)
- David Bennett (UI)

Jeff Osborn reported that he received a call from Marcelle Lynde, GeoEngineers, requesting the RFQ. Jeff sent her a copy of the RFQ (exact email and attachments that Tracy sent to the other individuals).

Bob Rose noted that it may be beneficial to select more than one individual to conduct the work. He sees the next step as identifying the contractor(s) and fine-tuning the objectives of the study.

Bob Rose noted that he was able to get the "Manual for Artificial Hatching of Arctic Lamprey (2008 Edition)" translated from Japanese to English. Tracy was directed to share the document with the RRFF, but the Forum is not to share the document with others because of possible translation errors. Bob indicated that he has contacted an OSU graduate student that is fluent in Japanese and lamprey issues, and can help with reviewing documents written in Japanese. Bob stated that the decline in lamprey is a problem around the Pacific Rim and there appears to be a possible solution (i.e., artificial propagation). Bob's vision is to hold two workshops: (1) Local Workshop, which would be inexpensive and include Columbia Basin experts and (2) Global Workshop, which would include experts from around the world. The former would provide information that would benefit the RRFF endeavor, while the latter would be a more technical workshop that would advance the science on lamprey propagation. Bob noted that CRITFC and the YN have some funds that could be used to provide stipends.

Adult Lamprey Sampling

With regard to trapping upstream migrating adult lamprey in the tailrace of Rocky Reach Dam, Bob Rose indicated that he would like to meet with Steve Hays, Jeff Osborn, and Josh Murauskas to discuss possible approaches that could be implemented in 2011.

Action item:

- ✓ Tracy Hillman will share with the Consultants the recommendations of the RRFF on the Literature Review, Analysis, and Recommendations for Pacific Lamprey Upstream Passage Improvements report.
- ✓ Tracy Hillman will ask the Consultants to present their results at the next meeting (24 May).

- ✓ Jeff Osborn will send the final Juvenile Lamprey Impingement Monitoring Plan to the RRFF.
- ✓ Jeff Osborn will provide an update regarding Reservoir investigations for ammocoetes
- ✓ Jeff Osborn will continue his mapping investigation
    - o ID sampling locations within Rocky Reach Reservoir
    - o Ability to use GIS for identifying aquatic habitats within the reservoir
    - o List and location of monitoring transects in the reservoir
- ✓ Bob Rose, Steve Lewis, and Molly Hallock will conference with Howard Schaller to discuss ammocoete sampling.
- ✓ Tracy Hillman will send responses to the RFQ to the Lamprey Subcommittee. The Subcommittee will conference on Monday, May 17 from 1:00-3:00 pm to review responses. The Subcommittee will make recommendations to the RRFF at the next meeting.
- ✓ Tracy Hillman will send Steve's paper on sampling ammocoetes in the reservoir to the RRFF.
- ✓ Tracy Hillman will send the English version of the "Manual for Artificial Hatching of Arctic Lamprey" to the RRFF.
- ✓ Bob Rose will meet with Steve Hays, Jeff Osborn, and Josh Murauskas to discuss possible approaches to collecting adult Pacific lamprey downstream from Rocky Reach Dam.

White Sturgeon

Joe Miller reported that the contract between Chelan PUD and the YN for sturgeon rearing at Marion Drain is in review and should be issued soon. The scope of work includes mating, early life history, grow-out, and planting. Joe also noted that Chelan PUD, YN, and WDFW coordination of brood stock collection activities in McNary, Wanapum, and Priest Rapids reservoirs are moving forward.

Bob Rose updated the RRFF on the tour of the YN sturgeon facilities at Toppenish that occurred on Wednesday, 7 April. Bob noted that during the tour they talked about logistics and conducted a practice run of transferring adult sturgeon to the facility. Bob also reported that fish are ripening a little early and that they have already successfully spawned fish at the facility this spring.

Tracy Hillman reported that he contacted Brad James to see if he had any comments on the White Sturgeon Plan. Brad responded that he was comfortable with the plan.

Joe Miller suggested that the Sturgeon Subcommittee should convene to discuss technical issues and timeframes related to collecting broodstock. This would give the Subcommittee an opportunity to discuss issues with the Golder representatives and to observe broodstock activities. Joe indicated that he would contact the Subcommittee to set up a meeting. He will coordinate this with the Priest Rapids group.

Action item:

- ✓ Joe Miller will set up a Sturgeon Subcommittee meeting.

Resident Fish

Comments on the Draft Resident Fish Study Plan were due to Art Viola on Friday, 23 April. Tony Eldred, Art Viola, and Jeff Osborn provided edits and comments. Art is currently integrating those comments and edits into the study plan.

Tracy Hillman noted that according to the schedule, the RRFF is to receive the next draft from Art on Friday, 21 May. Because the next meeting of the RRFF is on 24 May, the RRFF will review the document during the June meeting (Thursday 24 June).

Art, on behalf of Dave Burgess, asked if Chelan PUD has GIS capabilities, which can be used to help develop habitat strata within the reservoir. Jeff Osborn will check with the GIS folks at the PUD and then communicate directly with Dave. Art asked when the resident fish studies are scheduled to begin. Jeff indicated that they need to begin spring 2011.

Jeff Osborn asked how the bioenergetics modeling will be used. Art indicated that it is primarily for describing predator-

prey dynamics. Given the cost of doing bioenergetics modeling, and the fact that there is a cap on the amount of money available, the modeling exercise may need to be scaled back. Art will review the necessity of the modeling effort with Dave.

Steve Hays noted that he has no water quality plan update for the RRFF. He will provide an update during the May meeting.

Pat Irle questioned the duration of the resident fish studies. Jeff noted that the studies are intended to last four years. Steve Hays commented that there are check-ins over the course of the license, but there is also a cap on the amount of money available to do the studies.

Action item:

- ✓ Waikele Hampton and Steve Hays will develop a water quality sampling plan to present to the RRFF at the June meeting, portions of which could be included in the Resident Fish Study.
- ✓ Jeff Osborn will check with GIS folks at Chelan PUD to see if they can help with developing strata within the reservoir.
- ✓ Art Viola will send the revised draft Resident Fish Study Plan to Tracy on Friday, 21 May. Tracy will distribute the draft to the RRFF on Monday, 24 May. The RRFF will review the plan during the June meeting.

Misc

Tentative agenda items for the next meeting:

- Presentation by the Consultants on the literature review.
- Selection of individual(s) to conduct the lamprey artificial propagation tasks.
- Update on sampling ammocoetes in the reservoir.
- Update on trapping of upstream-migrating lamprey adults in the tailrace of Rocky Reach Dam.
- Update from the Sturgeon Subcommittee.
- Update on the water quality sampling plan.
- Update on the resident fish study plan.

Next meeting is Monday, 24 May 2010

From: Bao Le
Sent: Wednesday, May 05, 2010 1:39 PM
To: Tracy Hillman
Cc: Emily Andersen; 'Bryan Nass'; Deborah Bitterman
Subject: RE: RRH literature review outline - response to comments

Thanks for the feedback Tracy. In Section 5.0 of the document, our intent is to identify potential structural and operational modifications that may be applicable at the Rocky Reach fishway. These recommendations will be based upon a collective evaluation of the existing site specific information (2004 BioAnalyst study, Golder evaluation, fishway design drawings), observations gathered from the fishway tour, results of modifications implemented/evaluated at other Columbia Basin projects (Section 3.0), and our best professional judgment. We'll provide our rationale as to why we think each recommendation is appropriate and intend to use all pertinent information available as described above. Lastly, we have linked all measures described in Section 3.0 with the CBFWA metrics per Bob Rose's email (received 3/29/10). Best regards, Bao

---

From: Tracy Hillman [mailto:tracy.hillman@bioanalysts.net]
Sent: Wednesday, May 05, 2010 12:47 PM
To: Bao Le
Cc: Emily Andersen; 'Bryan Nass'; Deborah Bitterman
Subject: RE: RRH literature review outline - response to comments

Hi Bao,

Thanks for responding to the comments offered by the RRFF. The Forum reviewed your responses and in general agrees with your concerns. The Forum agrees that it is not necessary under your existing contract to describe the velocity and hydraulic characteristics associated with the different structures. That is more of an engineering assessment that may be conducted at a later time. However, based on your review of the literature and your discussions with researchers, the Forum would like you to identify those structures and operations that may work at Rocky Reach Dam, and provide a brief description of your rationale as to why you believe these structures and operations may be effective. Your recommendations would be based on your assessment of the literature. To the degree that the literature provides estimates of velocity profiles and hydraulic conditions, the Forum trusts that you will use those in your evaluations.

The Forum would also like you to link the measures (structures and operations) with the adult lamprey metrics being developed by the CBFWA Lamprey Technical Workgroup. The Forum does not see this as an exhaustive exercise. Rather, this effort should only take an hour or two to complete.

The RRFF appreciates your efforts and your response to comments.

Please let me know if you have any questions or concerns.

Thanks,
Tracy

From: Bao Le [mailto:ble@longviewassociates.com]
Sent: Monday, April 19, 2010 2:21 PM
To: Tracy Hillman

Cc: Osborn, Jeff; Emily Andersen; Bryan Nass
Subject: RRH literature review outline - response to comments

Hi Tracy. After review of the comments received from the Rocky Reach Fish Forum (Forum) on the literature review outline and a brief call with Jeff, the Team concluded that several of the comments, if implemented, would require additional work outside of the current agreed to contract scope. We've prepared a memo outlining these specific comments (note that all other comments on the document were accepted) and provided responses to each for discussion at the next Forum meeting. In general, we felt that the comments were very constructive and could be addressed but would require additional effort and a modification of the existing scope of work. We leave it to you and the Forum to decide how you'd like to proceed. Please let us know if you or members of the Forum have any questions.

Best Regards,
Bao

Bao Le
Long View Associates, Inc.
p-503-719-7355
c-503-309-9423

Rocky Reach Fish Forum Meeting Minutes

Date: 24 May 2010
Time: 8:00 am – 12:00 pm
Location: Chelan PUD Headquarters, Wenatchee, WA
Second Floor Conference Room

Call in number: (509)661-4844, Password is 4000.

Meeting called by:	Jeff Osborn, Chelan PUD	Type of meeting:	RRFF Meeting
		Note taker:	Debby Bitterman

Representatives

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Viola, Art	WDFW	(509) 665-3337	violaaev@dfw.wa.gov
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James, Brad	WDFW	(360) 906-6716	jamesbwj@dfw.wa.gov
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Miller, Joe	Chelan PUD	(509) 661-4473	joseph.miller@chelanpud.org
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Le, Bao phone	Long View Assoc		
Nass, Bryan	LGL		

Attendees in BOLD

Meeting Purpose: Meeting of the Rocky Reach Fish Forum to continue Rocky Reach license implementation

Minutes

Tracy Hillman welcomed everyone to the Rocky Reach Fish Forum (RRFF) meeting and made known that voice recording of the meeting was initiated.

Tracy reviewed the agenda with the Form and asked if the Forum had any additions or corrections to the agenda. No additions or corrections were made.

April meeting minutes were reviewed and approved with one edit by Bob Rose.

A supplementary Rocky Reach Fish Forum Meeting Protocol Summary document was approved by the Forum. This summary document will be appended to the Rocky Reach Fish Forum Final Protocols that were approved 10/29/09.

Pacific Lamprey

Consultant Presentation on Lamprey Literature Review

Bryan Nass, LGL, gave a presentation on the Literature Review and Recommendations for the Pacific Lamprey Upstream Passage Improvements and Future Studies report that is being developed. The presentation outlined:

- Scope of work
- Approach
- Report sections
- Rocky Reach fishway tour
- Literature review
- Modifications Table
- Recommendations

Bryan noted that the draft report will be submitted to the RRFF for review/comments on 28 May 2010. The final report is due 30 June 2010. It was noted that the report will include all the literature cited within the report.

Action Items:

- Bob Rose will add Bryan to Ralph Lampman's email list. Ralph, a graduate student at Oregon State University, may have useful information pertaining to Columbia Basin Pacific lamprey artificial propagation.
- Bob will provide the RRFF with the "Latest Lamprey News from Japan."
- Jeff Osborn will report to the RRFF what the water velocity is in the trifurcation pool.
- RRFF members will review the draft Pacific Lamprey Upstream Passage Literature Review report and be prepared to discuss it at the next RRFF meeting, which is scheduled for Monday, 14 June 2010.

Pacific Lamprey Artificial Production SOQs

Molly Hallock reported that the Pacific lamprey subcommittee had a conference call on 17 May 2010. The purpose of the call was to review the Pacific lamprey artificial production Statement of Qualifications (SOQs). Molly noted that the Forum received four SOQs; the Forum requested qualifications from 19 individuals. The subcommittee recommended that more than one individual/entity conduct the work. The tasks would be partitioned as follows:

Task 1: John Monahan, GeoEngineers.

- Rearing juveniles in riverine environments.
- GeoEngineers would also consolidate all three components (Tasks 1, 2a, and 2b) into a single, final report.

Task 2a: Ken Ostrand, U.S. Fish and Wildlife Service.

- Literature review for worldwide artificial propagation.

Task 2b: Matt Mesa, USGS.

- Rearing juveniles in man-made structures.

The subcommittee also recommended that the contract be set up having GeoEngineers as the prime contractor and Matt Mesa and Ken Ostrand as the sub-contractors. The contract will be drafted as a not-to-exceed total budget, with budgets identified for each task.

The Forum agreed with the subcommittee's recommendation to offer a three-team contract: GeoEngineers-prime and Ken Ostrand-Task 2a and Matt Mesa-Task 2b as subs.

Action Item:

- Bob Rose, Jeff Osborn, Molly Hallock, and Tracy Hillman will draft task language to present to GeoEngineers, Ken Ostrand, and Matt Mesa.
- The draft task language will be sent to Tracy by 28 May 2010. Tracy will forward the draft language to the rest of the Pacific lamprey subcommittee for review.
- The Pacific lamprey subcommittee will provide comments/review on draft task language to Tracy by 4 June 2010.
- Jeff Osborn will contact GeoEngineers to propose the combination of consultants (prime and sub-contractors).
- Jeff Osborn will draft a congratulations letter to GeoEngineers, Ken Ostrand, and Matt Mesa.
- Jeff Osborn will draft a notice of non-selection to Cramer Fish Sciences.

Reservoir investigations for ammocoetes

Steve Lewis discussed his Juvenile Lamprey and Reservoir Habitat white paper (handout provided).

Action Item:

- The Forum will provide comments to Steve regarding his white paper.
- Steve Lewis will contact Howard Schaller, USFWS, regarding permitting and potential take based on a three-day sampling effort.
- Bob Rose will contact Bryan Nordlund, NOAA Fisheries, regarding guidelines for electrofishing sampling in the reservoir.
- Jeff Osborn will identify sampling locations within Rocky Reach Reservoir.
- Jeff Osborn will provide GIS mapping of aquatic habitats within the reservoir.

Impingement Monitoring update

Jeff Osborn reviewed with the Forum the results of monitoring juvenile Pacific lamprey impingement at Rocky Reach Dam (based on the 7 May 2010 report, which was provided as a handout during the meeting). Based on the screens monitored during the period 19 April through 30 April, no lamprey have been impinged.

White Sturgeon update

Josh Murauskas reported that the White Sturgeon subcommittee will have a conference call on 10 June 2010 at 2:00 pm. Josh also noted that contract discussions with the Yakama Nation are moving forward.

Resident Fish

Resident Fish Study Plan update

No update information regarding the draft Resident Fish Study Plan was available.

Action item:

- Jeff will forward Art Viola's objectives and goals for recreational fishing opportunities to Tracy. Tracy will forward the document to the RRFF.
- Tracy will contact Art regarding the status of the draft Resident Fish Study Plan.

Water Quality Plan Development update

Steve Hays will give a status update on the Water Quality Plan to the Forum at the next meeting.

Coordination of Resident Fish Studies with HCP Survival Studies

Jeff Osborn reported that Chelan PUD will conduct a 30-34 day HCP survival study with yearling Chinook smolts at the Rocky Reach Project in 2011. The study will consist of 30 fish releases (15 daytime and 15 nighttime releases) totaling 900 acoustic-tagged yearling Chinook released downstream from Wells Dam. Tagged fish will be present in the reservoir from about 28 April to 5 June and will be vulnerable to certain sampling gears. Fish sampling techniques, especially those using gill nets (with experimental mesh sizes) and electrofishing, may capture or injure tagged smolts. Affected fish will introduce a negative bias to the survival study. Each tagged fish is important to the survival study, so coordination and communication of any fish sampling methods and sampling locations will be critical during Chelan's HCP survival study in 2011. If there is a possibility of conducting resident fish sampling outside the HCP survival study window, then this would be preferred by Chelan PUD in 2011 and potentially in future years when HCP survival studies are conducted.

Action item:

- Tracy will ask Dave Burgess to contact Teresa Scott regarding HCP guidelines and survival studies.
- Jeff will contract Dave Burgess to discuss scheduling of the sampling and release schedules.

It was proposed to move the next RRFF meeting from Thursday, 24 June to Monday, 14 June, 9:00 a.m. to 3:00 p.m. An earlier meeting date is needed to review the Consultants draft Pacific Lamprey Upstream Passage Literature Review report. This will give the Consultants time to address any issues the RRFF may have with the draft report. The final report from the Consultants is due on 30 June 2010.

Action item:

- Tracy will send an email to the RRFF asking them if there is any concern with moving the next meeting date to Monday, 14 June.

From: Bao Le
Sent: Friday, May 28, 2010 3:02 PM
To: Tracy Hillman
Cc: Osborn, Jeff; Bryan Nass; Emily Andersen
Subject: RRH Pacific Lamprey Literature Review Document - Draft for review
Attachments: PLMP lit review and recommendations document 05-28-10 DRAFT.pdf; PLMP lit review and recommendations document 05-28-10 DRAFT.doc

Hi Tracy. Please find attached the first draft of the Pacific Lamprey Upstream Passage Modifications Literature Review and Recommendations document for review by the Rocky Reach Fish Forum. Please note that we've also included a pdf file of the document and that Figure 1 (Rocky Reach Dam fishway) is only included in the pdf. Furthermore, for the final report, the fishway section labels cited in Figure 1 (pdf) will require a few minor edits to be consistent with the report text (e.g., transport channel to transportation channel) since we were unable to acquire the figure file from Bryan and make the changes for this draft as he is currently unavailable. I would recommend that RRFF members read and comment using the word version. When they get to Section 4.0 of the document, Figure 1 in the pdf file may be useful in helping readers to better understand the terminology we're using for different fishway sections in the report. Please let me know if you have any questions. Thanks, Bao

Bao Le
Long View Associates, Inc.
p-503-719-7355
c-503-309-9423

From: Tracy Hillman [tracy.hillman@bioanalysts.net]
Sent: Wednesday, June 16, 2010 11:15 AM
To: Bao Le
Cc: Emily Andersen; Bryan Nass; Molly Hallock; Bob Rose; Steve Lewis; Pat Irle; Jeff Osborn; Steve Hays; Josh Murauskas; Deborah Bitterman
Subject: Comments on the Lamprey Literature Review Document
Attachments: PLMP lit review and recommendations document 05-28-10 DRAFT (RRFF edits).doc

Hi Bao,

On Monday, the RRFF reviewed your document titled, "Pacific Lamprey Upstream Passage Modifications Literature Review and Analysis and Recommendations for Passage Improvements in the Rocky Reach Fishway." Overall, the Forum was impressed with the document. They did, however, provide a few edits and comments within the document (see attachment). Please let me know if you have any questions about the edits or comments.

The Forum thanks you for providing the draft document for their review and they look forward to seeing the final report.

Thanks,
Tracy Hillman

DRAFT

Pacific Lamprey Upstream Passage Modifications Literature Review and Analysis and Recommendations for Passage Improvements in the Rocky Reach Fishway

Rocky Reach Hydroelectric Project (FERC No. 2145)

Prepared for:
Public Utility District No. 1 of Chelan County
Wenatchee, Washington

Prepared by:

Emily Andersen and Bao Le
Long View Associates
Portland, Oregon

Bryan Nass
LGL Limited
Ellensburg, Washington

May 2010

Executive Summary

Pursuant to the Rocky Reach Project (Project) Pacific Lamprey Management Plan (Chelan PUD 2006), Public Utility District No. 1 of Chelan County (Chelan PUD) is required to complete, in consultation with the Rocky Reach Fish Forum (RRFF), a literature review of the effectiveness of upstream lamprey passage measures implemented at other hydroelectric projects in the Columbia and Snake rivers, and to evaluate implementation of similar measures at the Project. The RRFF selected a team of consultants (Long View Associates, LGL Limited, Blue Leaf, and S. P. Cramer and Associates) to perform this work.

The Pacific Lamprey Upstream Passage Modifications Literature Review and Analysis and Recommendations for Passage Improvements in the Rocky Reach Fishway (Literature Review Document) summarizes the results of upstream lamprey passage measures implemented and evaluated at other hydroelectric projects in the Columbia River basin. In addition, this document describes site-specific assessments regarding the fishway facility at Rocky Reach Dam, including observations gathered during a site visit to the facilities in February 2010. Based upon review of this information, a list of potential modifications for the Rocky Reach fishway was developed. The recommendations are intended to provide a basis for future RRFF discussions regarding prioritization, identification of additional information needs, and the selection of the initial set of modifications to evaluate for the purposes of improving adult lamprey passage at the Rocky Reach Project.

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1.0 Introduction

1.1 General Description of the Rocky Reach Hydroelectric Project

The Rocky Reach Hydroelectric Project (Rocky Reach Project or Project), the largest of the Public Utility District No. 1 of Chelan County's (Chelan PUD) three hydroelectric projects licensed by the Federal Energy Regulatory Commission (FERC), is located on the Columbia River in Chelan County, Washington, approximately seven miles upstream of the city of Wenatchee, Washington. The Project utilizes the waters of the Columbia River, whose drainage basin extends over substantial portions of northern Washington, Idaho, Montana and into Canada.

The Project impounds 43 river miles and has a surface area of 8,235 acres at the normal maximum pool elevation of 707 feet above mean sea level (MSL).[1] The Project consists of a dam, which incorporates a spillway, powerhouse and non-overflow structures, as well as power transmission, fish passage and visitor facilities. The spillway consists of 12 spillway gates with a combined hydraulic capacity of 980 kcfs. The powerhouse contains eleven generating units. The Project's total installed capacity is 865.76 MW.

1.2 Purpose of the Report

As set forth in the Pacific Lamprey Management Plan (PLMP; dated February 3, 2006) and consistent with ~~the terms of the 401 Water Quality Certification (issued by the Washington Department of Ecology [WDOE] on March 17, 2006) and~~ the Project License Order (issued by the FERC on February 19, 2009):

> *Chelan PUD shall, within one year of the effective date of the New License, complete a literature review of the effectiveness of upstream lamprey passage measures implemented at other hydroelectric projects in the Columbia and Snake rivers, such as plating over grates, improvement in orifices for passage, rounding sharp edges, constructing rest areas in front of submerged orifices, and reducing diffuser grating spacings. Chelan PUD shall, in consultation with the Rocky Reach Fish Forum (RRFF), evaluate whether it would be appropriate and reasonable to implement similar measures at Rocky Reach Dam.*

To fulfill these requirements, this document is structured as follows:

1. Section 2.0: General information regarding upstream passage at dams and efforts to implement and evaluate structural and operational modifications in the Columbia River Basin as well as information regarding Pacific lamprey-related research and improvement activities at the Project.

2. Section 3.0: Information resulting from the literature review of the effectiveness of upstream lamprey passage measures and studies implemented at other hydroelectric projects in the Columbia River basin.

[1] All elevations in this document are referenced to the National Geodetic Vertical Datum of 1929.

3. Section 4.0: A summary of observations made during the February 25, 2010 tour of the Project's existing fishway facilities.

4. Section 5.0: A recommendation list of potential modifications in the Project fishway to improve upstream passage and the supporting rationale for each modification. The list of potential modifications to be considered are based upon an evaluation of upstream passage improvement measures listed in Section 3.0, the available site specific information, and a qualitative evaluation of a modifications applicability at the Project.

1.3 Consultation

~~Chelan PUD~~The Consultants provided a draft outline of contents for the Pacific Lamprey Upstream Passage Modifications Literature Review and Analysis and Recommendations for Passage Improvements in the Rocky Reach Fishway (Literature Review Document) to the Rocky Reach Fish Forum ~~(RRFF)~~ on March 18, 2010. Written comments were provided ~~received~~ by the RRFF March 29, 2010, to which, the Consultants~~Chelan PUD~~ provided preliminary written responses to the RRFF on April 19, 2010, with additional follow-up via an email exchange between the RRFF and Bao Le (Long View Associates) on May 5, 2010 (Appendix A). [If outline/document was discussed at the April 29 RRFF meeting, note here and include meeting notes in Appendix A.] Subsequently, the Consultants~~Chelan PUD~~ provided a complete draft of the Literature Review Document to the RRFF on May 28, 2010 for review. Comments were received by [insert commenter and date]. [Note that document was discussed at May 24 meeting and include meeting notes in Appendix A.] A summary of comments by the RRFF as received by the Consultants~~Chelan PUD~~ on the outline and draft Literature Review Document have been summarized along with the Consultants ~~Chelan PUD's~~ responses in Appendix B.

2.0 Background

The Pacific lamprey (*Entosphenus tridentatus*) is an anadromous member of the jawless fish family (Petromyzontidae) that inhabits marine and freshwater systems in western North America and eastern Asia. The fish are indigenous to the Columbia River basin. In general, their historic distribution coincides with that of Pacific salmon. The current distribution of Pacific lamprey in the Columbia River extends as far upstream as Chief Joseph Dam, and in the Snake River as far upstream as Hells Canyon Dam. The Pacific lamprey is parasitic on various ocean fishes for one to two years. After maturing in the ocean, they return to the Columbia River in the summer and fall, migrating upstream before overwintering. The following spring, lamprey spawn over gravel substrate, constructing a nest in shallow water up to two feet in diameter, and die soon after spawning. Juveniles live in the high sediment and slow water habitats of streams for five to six years, filter feeding on detritus, algae and micro-organisms before entering the ocean where they become parasitic. They appear to have little impact on marine fish populations and do not feed when they move into streams to spawn.

Adult lamprey counts have decreased at all Columbia and Snake river dams as compared with historical estimates, with the greatest declines occurring at the upper Columbia and Snake river projects. Annual lamprey counts at Bonneville Dam prior to the 1970's often exceeded 250,000

fish. In 2009, only 8,622 were counted at Bonneville Dam (DART 2010). Causes of population decline may include: 1) passage problems for adult and juvenile lamprey migrating past dams; 2) declining conditions of spawning and rearing habitat in freshwater; 3) a decline of prey available in the marine environment; 4) industrial and agricultural pollution; 5) urbanization; 6) dewatering of streams; and 7) adult losses at sea (Close 2002; Moser and Close 2003a; 2003b). Based on the decreasing trend of adult Pacific lamprey, conservation groups filed a lawsuit against the U.S. Fish and Wildlife Service (USFWS) in May 2004 to compel the USFWS to act on their January 27, 2003 petition to list four species of lamprey, including Pacific lamprey. On December 22, 2004, the USFWS announced that a petition to list four species of lamprey did not contain sufficient information to warrant further review at that time.

In the Columbia River basin, recent planning efforts to develop Pacific lamprey management and recovery strategies by the USFWS, Northwest tribes, and public and private hydroelectric operators reflect the growing need to begin actively addressing decreasing lamprey population trends. Based upon the recognition that dam passage is a major contributing factor to the species' decline, a significant amount of lamprey research over the past decade has been focused on identifying potential impediments to adult passage at hydroelectric facilities. Results of this research coupled with regional planning efforts and an increase in activity focused on implementing and evaluating the efficacy of project specific fishway modifications towards improving passage have provided a beginning framework for lamprey recovery and conservation.

Specific to the Project, in 2004, a radio-telemetry study was conducted at Rocky Reach Dam to assess passage proportions and passage times of adult lamprey (BioAnalysts 2005) through various sections of the fishway in order to better understand potential Project impacts to lamprey migration (Figure 1). Analysis of the data determined that:

1. Forty-five percent (n=50) of lamprey entering the fishway (n=110) dropped out of the fishway or were last detected residing in the fishway (did not pass). Further, 25% (n=6) of lamprey released in the Upper Ladder (n=25) did not exit. Results for the points of furthest migration in the fishway were not provided in the report;

2. Twenty-two percent (n=17) of lamprey exiting the fishway into the forebay fell back downstream through the dam. Some of these fish reascended the fishway resulting in a net fallback rate of 13% (n=10);

3. Six percent (n=7) of lamprey arriving at the Project (n=117) did not enter a fishway (i.e., 94% approaching do enter); and

4. Migration rate was slowest in the Upper Ladder (between the diffuser in the control weir section and the Fishway Exit), and was progressively faster for the lower fishway (between the end of Transition Ladder and the Upper Ladder), the Transportation Channel, and the entrance channels (between entrances and the Trifurcation Pool).

NOTE: During the development of the final document, the terms used for fishway elements in Figure 1 will be revised to be consistent with those used in the text.

Comment [MSOffice1]: Please define "drop out" and "fall back."

Comment [MSOffice2]: Tag life may have expired when the fish were in the ladder or in the tailrace. Therefore, is it correct that they "did not pass?" Recommend deleting "did not pass."

Figure 1. Rocky Reach Dam fishway.

[Placeholder for PDF of figure used in presentation to RRFF May 24 (Bryan emailed May 17).]

Although a single year of data does not typically provide an adequate foundation to develop rigorous conclusions, the study results did provide some clear trends. Drop-out from the fishway combined with residualization of tagged lamprey that entered the fishway was the largest "loss" from successful passage. Fallback accounted for the second largest "loss" from successful passage, followed by fish detected in the tailrace that did not enter the fishway. In general, the results of the 2004 passage assessment indicate that there are areas in the fishway where modifications may be appropriate to improve adult lamprey passage success.

Golder (2006) investigated issues and potential solutions regarding adult and juvenile lamprey passage at hydro facilities in the lower Columbia River by conducting interviews with researchers. As applied to the Rocky Reach fishway, several potential issues were identified: 90 degree corners on bulk-head/stop-log slots and orifice openings, standard diffusion grating (incongruent attachment surfaces), and potentially high water velocities at the Right Fishway Entrance. Possible structural solutions considered include: lamprey passage system (LPS) if an area of lamprey congregation area exists, plating on diffuser grates, and filling bulk-head/stop-log slots to provide flat surfaces. Possible operational solutions included: slow dewatering of fishway for servicing to promote voluntary drop-out, configuring orifice gate openings on the collection channel to minimize water current differentials, and the use of multiple openings at the Left Fishway Entrance to maintain flow but decrease velocity.

Chelan PUD's PLMP summarized information from BioAnalysts' report (2005) and concluded that the 2004 study "suggests that adult passage impediments may exist within the Rocky Reach fishway". However, it did not define any specific locations or structures.

3.0 Literature Review

This section provides a summarization of activities occurring in the Columbia River basin related to Pacific lamprey upstream passage improvement measures and research. Activities identified in Table 1 include those that have been implemented, planned and/or evaluated at a Columbia River basin hydroelectric facility. Details include the project(s) where the activity has or will occur, river of each project, lead entity, a description of the measure and if applicable, the evaluation results. In addition, for each improvement measure, the intended "Adult Lamprey Metric" (as being developed by the Columbia Basin Fish and Wildlife Authority [CBFWA] Technical Workgroup) is indicated (CBFWA Technical Workgroup 2010). The three potential passage categories include:

1. Entrance efficiency;
2. Ladder passage (passage efficiency within the fishway and ability to count); and
3. Fallback from forebay back to tailrace.

Table 1 Upstream lamprey passage improvement measures and studies implemented at hydroelectric projects in the Columbia River basin.

Comment [MSOffice3]: In the table, add discussion on grating size.

	Hydroelectric Project (River)	Project Owner (Study Lead(s))	Measure Planned (P), Implemented (I), and/or Evaluated (E)	Measure Description and Evaluation Results (if applicable)
	Structural Modifications			
1.	**Measure:** Install Lamprey Passage Structures (LPS) **Intended Metric Category:** Ladder Passage			
1a	Bonneville (Columbia), Bradford Island auxiliary water supply (AWS)	Army Corps of Engineers (ACOE) (National Marine Fisheries Service [NMFS], Pacific States Marine Fisheries Commission, and the University of Idaho)	I, E	In 2004-2005, a prototype LPS was operated in the Bradford Island AWS channel. In 2005, 8,889 untagged lamprey were counted as they exited the AWS LPS, and estimated that this represented 29% of the lamprey at the top of the Bradford Island fishway in 2005. Of the PIT-tagged lamprey released into the AWS, 42% were detected in the LPS. Median time required to pass through the LPS was 1.5 h, and of fish detected in the AWS LPS, 94% successfully exited. There was no evidence that lower flow through the LPS resulted in either significantly higher counts of lamprey, more rapid passage rates, or higher passage success. (Moser et al. 2008) In 2006, the LPS was bolted to the walls of the AWS channel, and its original configuration was changed to include dual ramps for improved lamprey collection. In the 2006 evaluation, 38% of the lamprey that reached the top of the Bradford Island fishway were estimated to have used the AWS LPS. Seven percent of the PIT-tagged lamprey were detected in the LPS. In addition, 14% of the fish detected at The Dalles Dam were known to have used the LPS at Bradford Island. The median time lamprey required to pass through the LPS was 45 min, and 99% of the fish successfully exited the AWS LPS. Based on the 2005 and 2006 results, it was clear that the structural modifications made in 2006 improved lamprey collection, rate of passage, and passage success through this structure. (Moser et al. 2009) The 2007 and 2008 data is currently being evaluated; however, preliminary results indicate that, in 2007, 464 untagged lamprey and 12 with PIT-tags were caught and in 2008, 490 untagged lamprey and 17 with PIT-tags were caught. (personal communication with M. Moser, NMFS Northwest Fisheries Science Center, 4/19/10)

Table 1, continued…

	Hydroelectric Project (River)	Project Owner (Study Lead(s))	Measure Planned (P), Implemented (I), and/or Evaluated (E)	Measure Description and Evaluation Results (if applicable)
1b	Bonneville, Washington-shore AWS	ACOE (University of Idaho and NMFS)	I, E	In 2009, lamprey use of the Washington-shore AWS channel proved difficult to evaluate using radiotelemetry because the close proximity of antennas in the ladder and AWS allowed transmitters to be detected at both locations simultaneously. The lampreys that had clear evidence of AWS use either entered laterally from the serpentine weir section of the ladder or entered through the picketed lead at the downstream end of the AWS. Collection efficiency of the LPS located inside the AWS was 7% for all double-tagged (radio and half-duplex PIT) fish in the study area (5 of 74) and 87% (7 of 8) for fish known to be in the upstream end of the AWS channel. A better understanding of the inter-related effects of water temperature, forebay elevation, and water transfers between the AWS and serpentine weirs is needed. There was strong evidence that forebay elevation plays a role in lamprey passage through this area. Increased monitoring of depth, water temperature, current direction and velocity is needed to help resolve these or other causal mechanisms. (Keefer et al. 2010a)
1c	Bonneville, Washington-shore fishway entrance	ACOE (NMFS, Pacific States Marine Fisheries Commission, and the University of Idaho)	I, E	The first iteration of a lamprey collector at a fishway entrance was fabricated and installed at Bonneville Dam in 2005. During its first full year of operation, 135 lamprey used the LPS collector at the downstream north entrance to the Washington-Shore fishway. This collector was modified in 2006 to provide less turbulent flows on the collector ramp. However, lamprey use of this structure was still low, indicating that further modification or better siting is needed. There was some evidence that fewer lamprey entered the collector during periods of high flow emanating from the Washington-shore fishway entrance. (Moser et al. 2009) In 2008, the Washington-shore fishway entrance collector captured 490 lamprey and 16 of these had a PIT tag (3%). Both the efficiency and collection rate for this structure were higher than in any other year of operation (2005-08). (ACOE 2008)

Table 1, continued…

	Hydroelectric Project (River)	Project Owner (Study Lead(s))	Measure Planned (P), Implemented (I), and/or Evaluated (E)	Measure Description and Evaluation Results (if applicable)
1d	Bonneville, Cascade Island fishway entrance	ACOE (University of Idaho and NMFS)	I, E	As part of modifications made to the entrance of the Cascade Island fishway during the 2008-2009 winter work period, a LPS was installed inside the fishway opening that allowed volitional passage to the elevation of the dam forebay. Although lampreys were collected at the top of the new LPS, none of the HD-PIT tagged lampreys were recorded using this structure in 2009. It was not clear whether the relatively limited use was due to siting, the distribution of attraction flows inside the fishway and near the LPS, or other factors. In other LPS's at Bonneville Dam, lamprey use of the structures was relatively lower in the installation year compared to subsequent years. A possible explanation is that the newly-installed metal is unattractive to some lamprey for olfactory or other reasons. If this is the case with the Cascade Island LPS, then it is possible that collection efficiency will improve at this site in future years (Clabough et al. 2010). An additional detailed evaluation of the new LPS will be presented in a companion report (Moser et al. *in prep*).
1e	Three Mile Dam (Umatilla)	Confederated Tribes of the Umatilla Indian Reservation (CTUIR)	I	In late summer 2009, a LPS was installed at Three Mile Dam. A few adult lamprey have been observed using the structure but most of the migration had occurred prior to the installation. Effectiveness testing is planned for 2010. (personal communication with Aaron Jackson, CTUIR 10/19/09)

Table 1, continued…

	Hydroelectric Project (River)	Project Owner (Study Lead(s))	Measure Planned (P), Implemented (I), and/or Evaluated (E)	Measure Description and Evaluation Results (if applicable)
2.	**Measure:** Modifications at entrance **Intended Metric Category:** Entrance Efficiency			
2a	Priest Rapids and Wanapum (Columbia)	Grant Public Utility District (PUD) (LGL Limited)	I, E	During construction of Wanapum Dam, keyhole entrances were installed at several locations. During the 1996-1997 fish ladder outage period and during the 2004-2005 construction of the Future Unit Fish Bypass, keyhole entrances were installed at remaining locations. During the 1998-1999 fish ladder outage period, keyhole entrances were installed at Priest Rapids Dam. (personal communication with Mike Nichols, Grant PUD 5/17/10) In 2001-2001, Grant PUD conducted a comprehensive passage evaluation at both dams. Entrance efficiencies ranged between 53% and 100% for Priest Rapids Dam and 54% and 100% for Wanapum Dam for the two years of study. Small sample size in 2001 confounded interpretation between years. The largest differences were found between different types of entrances; more specifically, the entrance efficiency of orifice entrances were significantly lower compared to the larger main entrances (which contained key hole entrances) on the powerhouse and spillway. (Nass et al. 2003)
2b	Bonneville (Columbia), Cascade Island fishway entrance	ACOE (University of Idaho and NMFS)	I, E	As part of modifications made to the entrance of the Cascade Island fishway during the 2008-2009 winter work period, a variable width entrance weir (keyhole entrance) was constructed. Lamprey entrance efficiency at the Cascade Island fishway (58.8%) was higher in 2009 than 2008 (33.3%; P =0.002), suggesting some post-modification benefit for lampreys. Entrance efficiency was also higher in 2007 (50.0%) than 2008, though this difference was not significant, possibly due to lower sample size. Entrance efficiency at the unmodified Bradford Island fishway did not differ significantly among years, supporting the hypothesis that the increase at Cascades Island in 2009 was related to the modification. Overall, the analyses indicated that the Cascade Island modifications may have improved entrance efficiency for adult Pacific lamprey and did not have strong positive or negative effects on other passage metrics. (Clabough et al. 2010)
2c	Willamette Falls (Willamette)	PGE	I, E	In the summer of 2008, bulkhead slot modifications were made at the project's "Leg 1" ladder entrance to allow for operation over the full range of tailrace operating conditions. The 2009 passage evaluation is still ongoing; however, preliminary data suggest~~s~~ that combined entrance efficiency (all 3 entrances) is approximately 82%. The role the modifications play in this result are unclear since past radio-telemetry studies were not designed at the scope necessary for pre and post modification comparisons. (personal communication with Tim Shibahara, PGE 4/7/10)

Table 1, continued…

	Hydroelectric Project (River)	Project Owner (Study Lead(s))	Measure Planned (P), Implemented (I), and/or Evaluated (E)	Measure Description and Evaluation Results (if applicable)
3.	**Measure:** Round sharp edges (entrances, bulkheads, orifices, tops of overflow weir walls, etc.) **Intended Metric Category:** Ladder Passage			
3a	Willamette Falls (Willamette)	Portland General Electric (PGE)	I, E	In the summer of 2008, footings were rounded to not have 90 degree angles for slot. The 2009 passage evaluation is still ongoing; however, preliminary data suggests that combined entrance efficiency (all 3 entrances) is approximately 82%. The role the modifications play in this result are unclear since past radio-telemetry studies were not designed at the scope necessary for pre and post modification comparisons. (personal communication with Tim Shibahara, PGE 4/7/10)
3b	Bonneville (Columbia), Bradford B-Branch entrance	ACOE (prepared by NMFS, Pacific States Marine Fisheries Commission, and the University of Idaho)	I, E	In 2000, bulkheads adjacent to the Bradford B-Branch entrance were rounded to provide more attachment areas for lamprey. Evaluations indicated that entrance efficiency at this entrance was higher in 2000 than in 1998 or 1999. (Moser et. al. 2000)
3c	Dalles (Columbia)	ACOE	I	During the 2009-2010 winter work period, at the 3 locations in the east and north ladders, corners were rounded from 90 degrees to 2-in radius. No evaluation is planned. (personal communication with Sean Tackley, ACOE 4/12/10)
3d	McNary (Columbia)	ACOE	I	During the 2009-2010 winter work period, the edges of the 26 inch by 26 inch salmon orifices located at the Oregon shore fish ladder exit were smoothed/rounded through the installation of additional metal plating to increase attachment area for Pacific lamprey. Future evaluations of this modification are not currently planned. (personal communication with Derek Fryer, ACOE 5/6/10)

Table 1, continued…

	Hydroelectric Project (River)	Project Owner (Study Lead(s))	Measure Planned (P), Implemented (I), and/or Evaluated (E)	Measure Description and Evaluation Results (if applicable)
4.	**Measure:** Replace diffuser grating with reduced gap spacing or modify/maintain in some manner **Intended Metric Category:** Ladder Passage			
4a	John Day (Columbia)	ACOE	P	During the 2010-2011 winter work period, gratings at the north and south ladders will be replaced (1-inch to ¾- inch). (personal communication with Sean Tackley, ACOE 4/12/10)
4b	Wells (Columbia)	Douglas PUD	P	If additional passage improvement measures are deemed necessary by work group members during implementation of the Wells Project Pacific Lamprey Management Plan, such measures may include modification, maintenance, or replacement of diffuser grating that adversely affect passage of adult Pacific lamprey.
5.	**Measure:** Install plating over diffuser grating along base of walls and weirs, and through orifices **Intended Metric Category:** Ladder Passage			
5a	Rocky Reach (Columbia)	Chelan PUD	I	Installation of plating around the perimeter of diffuser grating to eliminate gaps between the grating and concrete started during the 2007-2008 fishway overhaul and has been ongoing during subsequent overhauls. No evaluation is planned. (personal communication with Lowell Rainey, Chelan PUD, 4/29/10)
5b	Priest Rapids (Columbia)	Grant PUD	I	During the 2009-2010 winter work period, aluminum plating over the diffuser grates was installed. An evaluation will be conducted in summer 2010. (Nass et al. 2009)
5c	McNary (Columbia)	ACOE	I	During the 2009-2010 winter work period, steel plating was installed over a portion of the fish ladder diffuser grating. The plating was installed around the perimeter of three main sections (at the bottom of the fish ladder grating and up one side) at the Oregon shore fish ladder. Future evaluations of this modification are not currently planned. (personal communication with Derek Fryer, ACOE, 5/6/10)
5d	Ice Harbor (Snake)	ACOE	I	During the 2009-2010 winter work period, a total of 8 diffuser grating sections in the fish ladder were plated. Diffuser sections 8-11 were no longer operational and were fully plated (entire section covered) and diffuser sections 4-7 received partial plating (perimeter). Future evaluations of this modification are not currently planned. (personal communication with Derek Fryer, ACOE, 5/6/10)
5e	John Day (Columbia)	ACOE	P	In 2010-2011, at the north ladder, a 12-inch-wide metal strip will be installed over the south side of floor diffuser 16. (ACOE 2009a)

Table 1, continued…

	Hydroelectric Project (River)	Project Owner (Study Lead(s))	Measure Planned (P), Implemented (I), and/or Evaluated (E)	Measure Description and Evaluation Results (if applicable)
6.	**Measure:** Install ramps at sills and perched orifices **Intended Metric Category:** Ladder Passage			
6a	Willamette Falls (Willamette)	PGE	I, E	In the summer of 2008, a sill located at the base of the entrance was ramped. The 2009 passage evaluation is still ongoing; however, preliminary data suggests that combined entrance efficiency (all 3 entrances) is approximately 82%. The role the modifications play in this result are unclear since past radio-telemetry studies were not designed at the scope necessary for pre and post modification comparisons. (personal communication with Tim Shibahara, PGE 4/7/10)
6b	Priest Rapids (Columbia)	Grant PUD	I	During the winter of 2009-2010, aluminum ramps at elevated sills and lips were installed. An evaluation will be conducted in summer 2010. (Nass et al. 2009)

Table 1, continued…

	Hydroelectric Project (River)	Project Owner (Study Lead(s))	Measure Planned (P), Implemented (I), and/or Evaluated (E)	Measure Description and Evaluation Results (if applicable)
7.	**Measure:** Modify fishway count stations **Intended Metric:** Ladder Passage			
7a	Priest Rapids and Wanapum (Columbia)	Grant PUD	I	During the winter of 2009-2010, lamprey-specific fish crowder structures were installed at the count stations. An evaluation is planned for summer 2010. (Nass et al. 2009)
7b	Rocky Reach (Columbia)	Chelan PUD	I	During the 2008-2009 fishway overhaul (December 2008 through the first week of March 2009), brush strips were added to the counting backboard and the upstream picket barrier trashrack edges to prevent lamprey from evading the counting window. Also during the 2008-2009 overhaul, a bulkhead seal was added to the downstream end of the counting board to also prevent lamprey from evading the window. Evaluation of these modifications for lamprey has not occurred. (personal communication with Lowell Rainey, Chelan PUD, 4/29/10)
7c	John Day (Columbia)	ACOE	P	In 2010, the following modifications will be made at the north ladder: (ACOE 2009a) - Raise count station floor one foot to match invert at new weir 1 (holey wall site) - Remove 23-inch ramp through count slot and lower viewing window by 11.5 inches - Upgrade count station lighting and add automated brush cleaner for viewing window - Replace antiquated crowder, adding new transition farings and horizontal vanes Video monitoring is planned for summer 2010 to verify that the count station modifications are functioning properly.
7d	Wells (Columbia)	Douglas PUD	P	Per the Wells Project Pacific Lamprey Management Plan (Douglas PUD unpublished), Douglas PUD, in consultation with work group members, may modify existing count stations to utilize alternative passage routes as a counting facility for adult Pacific lamprey to improve the accuracy of lamprey counts at the project.

Table 1, continued…

	Hydroelectric Project (River)	Project Owner (Study Lead(s))	Measure Planned (P), Implemented (I), and/or Evaluated (E)	Measure Description and Evaluation Results (if applicable)
8.	**Measure:** Install flow reduction structures **Intended Metric:** Ladder Passage			
8a	Bonneville (Columbia), Cascade Island entrance	ACOE	I, E	As part of modifications made to the entrance of the Cascade Island fishway during the winter of 2008-2009, bollards (a.k.a. "artificial rocks") were installed in the lower fishway inside the fishway entrance. Overall, the Cascade Island entrance modifications did not appear to have had a substantive negative or positive effect on adult lamprey passage at the dam because there were not large and consistent changes in the measured passage metrics between pre- and post-modification years nor large increases in the metrics at Cascade Island compared to the Bradford Island entrance. (Clabough et al. 2010)
9.	**Measure:** Weir wall modifications **Intended Metric:** Ladder Passage			
9a	McNary (Columbia)	ACOE	I	During the 2009-2010 winter work period, 3-inch high by 18-inch wide lamprey orifice openings were constructed flush with the fishway floor at 10 tilting weirs (with perched orifices) in the Oregon shore fish ladder. Evaluation of any potential impacts to migrating adult salmon is currently being conducted. Preliminary observations using underwater video have observed no interactions by migrating adult salmon/steelhead with the one open lamprey orifice. To date, approximately 19,000 salmon/steelhead have passed McNary Dam. (personal communication with Derek Fryer, ACOE, 5/6/10)
9b	John Day (Columbia)	ACOE	P	The following modifications at the north ladder are planned for 2010-2011: (ACOE 2009a) - Remove all 18 serpentine weirs + holey wall and replace with 23 lamprey-improved, JDAS-type w/ 15- to 18-inch vertical slots and 18- by 18-inch orifices - Add electrically powered sill actuators and support structure for 22 new weirs

Table 1, continued…

	Hydroelectric Project (River)	Project Owner (Study Lead(s))	Measure Planned (P), Implemented (I), and/or Evaluated (E)	Measure Description and Evaluation Results (if applicable)
10.	**Measure:** Other ladder modifications **Intended Metric:** Ladder Passage			
10a	John Day (Columbia)	ACOE	P	The following modifications at the north ladder are planned for 2010-2011: (ACOE 2009a) - Remove 1st vertical slot and sill baffle in forebay transition area - Modify 2nd baffle in forebay transition
10b	Willamette Falls (Willamette)	PGE	P	Activities to restore portions of the existing "old fishway" to operability are planned for 2010. Current information indicated that lamprey congregate in an area of this fishway early in the migration season. Operations of this fishway will allow lamprey, including salmon and steelhead that are currently salvaged as necessary from this area, volitional passage to the forebay of the project. There is not a license commitment but there will likely either be enumeration effort or funding to an existing research project (Warm Springs Tribe) that is utilizing half duplex tags to the falls to evaluate lamprey. (personal communication with Tim Shibahara, PGE 4/7/10)

Table 1, continued…

	Hydroelectric Project (River)	Project Owner (Study Lead(s))	Measure Planned (P), Implemented (I), and/or Evaluated (E)	Measure Description and Evaluation Results (if applicable)
	Operational Modifications			
11.	**Measure:** Reduce water velocities during the night / improvement in hydraulic conditions at entrance **Intended Metric:** Entrance Efficiency			
11a	Bonneville (Columbia), spillway entrance	ACOE	I, E	In 2000, tests to determine whether lowering water velocity at the Bonneville Dam spillway entrance would improve lamprey entrance success were conducted. Velocity at entrances was decreased from approximately 2.4 m/s to 1.2 m/s at night (2100 to 0400 h) at alternating spillway entrances during the period from July 25 to October 1. Fifty eight lamprey approached the spillway entrances during this period and 36 of these fish made their approach during the velocity test period. Entrance efficiency was actually higher during the high velocity treatment than during the low velocity treatment for these fish, indicating that reducing the velocity at these entrances did not improve lamprey entrance performance. (Moser et al. 2002)
11b	Bonneville, Powerhouse 2 (PH2)	ACOE	I, E	In 2007 and 2008, ladder flows at PH2 fishway were placed on standby at night. The combined 2007 and 2008 results suggest that some reduction in entrance velocity is beneficial for lamprey passage, but that these benefits are velocity-dependent and that zero attraction flow is probably a deterrent. Entrances with higher velocities under normal operation (capable of a larger net reduction in velocity) may provide relatively more benefit from velocity reductions than entrances with lower velocities. (Johnson et al. 2009a and 2009b) The 2009 evaluation revealed that overall dam passage metrics in 2009 were similar to estimates observed in prior years. Of the 596 lamprey tagged and released, 471 (79%) approached the dam, 383 (64%) entered, 177 (29%) passed the dam thru September 30. Fifty-four percent of the tagged lamprey made their first approach at PH2 (two-thirds of these did so at one of the north openings). The greatest proportion first entered PH2 fishway openings (32%) followed by the spillway (20%) and PH1 openings (14%). Thirty-four percent of the entrances at Bonneville Dam had unknown locations or times and we presume that most of these were associated with entries at unmonitored floating orifice gates. Dam passage times were similar to previous years for all passage segments (e.g., median release-to-dam passage time = 8.7 d, range 1.7-57.8 d). In addition, comparison of treatment vs. control nights at PH2 entrances indicated that there was a benefit of the lower velocity treatment to entrance efficiency (entrance: approach ratio) for tagged lamprey. (ACOE 2009b)

Table 1, continued…

	Hydroelectric Project (River)	Project Owner (Study Lead(s))	Measure Planned (P), Implemented (I), and/or Evaluated (E)	Measure Description and Evaluation Results (if applicable)
11d	McNary (Columbia)	ACOE	I, E	In an effort to increase fishway entrance efficiency at McNary Dam, water velocities were manipulated in 2009 by lowering the telescoping entrance weirs in a randomized block design between the hours of 2100 and 0400 daily, July 2 – October 10. In 2009, relatively high percentages of radio-tagged lampreys were recorded approaching McNary Dam after release (68%), entering McNary Dam fishways (63%), and passing the dam (56%) compared to the previous four years of research. In the 2005–2008 studies, the rate of approach after release was 23–76%, rate of entrance was 17–56% and the rate of dam passage was 12–41%. Return to the dam and passage efficiency metrics in 2009 were the highest recorded with the exception of the rate of approach in 2008. Entrance efficiency (proportion that approached that subsequently entered the fishway) in 2009 was 93%, substantially higher than all years other than 2006. Consistent with a priori statistical power analyses, preliminary results of the first year of the two-year experiment suggest that the reduction of velocity during night did not have an extreme positive or negative effect on lamprey passage behavior. (Boggs et al. 2010) During the 2009-2010 winter work period, modifications of the gate were made to allow for better operational control. In 2010, a second year of alternative gate operations of the fishway entrance gates are planned. The gates will be lowered by 5-6 feet at nighttime (9pm-4am) to enlarge the opening that~~which~~ will send the same volume of water through the larger space resulting in lowered water velocities. (personal communication with Derek Fryer, ACOE, 5/6/10)
11e	Wells (Columbia)	Douglas PUD	I, E	In 2009, Dual-frequency Identification Sonar (DIDSON) was used to passively assess adult Pacific lamprey passage behavior in response to operational modifications at the Wells Dam fishway entrances. The 2009 lamprey run resulted in few fish observed at Wells Dam, precluding statistically significant evaluation of these results. Nonetheless, operational modifications implemented in 2009 suggest strong potential for increasing entrance efficiency. Pooling observations that occurred during reduced velocity treatments shows a 67% (2 of 3) entrance efficiency compared to 50% (1 of 2) under normal conditions. (Johnson et al. 2010) An additional DIDSON evaluation is planned for summer 2010.
11f	Ice Harbor (Snake)	ACOE	I	In 2009, the ACOE conducted a flow reduction study at fishway entrances at the project during the lamprey migration season. The change in fishway operations was not evaluated and implementation in 2010 is not planned. (personal communication with Derek Fryer, ACOE, 5/6/10)

Table 1, continued…

	Hydroelectric Project (River)	Project Owner (Study Lead(s))	Measure Planned (P), Implemented (I), and/or Evaluated (E)	Measure Description and Evaluation Results (if applicable)
12.	**Measure:** Turn off lights in fishway at night **Intended Metric:** Ladder Passage			
12a	John Day (Columbia)	ACOE	P	In 2010-2011, at the north ladder, a 7-ft wide walkway over the exit weir section will be installed to provide access to all sill actuators and the top of the sidewalls in the exit section will be raised 3 feet to block light into the fishway. (ACOE 2009a)

4.0 Rocky Reach Fishway Tour/Observations

Rocky Reach Dam has one fish ladder to aid the migration of adult fish around the Project. The fishway operates at all times of the year except when closed for annual maintenance which occurs for approximately eight weeks in the winter (See Figure 1 for terminology used for various fishway sections). The fishway consists of entrances, channels, a fish ladder, and an attraction water system (AWS). The Right Fishway Entrance Collection Channel runs from the right powerhouse entrance along the length of the powerhouse (Figure 1). From the Spillway Entrance, a tunnel runs under the west end of the spillway and towards the middle dam area. The tunnel connects first with the left powerhouse entrance at the bifurcation pool and then meets with the Right Fishway Entrance Collection Channel at the Trifurcation Pool. From the Trifurcation Pool, a Transportation Channel runs parallel to the collection channel where it connects to the Transition Ladder section of the fishway. Moving upstream, the Transition Ladder becomes the Lower Ladder and then the Upper Ladder as it winds around the south end of the powerhouse and exits on the west end of the south forebay parapet wall. A fish counting room is located in the Upper Ladder section, as well as a public fish viewing room. The AWS maintains proper attraction flow within the fishway and at the fishway entrances to aid adult fish in locating the entrances and to provide favorable hydraulic conditions for rapid passage through the facility.

On February 25, 2010, the Team (LGL, Long View Associates, Cramer Fish Sciences, and Blue Leaf) members met with participants of the RRFF to tour the fishway facilities at Rocky Reach Dam. Chelan PUD representatives guided the group to multiple locations along the fishway to discuss structural and operational characteristics relative to adult lamprey passage. During the tour, participants were briefed on the layout of the fishway and its general operational conditions. Previously documented information on water velocity at specific locations (Chelan PUD as presented in BioAnalysts [2005]) was described.

The fishway was not in operation at the time of the tour so the portion of the fishway from the Lower Ladder section of the fishway to the Fishway Exit was dewatered. The entrances, Right Fishway Entrance Collection Channel, Trifurcation Pool, and Transportation Channel were partially inundated (i.e., bulkhead not installed) so the fishway floor in these areas could not be seen. The primary observation points of the tour included (Figure 1):

- Upper Ladder/Fishway Exit: (from single diffusion chamber to the exit, including a series of control weirs and the adult trapping facility and count station);
- Transition Ladder (from end of Transportation Channel to the start of the Lower Ladder);
- Transportation Channel (from upper end of Trifurcation Pool to the Transition Ladder where pool and weirs start);
- Right and Left Fishway entrances;
- Right Fishway Entrance Collection Channel (from Right Fishway Entrance to Trifurcation Pool including orifice gates); and

- Trifurcation Pool (convergence area of Spillway Entrance Channel, Left Fishway Entrance Channel, and Right Fishway Entrance Collection Channel).

The Upper Ladder/Fishway Exit section includes the count station and a series of control weirs located immediately downstream. The adult salmon trapping facility and count station use a trash rack and vertical weir structure to route upstream moving fish past the video chamber and gated trap. The Chelan PUD representative explained that the structure was "fish tight" due to the small gap size (3/4 inch nominal) on the trash rack and the rubber gaskets sealing the panels to the fishway stem walls. All fish, including lamprey, must pass through the video chamber to exit into the forebay. Below the trapping/counting facility are a series of control weirs. These control weirs provide a 1 foot incremental increase in elevation within the Upper Ladder. Although orifice corners at these weirs have beveled edges, the orifice openings are perched. The top edges of the weirs in this section are beveled on the downstream side and have a 90 degree angle on the upstream side. The start of this fishway section (downstream end) contains a single AWS chamber and diffuser grating that spans the width of the fishway floor. All diffuser grating in the fishway has a 1-inch nominal gap. Adult lamprey trapping also occurs at this diffuser location.

The Lower Ladder section of the fishway is defined as the portion of the fishway between the Upper Ladder/Fishway Exit and the Transition Ladder. This section of the fishway is composed of pools separated by weir walls with orifice openings to facilitate passage. Edges at the tops of weirs and at the edges of orifices openings are apparently similar to weir and orifice edges in the Upper Ladder section.

The Transition Ladder section lies between the Lower Ladder and Transportation Channel. Unlike the control weirs in the Upper Ladder/Fishway Exit section, the orifice openings in this section are flush with the fishway floor. There are eight pools at the downstream end of this section that have diffuser grating that span the width of the floor. During previous fishway maintenance activities, some plating was added around the edges of diffusers.

The Transportation Channel is defined as the area of the fishway between the Trifurcation Pool and the Transition Ladder area that begins the ladder section of the fishway. This area of the fishway is simple in structure (no weir walls and is linear).

The Right Fishway Entrance Collection Channel connects the Right Fishway Entrance with the Trifurcation Pool. Also within this fishway section are a series of orifice gates evenly divided between the left and right bank ends of the channel. Six of these gates (gates 16, 18, 20 on the right bank and gates 1, 2, 3 on the left bank) are typically in operation for fish passage. Similar to the Transportation Channel, this section of the fishway is linear and simple in structure. However, diffuser grating is located at each of the areas where orifice gate openings are present. Staff at the Project did express an interest in closing these gates as previous assessment data indicate little use.

The Trifurcation Pool is the area where all three entrances (left, right, and spillway) converge and connect to the Transportation Channel. ~~A high frequency of d~~Diffuser grating ~~that~~ spans the entire width of the fishway floor throughout ~~exists in~~ this area. This section of the fishway was

partially inundated and observations about the conditions of the grating and whether any plating exists could not be confirmed.

The Left Fishway, Right Fishway and Spillway entrances are designed as rectangular slots that can accept bulkheads to provide complete or partial gating. The entrances were inundated, which limited observations; however, drawings indicate that floor diffuser grating that spans the width of the floor exists at the Left Fishway, Right Fishway and Spillway entrances.

During the fishway tour, issues of concern raised by participants relative to adult lamprey passage included the potential for water velocities that may impede entrance to the fishway, areas of the fishway with diffuser grating, and the perched orifices in the Upper Ladder.

5.0 Recommendations for Consideration

Based upon a review of existing site specific assessments (Section 2.0) and fishway design drawings, results of modifications that have been implemented and/or evaluated at other Columbia River basin projects (Section 3.0), observations gathered during the February 25, 2010 fishway tour (Section 4.0), and the Team's best professional judgment, a list of potential modifications for the Rocky Reach fishway are provided below. The recommendations presented in this section are not exhaustive, but reflect a collective evaluation of the body of existing information while qualitatively evaluating a measure's relative cost magnitude and potential benefit, probability of success, and applicability to site. The recommendations are intended to provide a basis for future RRFF discussions regarding prioritization, identification of additional information needs, and the selection of the first phase of modifications to be evaluated. These recommendations, considered collectively, are intended to represent a step-wise, iterative, and scientifically rigorous approach to improving adult lamprey passage at the Project.

1. **Entrance Synopsis:** Based upon the results of the 2004 study, fishway entrance efficiency was considerably higher than at other projects in the basin with 94% (n=110) of fish detected in the tailrace entering a fishway entrance (BioAnalysts 2005). During the fishway tour, fishway entrances were partially inundated so an evaluation of entrance structures (bulkhead slots, presence of sill, and other transition structures) was not possible.

   Recommendation: In evaluating the literature related to lamprey fishway entrance efficiency, relatively high water velocities at and inside fishway entrances have been identified as a major impediment to lamprey passage. Based upon a review of the available site-specific information, hydraulic barriers at or inside the fishway entrance do not appear to impede lampreys' ability to enter the Rocky Reach fishway. The 2004 study results indicate that entrance efficiency into the Rocky Reach fishway is high. The Team recommends continued monitoring during the next evaluation. The Team also recommends that during the next winter fishway outage when the entrance area is accessible, that a structural assessment of each entrance floor and walls for lamprey-friendly transitions, be conducted. If future monitoring of the fishway entrance identify significant decreases in performance, the RRFF may consider structural (e.g., rounding corners) or operational (e.g., nighttime reduction of water velocities) measures at that time.

Comment [MSOffice4]: Please add a range of entrance efficiencies at these other projects.

2. **Collection Channel / Entrance Channels / Trifurcation Pool Synopsis:** Travel rates were relatively high from the Right Fishway Entrance and Orifice Gate (O.G.) Entrances 18-20, but substantially lower from O.G. Entrances 1-3 and the Left Fishway Entrance (BioAnalysts 2005). The 2004 study notes that downstream movement within the collection channel was detected after entrance to the channel from O.G. Entrances 1-3. Fishway design drawings show large areas of diffuser grating that span the width of the fishway floor immediately inside the Spillway Entrance, Left Fishway Entrance, and O.G. Entrance. Further, travel rates through the Trifurcation Pool were "somewhat surprising" (i.e., relatively fast) given the ~~high frequency~~continuous expanse ~~-~~of diffuser grating in this location (BioAnalysts 2005). Although a visual evaluation of the fishway floor at the Trifurcation Pool was not possible during the tour, Project schematics confirm that the floor in this area consists entirely of diffusion grating.

   Of the 110 tagged lamprey entering the fishway, all of them progressed upstream and were detected at the Trifurcation Pool. Therefore, these fish traveled the entire segment from a respective entrance to the start of the Trifurcation Pool. They also displayed the highest travel rates (m/min) for a monitored segment of the fishway (Table 5, BioAnalysts 2005). However, 45% of these lamprey dropped out of the fishway (n=30) or were last detected residing in the fishway or AWS system (n=20).

   Comment [MSOffice5]: Need to address the tag life issue.

   Data regarding the extent of progression past the Trifurcation Pool was not reported on~~;~~, however, these data indicate that after lamprey arrive at the Trifurcation Pool, structural and/or hydraulic impediments exist that reduce continued upstream migration or causes them to drop-out from the fishway into the tailrace.

   Using their oral disks, Pacific lamprey exhibit a burst and attach behavior to negotiate areas of difficult passage and high water velocity. In fishways, this type of behavior can be ineffective, particularly where suitable attachment surfaces are unavailable (Keefer et al. 2010b). Diffuser grating serves as the structural interface between the AWS and fishways. These structures have been identified as potential problem areas for lamprey because of their lack of solid continuous surfaces. Within the Right and Left Fishway Entrance channels, Trifurcation Pool, and Transition Ladder, a high frequency of diffuser grating was identified.

   Recommendation: Conduct additional analyses of the 2004 data to determine the number of unique lamprey detected by detection zone, and more specifically, determine the extent of upstream movement in the fishway for each individual. This analysis would demonstrate the progression of some individuals and the attrition of others. If the segment of the fishway where the majority of the "losses" can be identified, then site specific measures may be developed.

   Provide solid continuous aluminum plating (18-inch wide) around the entire perimeter of each diffuser grate (along walls and across end points) through the Right and Left Fishway Entrance channels, Trifurcation Pool, and Transition Ladder (Table 1, Measure 5). Installing plating to the diffuser grating perimeter at these locations will provide migrating lamprey a continuous, solid surface in which to exhibit burst and attach swimming behavior, thus improving passage times, reducing entrance into the AWS system, and reducing frequency of drop back into the tailrace after entering the fishway.

Consider the closure of O.G. Entrances 1-3. These gates had relatively low (12% of fish entering used these locations) use during the 2004 study and lamprey were reported as having a high frequency of downstream movement after entrance. Further, these gates provide entrance directly into areas with diffusion plating. It is likely overall entrance efficiency would not be impacted at the Project due to the other numerous options for entering the fishway.

3. **Transportation Channel Synopsis:** This section of the fishway is completely concrete without any weirs or diffusion chambers. There is no indication that lamprey migration may be impeded through this section by structural or operational conditions.

   Recommendation: None.

4. **Transition Ladder and Lower Ladder Synopsis:** The Transition Ladder area contains a set of 9 diffuser grates in pool and weir structures. All orifices in these pools are flush with the fishway floor, and corners of orifice openings are beveled. The Lower Ladder section of the fishway appears to be similar to the Transition Ladder section; however, no diffuser grating is present. During the tour, the Team was unable to access the Lower Ladder section of the fishway to confirm that orifice openings were flush with the fishway floor and that the corners of orifice openings were beveled.

   Recommendation: The Team recommends 18-inch wide perimeter aluminum plating around all diffuser grating in the Transition Ladder section (Table 1, Measure 5). This should allow migrating lamprey a continuous, solid surface along the perimeter of each pool to bypass upwelling flows created by diffusers and should improve passage times, reduce entrance into the AWS system, and may reduce the frequency of drop back after entering the fishway. The Team also recommends confirming that all other orifice openings in this Lower Ladder section are flush with the fishway floor and at that corners of orifice openings are beveled.

5. **Upper Ladder Synopsis:** This area contains one large diffuser grating that begins the Upper Ladder section of the ladder. This area also served as the location where lamprey were trapped for the 2004 study. Upstream of the lamprey trapping area are a series of control weirs that contain perched orifices (i.e., orifice has sill and is not flush to fishway floor). Although the corners of the orifice opening are beveled, perched orifices have been identified as potential passage impediments at other basin projects. Generally, velocity differentials between the areas below the sill (below the main orifice flows and lower then flows directly in orifice opening) and over the sill (within the orifice where flows are at a maximum) create hydraulic barriers that may be problematic to migrating lamprey. Burst and attach behavior is not well adapted to transition areas with high differentials in velocities. Allowing for more gradual changes both structurally and hydraulically at perched orifices is more complimentary to lamprey swimming behavior.

   Recommendation: The Team recommends 18-inch wide perimeter aluminum plating around the diffuser grating (Table 1, Measure 5). Allowing lamprey a continuous, solid surface along the perimeter of this area to bypass upwelling flows should improve passage times, reduce entrance into the AWS system, and may reduce the frequency of drop back after entering the fishway. Note that during evaluations, plating in this area of the fishway may reduce trapping efficiency. The Team also recommends constructing ramps upstream

Comment [MSOffice6]: Fish already miss the trap by the time they reach the grating; therefore, the plating would have no effect on trapping efficiency. Recommend deleting sentence.

and downstream of all perched orifices in this Fishway Exit section to ensure a gradual structural and hydraulic transition through the orifice (Table 1, Measure 6) more complimentary to lamprey swimming behavior.

6. **Count Window Synopsis:** Historically, the potential for lamprey to bypass the count station existed due to gaps in the associated structures of the fish count window. However, Chelan PUD implemented the following during the 2008-2009 winter fishway outage to prevent lamprey from evading the counting window (Table 1, Measure 7):

   a. Three-quarter inch nominal mesh trash rack was installed.

   b. Brush strips were added to the counting backboard and the trash rack edges.

   c. A rubber seal was added to the downstream end of the counting board.

   Recommendation: The Team recommends continued monitoring during the next evaluation and reporting of higher resolution tag detection data to assess whether passage delays due to hydraulic barriers exist at the count station or whether lamprey are bypassing the count window.

7. **Fallback after Ladder Exit Synopsis:** The 2004 study indicated a conditional fallback rate of 21.5% and a net fallback (after considering re-ascension) rate of 14.5% (slightly higher than other facilities in the basin). From a review of the fishway design drawings, the orientation of the Fishway Exit may be perpendicular to the flow of the river and is directly upstream of the powerhouse. Lamprey exiting into the forebay upstream of the powerhouse will have a tendency to sound to greater depths due to their demersal behavior. Since lamprey are relatively poor swimmers as compared to salmonids, they are more likely to be entrained in powerhouse flows. The results of the 2004 study indicated fallback through powerhouse units 1-4 with the highest frequency through unit 1~~ which is located directly downstream of the Fishway Exit (8 fish)~~.

   Recommendation: Since all potential modifications to address fallback have a relatively high cost with uncertain benefit, the Team recommends evaluating frequency of fallback during the next adult lamprey passage evaluation to increase sample size toward validating the 2004 study conclusions. Toward consideration of having to address fallback at the Project in the future, it is recommended that the next passage evaluation consider three additional study design elements: 1) Identify a location in the Upper Ladder/Fishway Exit section where lamprey may be collected. As an example, it may be possible to open a small section of the picketed lead downstream of the count window and provide a ramp to a trap box similar to LPS structures at other facilities in the Lower Columbia River; 2) Tag and release an appropriate number of lamprey at pre-determined distances upstream of the Fishway Exit along the right bank to determine the distances upstream of the fishway where lamprey may be outside the influence of entrainment flows; 3) If hydraulic data of the Rocky Reach forebay exist, utilize the information to assess the potential for lamprey entrainment as based on bulk flow patterns, water velocities and bathymetry.

   If future study results identify fallback as substantial, data collected from these additional study components will help to inform the design and location of collection systems (e.g., LPS

Comment [MSOffice7]: This paragraph should focus on what is known. Currently, too many assumptions and speculation.

Comment [MSOffice8]: Recommend deleting this sentence. The flow is not perpendicular to the exit.

Comment [MSOffice9]: Entrainment is not an issue at the exit. It may be an issue upstream from the exit.

Comment [MSOffice10]: Recommend deleting these two sentences because they are inaccurate.

system) where fish can access this alternative passage system at an Upper Ladder location (e.g., exit pool, at count station, trapping location) and migrate volitionally upstream (distance to be determined by study data) along the right bank shoreline to an exit location outside of the influence of entrainment flows. Another alternative modification may include a modified LPS to a trap box (Table 1, Measure 1) where fish would then be transported upstream to an area upstream of the influence of entrainment flows.

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Appendix A
RRFF Comments on Outline and Draft Literature Review, Analysis, and Recommendations for Pacific Lamprey Upstream Passage Improvements

[Will include written comments received on outline and/or draft document.]

[Insert into final PDF, PDFs of emails, written letters, relevant meeting notes, etc.]

Appendix B
Summary of RRFF Comments on Outline and Draft Literature Review, Analysis, and Recommendations for Pacific Lamprey Upstream Passage Improvements and Chelan PUD's Responses

Summary table of RRFF ~~resource agency and tribal~~ comments on the Pacific Lamprey Upstream Passage Modifications Literature Review and Analysis and Recommendations for Passage Improvements in the Rocky Reach Fishway and Consultants~~helan PUD~~ responses

Submitting Entity	Date Received	Paragraph #	~~Agency~~ RRFF Comment	Consultants~~helan PUD~~ Response

From: Irle, Pat (ECY) [PIRL461@ECY.WA.GOV]
Sent: Tuesday, June 22, 2010 10:53 AM
To: Hallock, Molly (DFW); Stephen_Lewis@fws.gov; Tracy Hillman
Cc: Bao Le; Bryan Nass; Bob Rose; Deborah Bitterman; Emily Andersen; Jeff Osborn; Josh Murauskas; Steve Hays
Subject: RE: Comments on the Lamprey Literature Review Document
Attachments: image001.gif; image002.png; image003.png

I usually support I good, healthy discussion, so I could support a discussion by the workgroup on all the information that has been made available to them…

From: Hallock, Molly (DFW)
Sent: Tuesday, June 22, 2010 10:48 AM
To: Stephen_Lewis@fws.gov; Tracy Hillman
Cc: Bao Le; Bryan Nass; Bob Rose; Deborah Bitterman; Emily Andersen; Jeff Osborn; Josh Murauskas; Irle, Pat (ECY); Steve Hays
Subject: RE: Comments on the Lamprey Literature Review Document

I hate to do a switcharoo, but I agree with Steve. I think the consultants should rank the their recommendations, and the RRFF can do with that as we see fit. Too late for reopener on this?

Molly
Molly Hallock
Washington Department of Fish and Wildlife
Fish Biologist (Freshwater Native Nongame)
Workdays: Monday-Wednesday
600 Capitol Way North
Olympia WA 98501
(360)902-2818

From: Stephen_Lewis@fws.gov [mailto:Stephen_Lewis@fws.gov]
Sent: Tuesday, June 22, 2010 10:02 AM
To: Tracy Hillman
Cc: Bao Le; Bryan Nass; Bob Rose; Deborah Bitterman; Emily Andersen; Hallock, Molly (DFW); Jeff Osborn; Josh Murauskas; Irle, Pat (ECY); Steve Hays
Subject: Re: Comments on the Lamprey Literature Review Document

Hi Folks-

Thanks for providing the meeting minutes for review. Although, I'm not quite sure I'm totally sold on the end product for the recommended measures to improve lamprey passage at Rocky Reach, as eluded to in the meeting minutes. In my mind, it should be Longview's obligation to assess potential modifications at Rocky Reach (as they did) and bring forward their best recommended alternative for the upcoming year to the RRFF. The RRFF would then assess whether or not to adopt this alternative. I think this type of strategy makes for a more productive meeting on July 29th. Otherwise, I think our discussions on July 29th will simply be too tangential. Just some food for thought.

S-

****

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"Tracy Hillman" <tracy.hillman@bioanalysts.net>

"Tracy Hillman"
<tracy.hillman@bioanalysts.net>

06/16/2010 11:15 AM

To"Bao Le" <ble@longviewassociates.com>

cc"Emily Andersen" <eandersen@longviewassociates.com>, "Bryan Nass" <bnass@lgl.com>, "Molly Hallock" <hallomh@dfw.wa.gov>, "Bob Rose" <brose@yakama.com>, "Steve Lewis" <stephen_lewis@fws.gov>, "Pat Irle" <pirl461@ecy.wa.gov>, "Jeff Osborn" <jeffa@chelanpud.org>, "Steve Hays" <steveh@chelanpud.org>, "Josh Murauskas" <Josh.Murauskas@chelanpud.org>, "Deborah Bitterman" <Deborah.Bitterman@chelanpud.org>

SubjectComments on the Lamprey Literature Review Document

Hi Bao,

On Monday, the RRFF reviewed your document titled, “Pacific Lamprey Upstream Passage Modifications Literature Review and Analysis and Recommendations for Passage Improvements in the Rocky Reach Fishway.” Overall, the Forum was impressed with the document. They did, however, provide a few edits and comments within the document (see attachment). Please let me know if you have any questions about the edits or comments.

The Forum thanks you for providing the draft document for their review and they look forward to seeing the final report.

Thanks,
Tracy Hillman*(See attached file: PLMP lit review and recommendations document 05-28-10 DRAFT (RRFF edits).doc)*

From: Tracy Hillman [mailto:tracy.hillman@bioanalysts.net]
Sent: Friday, June 25, 2010 3:06 PM
To: Art Viola; Bob Huber; Bob Rose; Brad James; Bryan Nordlund; Catherine Willard; Chad Jackson; Dave Burgess; Deborah Bitterman; James Blanchard; Jeff Osborn; Jerry Marco; Jim Harris; Joe Miller; Josh Murauskas; Keith Truscott; Keith Vradenburg; Ken Finicle; Lance Keller; Molly Hallock; Pat Irle; Patrick Verhey; RD Nelle; Reed Glesne; Steve Hays; Steve Hemstrom; Steve Lewis; Susan Rosebrough; Tony Eldred; Waikele Hampton
Cc: Bao Le; Bryan Nass
Subject: RRFF: Consultants Final Lamprey Literature Review Report

Hello RRFF,

Several members of the Forum have requested that the Consultants rank or prioritize the recommendations in the Lamprey Literature Review Report. I discussed this with Bao Le and he indicated that they would prioritize their recommendations based on professional judgment and their visit to Rocky Reach Dam. He noted that the Forum will need to determine if the recommended actions are feasible. I will send you the final report on Wednesday, 30 June.

Let me know if you have any questions.

Have a good weekend.
Tracy