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March 11, 2015

Kimberly D. Bose, Secretary
Federal Energy Regulatory Commission
Mail Code: DHAC, PJ-12
888 First Street, N.E.
Washington, D.C. 20426

RE: Priest Rapids Hydroelectric Project No. 2114-174
License Compliance Filing – Article 401(a)(12) – 2014 Pacific Lamprey Management Plan Comprehensive Annual Report

Dear Secretary Bose,

Please find enclosed the 2014 Pacific Lamprey Management Plan (PLMP) Comprehensive Annual Report consistent with the requirements of Article 401(a)(12) and the Washington State Department of Ecology 401 Water Quality Water Quality Certification Condition of 6.2(6)(b) (Appendix C) for the Priest Rapids Project.

The 2014 PLMP Comprehensive Annual Report summarizes the on-going activities undertaken at the Priest Rapids Project (Project) in 2014, as identified in the PLMP, for the purpose of identifying and addressing Project impacts on Pacific lamprey. Any variations from the implementation schedule provided in the PLMP have been identified in this document. This report also describes, consistent with the 401 Certification, recent Pacific lamprey passage, behavioral, and survival investigations and measures undertaken in the Columbia River basin, as well as an evaluation to determine if these investigations and measures are: (i) consistent with similar measures taken at other projects; (ii) appropriate to implement at the Priest Rapids Project; and (iii) cost effective to implement at the Priest Rapids Project.

On February 24, 2014, a horizontal fracture was discovered in the spillway monolith #4 at Wanapum Dam. This event required the immediate implementation of Grant PUD's Emergency Action Plan (EAP) which included the drawdown of Wanapum Reservoir. In consultation with PRFF members, Grant PUD took advantage of this opportunity to continue monitoring juvenile lamprey within the Project area in reservoir habitat below normal operating elevations.

An additional result of the EAP-related drawdown of the Wanapum Reservoir included the inoperability of Wanapum Dam fish ladders. To facilitate salmon and lamprey passage in the ladders for the 2014 migration season, an Interim Fish Passage Operations Plan (IFPOP) was developed by Grant PUD in consultation with PRFF members. The IFPOP included the installation of Fishway Passage Exit Systems (i.e., weir boxes) with lamprey ramps in each Wanapum fish ladder (Priest Rapids Dam fish ladders were unaffected). Grant PUD trapped and transported lamprey collected at Priest Rapids and Wanapum dam

ADDRESS PO Box 878
Ephrata, WA 98823
PHONE 509 766 2505
FAX 509 754 6770
grantpud.org

fish ladders during the peak of upstream adult lamprey migration. Captured fish were released to various locations within and upstream of the Project area.

On January 29 2015, Grant PUD prepared and disseminated the draft 2014 PLMP Comprehensive Annual Report to members of the Priest Rapids Fish Forum including the Washington Department of Ecology (WDOE) U.S. Fish & Wildlife Service, Washington Department of Fish & Wildlife, Colville Confederated Tribes, Yakama Nation, the Columbia River Inter-Tribal Fish Commission (CRITFC), Bureau of Indian Affairs, and the Confederated Tribes of the Umatilla Indian Reservation. A request for comments on the draft plan was also distributed to the Wanapum Indians, and other participating stakeholders. Comments were received from CRITFC on March 2, 2015. These comments can be found in Appendix A and comment/comment response summary table (showing the agency comment and Grant PUD's response).

This same report has also been provided to WDOE on January 29, 2015. On February 23, 2015 WDOE approved the report (Appendix A).

Federal Energy Regulatory Commission staff with any questions should contact Tom Dresser at 509-754-5088, ext. 2312, or at tdresse@gcpud.org.

Sincerely,

Ross Hendrick, Manager
License Compliance Manager
rhendr1@gcpud.org

CC: Patrick McGuire – WDOE
Priest Rapids Fish Forum

2014
Pacific Lamprey Management Plan
Comprehensive Annual Report

Priest Rapids Hydroelectric Project (FERC No. 2114)

Prepared for:
Public Utility District No. 2 of Grant County
Ephrata, Washington

Prepared by:

Bao Le
HDR Engineering, Inc.
Portland, Oregon

Sara Twitchell
HDR Engineering, Inc.
Portland, Oregon

Rod O'Connor
Blue Leaf Environmental
Ellensburg, Washington

Mike Clement
Public Utility District No. 2 of Grant County
Ephrata, Washington

March 2015

Executive Summary

In accordance with the Priest Rapid Project's License Order, issued by the Federal Energy Regulatory Commission (FERC) on April 17, 2008 (FERC 2008), and the 401 Water Quality Certification (WQC), issued by the Washington Department of Ecology (WDOE) on April 3, 2007 (WDOE 2007) and amended March 6, 2008 (FERC 2008), Public Utility District No. 2 of Grant County, Washington (Grant PUD) is required to develop, in consultation with the Priest Rapids Fish Forum (PRFF), a Pacific Lamprey Management Plan Comprehensive Annual Report (PLMP Comprehensive Annual Report) to be filed with FERC on or before March 31 of each year.

The PLMP Comprehensive Annual Report summarizes the on-going activities undertaken at the Priest Rapids Project (Project) in 2014, as identified in the PLMP, for the purpose of identifying and addressing project impacts on Pacific lamprey. Any variations from the implementation schedule provided in the PLMP have been identified in this document. This report also describes recent Pacific lamprey passage, behavioral, and survival investigations and measures undertaken in the Columbia River Basin as well as an evaluation to determine if these investigations and measures are: (i) consistent with similar measures taken at other projects; (ii) appropriate to implement at the Project; and (iii) cost-effective to implement at the Project.

During the sixth year of implementation of the PLMP, Grant PUD continued, for a fifth year, its assessment of Pacific lamprey behavior and passage efficiency through fishways at Priest Rapids and Wanapum dams to evaluate the efficacy of design enhancements installed during the 2009-2010 winter fish ladder maintenance outage. For the 2010 through 2014 migrations, Grant PUD tracked a total of 380 and 258 HDX-PIT-tagged lamprey at Priest Rapids and Wanapum dams, respectively. During this time period, preliminary data indicates that fishway passage efficiency for lamprey was 74% and 63% at Priest Rapids and Wanapum dams, respectively. However, as discussed below, 2014 represented anamolous conditions for fish passage at Priest Rapids and Wanapum dams. As such, results in this report were summarized for the 2010-2013 period separately from 2014. Upon receiving HDX-PIT data from Rock Island Dam (not available at the time of reporting), passage efficiency results will be updated as appropriate in the 2015 Annual Report.

During the 2014 reporting period, the sampling of juvenile lamprey in the Project area continued. On February 24, 2014, a horizontal fracture was discovered in the spillway monolith #4 at Wanapum Dam. This event required the immediate implementation of Grant PUD's Emergency Action Plan (EAP) which included the drawdown of Wanapum Reservoir. In consultation with PRFF members, Grant PUD took advantage of this opportunity to continue monitoring juvenile lamprey within the Project area in reservoir habitat below normal operating elevations. On March 4 – 7 and 13-14, 2014 a field crew assessed presence/absence of juvenile Pacific lamprey in areas affected by the abnormal drawdown. Three juvenile lamprey were captured and another was observed during sampling on March 4 in the vicinity of Sunland Estates (RM 431). Small numbers of dead juvenile Pacific lamprey were observed in the vicinity of Walling Canyon (RM 449), Crescent Bar (RM 441), and Sunland Estates. Additional sampling in the Wanapum Reservoir at low operational elevations is planned for 2015 after the reservoir returns to normal operating levels.

An additional result of the EAP-related drawdown of the Wanapum Reservoir included the inoperability of Wanapum Dam fish ladders. To facilitate salmon and lamprey passage in the

ladders for the 2014 migration season, an Interim Fish Passage Operations Plan (IFPOP) was developed by Grant PUD in consultation with PRFF members. The IFPOP included the installation of Fishway Passage Exit Systems (i.e., weir boxes) with lamprey ramps in each Wanapum fish ladder (Priest Rapids Dam fish ladders were unaffected). Evaluation of these exit systems indicated that of the 28 adult lamprey tagged with HDX-PIT tags and released into the upper Wanapum Dam left bank fishway, within six days 26 tagged fish were last detected at the left bank exit PIT array, 1 fish moved downstream within the fishway, and 1 fish was not detected after release.

In addition to facilitating volitional passage, Grant PUD trapped and transported lamprey (n=2,263) collected from Priest Rapids and Wanapum dam fish ladders during the peak of the upstream adult lamprey migration. Captured fish were released to various locations within and upstream of the Project area. Already tagged fish were released immediately upstream of the dam where they were trapped. Untagged fish were released above Rock Island Dam.

As in previous years, Grant PUD continues to participate in regional research and forums in the basin to promote coordination and information exchange.

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1.0 Introduction

1.1 General Description of the Priest Rapids Hydroelectric Project

Public Utility District No. 2 of Grant County, Washington (Grant PUD) owns and operates two hydroelectric dams on the Columbia River in the State of Washington; Wanapum and Priest Rapids, known collectively as the Priest Rapids Project (Project), and operated under the terms and conditions of the Federal Energy Regulatory Commission (FERC) Hydroelectric Project License No. 2114.

Wanapum Dam is located at river mile (RM) 415, south of the I-90 bridge at Vantage, Washington; approximately 38 miles downstream of the Rock Island Hydroelectric Project owned and operated by Public Utility District No. 1 of Chelan County, Washington (Chelan PUD) and 18 miles upstream of Priest Rapids Dam. The dam is 8,637 feet long and 186.5 feet high and includes a left and right bank fish passage structure, each with an upstream fish ladder. Wanapum includes ten turbine units with a nameplate capacity of 1,038 megawatts (MW) and a spillway with 12 bays. In April 2008, Grant PUD finished construction of the Wanapum Future Unit Fish Bypass (WFUFB) in the vacant slot of future turbine unit 11 to aid in downstream migration of salmonids. The Wanapum Reservoir is approximately 38 miles long and has a surface area of approximately 14,680 acres. Active storage volume of the Wanapum Reservoir is 160,400 acre-feet and total storage is 693,600 acre-feet. Seven perennial streams (Douglas, Tarpiscan, Johnson, Skookumchuck, Whiskey Dick, Quilomene, Trinidad, and Sand Hollow Wasteway) enter into the Wanapum Reservoir.

Priest Rapids Dam is located at RM 397; approximately 18 miles downstream of Wanapum Dam and the last dam on the Mid-Columbia River before it enters the Hanford Reach. The nearest town is Desert Aire, Washington, which is located approximately two miles upstream on the east-bank from Priest Rapids Dam. The Priest Rapids facility is 10,103 feet long and 179.5 feet high and includes ten turbine units with a generating capacity of 855.0 MW and a spillway with 22 bays. The Priest Rapids Reservoir is approximately 18 miles long and has a surface area of approximately 7,725 acres. Active storage volume of the Priest Rapids Reservoir is 48,600 acre-feet and total storage is 237,100 acre-feet. Two perennial streams (Crab and Hanson) drain into the Priest Rapids Reservoir.

1.2 History of Pacific Lamprey related Activities at the Priest Rapids Hydroelectric Project

For more than a decade, Grant PUD has actively participated in the research of and mitigation for Pacific lamprey related to the Columbia River hydro system and the Project area. The development of Grant PUD's Pacific Lamprey Management Plan (PLMP) has been a formalization of recent research and implementation measures required in the Project's License Order as issued by the FERC on April 17, 2008 (FERC 2008), but is largely a continuation of prior activities. Grant PUD was the first mid-Columbia River utility to assess the passage of lamprey in and through its Project area (Nass et al. 2003) and to identify potential actions and modifications to improve successful passage (Final License Application, Grant PUD 2003) without compromising adult salmonid passage. Results of the 2001-2002 lamprey telemetry studies in the Project area formed the basis of proposed modifications which are being conducted as part of implementation of the PLMP. These past studies and measures are partly the result of participation at the regional level and cooperating with tribes, agencies, and other hydroelectric

operators to address resource challenges and their potential solutions. In particular, Grant PUD's past and present participation in the Columbia River Basin Lamprey Technical Work Group (CRBLTWG) has made them an integral part of the regional research foundation. As a founding participant, Grant PUD assisted in the development of the "Critical Needs and Uncertainties" document and provided information to support the Tribal Recovery Plan (Nez Perce Umatilla, Yakama, and Warm Springs Tribes 2011). More recently, Grant PUD has and continues to participate in and provide support to the U.S. Fish and Wildlife Service (USFWS) Lamprey Conservation Initiative, the Yakama Nation Lamprey Recovery Planning efforts, and the Columbia River Inter-Tribal Fish Commission's (CRITFC) Tribal Restoration Plan.

Past activities and future measures implemented by Grant PUD to mitigate for Project impacts to Pacific lamprey are extensive and on-going. Many of the actions and measures recommended by tribal and agency lamprey experts to address hydroelectric project impacts on lamprey are, in general, a result of actions or fish ladder modifications that are currently or were previously implemented by Grant PUD. These include fish counting facilities that operate 24 hours a day, 7 days a week for the upstream migration period; during fishway dewatering procedures, implementation of fish collection protocols by qualified biologists to ensure safe recovery of all fish species present (Grant PUD 2010); and juvenile lamprey protection as a result of Grant PUD's avian predation and Northern pikeminnow control programs that have been proven to be effective at minimizing impacts to juvenile salmonid outmigrants.

Physical fish ladder and dam modifications include the use of "slotted" (hour-glass style) fishway entrances that provide differential velocity elevations with a range of high and low velocity corridors to suit different species, improved 24-hour video fish counting stations to collect reliable and accurate count data, and downstream migrant bypass systems to meet juvenile salmonid survival criteria. Grant PUD believes measures developed to reduce impacts to juvenile salmonids will benefit juvenile Pacific lamprey as well. The slotted entrances were installed prior to the 2001-2002 lamprey study and have provided effective fishway entrance efficiency. In recent years, the Army Corps of Engineers (ACOE) have experimented with similar entrances at lower Columbia River dams (D. Clugston, ACOE, personal communication). The fish counting stations have undergone several staged modifications starting with the conversion from count board stations (visual) to dual orifice video stations, and in 2010, conversion to engineered crowders which utilize a single orifice video station and picket leads with 11/16 - inch gap spacing to accurately enumerate all adult lamprey. Significant improvements for downstream passage have been achieved by development of the WFUFB and the Priest Rapids top-spill bulkhead for juvenile salmon which presumably provides a high survival alternative passage route for juvenile lamprey.

Grant PUD's continued efforts have contributed to the state-of-the-science for Pacific lamprey including: participation in regional forums and conferences; conducting telemetric passage evaluations and literature research; evaluating turbine intake emergency wheelgate slot exclusion screens; providing upstream and downstream fish passage facilities; support for full-duplex (salmon) and half-duplex (HDX; lamprey) passive integrated transponder (PIT) detection systems for project-specific and basin-wide assessments; and providing educational opportunities for the public to understand the ecological and tribal importance of lamprey in the Columbia River Basin.

As referenced in the FERC Order (Order Modifying and Approving Pacific Lamprey Management Plan, Article 401(a)(12) and Water Quality Certificate Condition 6.2(5)(b)), 127

FERC ¶ 62, 091, Grant PUD is required to develop, in consultation with the Priest Rapids Fish Forum (PRFF), and implement a comprehensive evaluation of adult lamprey passage at the Project. As outlined in its PLMP, Grant PUD implemented measures to improve lamprey passage in 2010. These efforts include conducting inspections of the Project passage facilities by the PRFF members, and the installation of passage-enhancing structures in the fishways at Priest Rapids and Wanapum dams. New structures included diffusion grate aluminum plating, ramps ascending perched orifices, and lamprey-friendly video fish count crowders; all specifically designed to facilitate lamprey passage. To facilitate tagging and fish husbandry research, Grant PUD expanded its fish handling facilities at Priest Rapids Dam by building innovative adult lamprey trapping and holding facilities for the most efficient and non-invasive processing of study fish. Following the installation of these structures, Grant PUD, in consultation with the PRFF, conducted a study of the effectiveness of these modifications during the summers of 2010 to 2012. The extensive HDX-PIT array at Priest Rapids and Wanapum dams was operated to monitor the passage of lamprey originating from tagging activities conducted at dams downstream of Priest Rapids Dam. A total of 20 HDX-PIT arrays were operated each migration season to track lamprey through the Project area. All arrays were operational May through December in 2010 through 2012 and from March through December in 2013 and 2014. Further, yearly winter fishway maintenance operations recover adult lamprey during NOAA approved dewatering procedures. These lamprey are scanned for the presence of a PIT tag and released into the forebay of the respective dams. Comprehensive results of this long-term monitoring program are presented in Section 2.1.4 below.

In June 2012, monitoring of juvenile lamprey was initiated to assess their presence/absence, habitat use, and relative abundance in areas affected by Project operations. In the Wanapum Reservoir, 36 potential shoreline habit locations were sampled. In the Priest Rapids Reservoir, 12 potential shoreline habitat locations were sampled. One juvenile lamprey was captured in the Priest Rapids Reservoir and another was observed, but not captured, in the Wanapum Reservoir. On November 13-16 and December 11-14, 2012, a field crew continued efforts to assess presence/absence, habitat use, and relative abundance of juvenile Pacific lamprey in areas that may be affected by Project operations. Twenty-seven and 21 shoreline habit locations were sampled in the Wanapum and Priest Rapids reservoirs, respectively. Sampling was conducted at mid-range pool elevations of the FERC-allowed operational range; approximately 570.0 feet (ft) above mean sea level (msl) at the Wanapum Forebay and between 485.3-487.5 ft above msl at the Priest Rapids Forebay. No juvenile lamprey were collected. Additional sampling was completed on May 11 and 12, 2013. Ten potential shoreline habitat locations in the Wanapum Reservoir were sampled resulting in the collection of no juvenile lamprey sampled. The pool elevation at the Wanapum forebay was 569.0 above msl during this sampling event. On October 11 and 12, 2013, a final sampling of eight potential shoreline habit locations in the Priest Rapids Reservoir collected seven juvenile lamprey. An additional 10 lamprey were observed but not captured. The elevation of the Priest Rapids Forebay was 480.2 ft above msl during this effort (near allowable minimum reservoir elevation per the FERC license).

On February 24, 2014, a horizontal fracture was discovered in the spillway monolith #4 at Wanapum Dam. This event required the immediate implementation of Grant PUD's Emergency Action Plan (EAP) which included the drawdown of Wanapum Reservoir. In consultation with PRFF members, Grant PUD took advantage of this opportunity to continue monitoring juvenile lamprey within the Project area in reservoir habitat below normal operating elevations. On March 4 – 7 and 13-14, 2014 a field crew assessed presence/absence of juvenile Pacific lamprey

in areas affected by the abnormal drawdown. Generally, sampling was difficult and at times not feasible due to deep mud exposed by low pool elevation (543.3-544.0 ft above msl at the Wanapum forebay). Three juvenile lamprey were captured and another was observed during sampling on March 4 in the vicinity of Sunland Estates (RM 431). Small numbers of dead juvenile Pacific lamprey were observed in the vicinity of Walling Canyon (RM 449), Crescent Bar (RM 441), and Sunland Estates (Appendix B). Additional sampling in the Wanapum Reservoir at low operational elevations is planned for 2015 after the reservoir returns to normal operating levels.

An additional result of the EAP-related drawdown of the Wanapum Reservoir included the inoperability of Wanapum Dam fish ladders. To facilitate salmon and lamprey passage in the ladders for the 2014 migration season, an Interim Fish Passage Operations Plan (IFPOP) was developed by Grant PUD in consultation with PRFF members. The IFPOP included the installation of Fishway Passage Exit Systems (i.e., weir boxes with lamprey ramps) in each Wanapum fish ladder (Priest Rapids Dam fish ladders were unaffected). The effectiveness of these exit systems was also evaluated (see Section 2.1.4; Appendix C). In addition to facilitating volitional passage, Grant PUD trapped and transported lamprey (n=2,263) collected from Priest Rapids and Wanapum dam fish ladders during the peak of the upstream adult lamprey migration (Appendix D). Captured fish were released to various locations within and upstream of the Project area. Already tagged fish were released immediately upstream of the dam where they were trapped. Untagged fish were released above Rock Island Dam.

Grant PUD continues to be active with respect to investigations related to Pacific lamprey passage research through its historical activities and proactive implementation of research and mitigation measures included in the PLMP. Grant PUD is committed to continue into the future in a similar manner. This report illustrates the continued allocation of effort and capital resources to achieve the goals and objectives of the PLMP.

1.3 Purpose of this Report

Grant PUD is required to submit the PLMP Comprehensive Annual Report (PLMP Comprehensive Annual Report) in accordance with the Project's License Order, issued by the FERC on April 17, 2008 (FERC 2008), and the 401 Water Quality Certification (WQC), issued by the Washington Department of Ecology (WDOE) on April 3, 2007 and amended March 6, 2008 (WDOE 2007; FERC 2008), which states:

> *<u>License Order:</u> The licensee shall file annually with the Commission by March 31, beginning 2010, their Annual Pacific Lamprey Management Report. The report shall include the reporting requirements identified under implementation measure 1 of the Biological Objectives and Implementation Measures under Appendix C of the Washington State Department of Ecology 401 Water Quality Certification. Additionally, the licensee's report shall include an updated implementation schedule and identify any variations from the schedule provided in the licensee's filed plan. The licensee shall prepare their report in consultation with the Priest Rapids Fish Forum and allow the Priest Rapids Fish Forum 30 days to review and comment on the report prior to filing with the Commission. The licensee's report shall include any resource agency and Tribe comments and the licensee's response to any comments. The Commission reserves the right to require changes to their plan based upon review of the report.*

401 Water Quality Certification, Appendix C: By March 31 following issuance of the New License, and each year thereafter for the term of the New License, [Grant PUD shall] provide an annual report summarizing activities undertaken to identify and address impacts of the Priest Rapids Project on Pacific lamprey, including results of those activities. This report shall include a compilation of information on other Pacific lamprey passage and survival investigations and measures being undertaken in the Columbia River Basin in order to determine if adult and juvenile measures being investigated and/or implemented at the Priest Rapids Project are: (i) consistent with similar measures taken at other projects; (ii) appropriate to implement at the Priest Rapids Project; and (iii) cost effective to implement at the Priest Rapids Project.

To fulfill the requirements, the report is structured as follows:

- Section 2.1: Background and existing information (i.e., through October 31, 2014) about Pacific lamprey passage and survival investigations and measures undertaken in the Columbia River Basin.
- Section 2.2: Information from the reporting year (i.e., November 1, 2013 through October 31, 2014) about passage and survival investigations and measures being undertaken throughout the Columbia River Basin.
- Section 3.0: Status report on Pacific lamprey activities underway at the Project, including identification of any variations from the schedule provided in the PLMP (Grant PUD 2009).
- Section 4.0: An evaluation of whether recent activities in the Columbia River Basin should be considered for the Project.
- Section 6.0: A summary of preliminary conclusions regarding Pacific lamprey activities to date, anticipated activities in the Columbia River Basin, and future activities at the Project for the upcoming year.

1.4 Consultation

Pursuant to the reporting requirements, Grant PUD provided a complete draft of the PLMP Comprehensive Annual Report and Biological Objectives Status Report to the PRFF on January 29, 2015 for a 30 day review and comment period. Comments were received on February 27, 2015 from Washington Department of Ecology (WDOE), and on March 2, 2015 from Columbia River Inter Tribal Fish Commission (CRITFC). All comments were reviewed and were addressed where appropriate. Appendix A provides a summary of comments and response to comments.

2.0 Pacific Lamprey Activities in the Columbia River Basin

2.1 Background and Existing Information

Pacific lamprey (*Entosphenus tridentatus*) are indigenous to many of the tributaries of the Columbia (Jackson et al. 1997a, Jackson et al. 1997b) and Snake rivers (Close et al. 1995). Wydoski and Whitney (1979) reported that the Pacific lamprey are one of three species of lamprey in the Columbia River Basin where river lamprey (*Lampetra ayresi*) and western brook lamprey (*Lampetra richardsoni*) have been known to exist. Western brook lamprey and river

lamprey distributions overlap with the more common Pacific lamprey but populations are concentrated to coastal tributaries and the lower reaches of the Columbia River (Kostow 2002).

The Pacific lamprey is an important fish of cultural, utilitarian, and ecological significance (Close et al. 2002). Close et al. (1995) reported that Native American tribes of the Pacific Coast and interior Columbia Basin harvested Pacific lamprey for subsistence, ceremonial, and medicinal purposes. In addition, a commercial fishery for Pacific lamprey also occurred during the 1940s and was used as food for livestock and cultured fish. Pacific lamprey are important ecologically throughout their life in terms of nutrient cycling, both as predator and prey. As juveniles, lampreys are filter feeders of detritus and algae, and a food source for fish and birds (Close et al 2002). In the past when they were more numerous, downstream migrants were likely an important food source to fish and birds and may have provided a buffer for juvenile salmon migrants. As adults, lamprey are opportunistic feeders and prey on a variety of fish species, thereby minimizing their impact on any particular one species. Adult Pacific lamprey are also a prey item to marine mammals such as sea lions and likely attract predation away from adult salmon (Close et al. 2002). Pacific lamprey carcasses are a food source to sturgeon, and decomposition provides marine-derived nutrients to riverine systems.

Adult lamprey counts have decreased at Columbia River Basin dams as compared with historical estimates, with the greatest declines occurring at the upper Columbia and Snake River projects. Passage counts of adult and juvenile lamprey at Bonneville, the Dalles, John Day, McNary, Ice Harbor, Rock Island, Rocky Reach, and Wells dams indicate a general decreasing trend; large declines occurred in the late 1960s and early 1970s (BioAnalysts 2000).

Based on the decreasing trend of adult Pacific lamprey, conservation groups filed a lawsuit against the USFWS in May 2004 to compel USFWS to act on their January 27, 2003 petition to list four species of lamprey for protection under the Endangered Species Act (ESA), including Pacific lamprey. On October 1, 2004, the USFWS initiated its 90-day finding process as part of a settlement with the conservation groups. 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.

Although Pacific lamprey are currently not ESA-listed, increased regional activity in the Columbia River Basin aimed at developing coordinated conservation and recovery strategies are proceeding. In addition to the ongoing efforts of the CRBLTWG and implementation activities associated with operations of FERC licensed and federal hydroelectric facilities (e.g., ACOE, Grant PUD, Chelan PUD, early implementation by Douglas PUD, and Portland General Electric [PGE]), the USFWS-led Pacific Lamprey Conservation Initiative, continued its activities by developing a multistate, tribal and Federal Conservation Agreement that will serve as the basis for regional working groups tasked with the development and implementation of conservation actions (USFWS 2012). These initiative activities and recommendations are not regulatory requirements.

2.1.1 General Biology and Ecology

Elongate and snake-like in form, the Pacific lamprey is a relatively poor swimmer in high velocity areas due to its anguilliform swimming motion as contrasted with the more efficient subcarangiform motion used by salmonids (Weihs 1982 as cited in Mesa et al. 2001). The lamprey does not have rigid fins, but rather dorsal and ventral fin-folds with minor cartilaginous

ray-like supports. In addition, it lacks a swim bladder and must continue swimming (or attach to substrate), or it will sink.

Pacific lamprey are cartilaginous, jawless, anadromous fish that develop morphologically and physiologically in three primary stages. First, Pacific lamprey begin as larvae that hatch after approximately 19 days at 15°C (Close et al. 2002). After hatching, larvae drift freely downstream until encountering suitable substrate (silt and sand) and flow conditions (low velocities) for a sedentary lifestyle (Pletcher 1963 as cited in Close et al. 2002). Ammocoetes reside burrowed in fine sediment (Close et al. 2002) for a period of 4 to 6 years filter feeding on diatoms, algae, and detritus by pumping water through their branchial chamber (Beamish and Levings 1991). Beamish and Levings (1991) observed peak downstream movement of ammocoetes during May and June (Table 1) and determined ages to range from two to six years (using statolith analysis; Volk 1986 as cited in Beamish and Levings 1991).

Table 1 Annual timing of key biological events in the freshwater life history of Pacific lamprey.

Annual Timing of Key Biological Events in the Freshwater Life History of Pacific Lamprey

Event	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Ammocoete downstream migration[1]	Unk											Unk
Young adult downstream migration[1]	Unk											Unk
Metamorphosis / Transition[2]												
Parasitic feeding initiated[3]												
Entry into saltwater[2]												

[1] Beamish and Levings (2001)
[2] Beamish (1980)
Peak period = dark shade

Pacific lamprey then enter a transformation phase characterized by morphological and physiological changes that begin in the latter period of substrate residence. The young adult stage continues during stream residence and into the period of downstream migration from their parent streams to the ocean. The causal mechanisms which initiate the transformation process, trigger emergence from the substrate, and result in migratory behavior are unknown or undocumented. Young adult lamprey are also termed macrophthalmia following major morphological changes, but prior to parasitic feeding (Hardisty and Potter 1971 as cited in Beamish 1980). Pacific lamprey transform from ammocoetes to macrophthalmia from July to November (Hammond 1979 and Close et al. 2002). During transformation, the shape and angle of the head and mouth changes, and the gut develops to allow consumption of flesh and fluids (Hart 1973). The onset of transformation occurs over a relatively large range in lengths. Beamish (1980) observed characteristics associated with metamorphosis in lamprey ranging from 47 millimeters (mm) to 160 mm in length. As such, there is overlap in the length distribution of larval ammocoetes and macrophthalmia. The macrophthalmia migrate to the ocean between late fall and spring (Table 1).

Beamish and Levings (1991) determined age distributions for macrophthalmia to be 4 to 8 years using statolith analysis (Volk 1986 as cited in Beamish and Levings 1991). Metamorphosing lamprey moved into progressively more rocky and higher flow environments over time (Richards 1980 as cited in Beamish 1980), which may be related to their specific stage of transition.

Concurrent downstream migrations of several different lamprey life-stages (including ammocoetes and young adults of many different stages of metamorphosis) has been observed (Table 1), providing evidence of natural variation in the timing and developmental stage of migrating lamprey (Beamish and Levings 1991).

Juvenile Pacific lamprey have been found to be largely nocturnal, with > 90% of their swimming activity restricted to hours of darkness (Moursund et al. 2000). This is consistent with prior reports that outmigrating individuals were more active at night while settling onto or into the substrate during the day (Hardisty and Potter 1971 as cited in Moursund et al. 2000; Beamish and Levings 1991). However, strict diel movement patterns appear to be restricted to the upper watershed areas, whereas the migration appears more or less continuous (night and day) in the lower parts of the river (Beamish and Levings 1991).

In the mid-Columbia River area, including the Project, juvenile lamprey are collected incidentally during juvenile salmon collection or salvage activities from April through June. At Priest Rapids and Wanapum dams, juvenile lamprey have also been observed during an evaluation of the emergency wheelgate slot exclusion screens (Wright et al. 2010). These results suggested that downstream run timing of juvenile lamprey coincides with spring runoff upstream of the Priest Rapids Project and throughout the Columbia River Basin and supports historical run timing trends of juvenile lamprey (Wright et al. 2010). Juvenile lamprey are also infrequently collected during the fish bypass operation of gatewell dipping (Grant PUD, unpublished data). A portion of these fish are counted and measured for length during juvenile salmonid survival and behavioral evaluations. All fish are subsequently released downstream of the Project. In some years, lamprey have been counted, but not identified beyond the genus level of classification (there are three species of lamprey in the Columbia River). In a separate operation, fyke net sampling at Wells Dam caught lamprey during the period March through August, with the highest catches occurring in May and June (BioAnalysts 2000).

Lamprey are considered adults once all transformations are complete and parasitic feeding begins; a process that is likely completed in salt water (Richards and Beamish 1981 as cited in Beamish and Levings 1991). In addition, laboratory research by Beamish (1980) surmised that completely transformed lamprey (i.e., adults) must move into a saline environment within a relatively short period of time, or they will die. Specifically young adults completing the transition to adulthood between June and September need to be in salt water by January. Physiological experiments showed that Pacific lamprey in the Fraser River begin entering saltwater in December and continue through June (Beamish 1980;Table 1). As an adult (100-700 mm), the animal is fully developed to handle life in salt water, which ranges from 1.5 to 3.5 years (Kan 1975 and Beamish 1980 as cited in Close et al. 2002). In the ocean, Pacific lamprey adults feed as external parasites on marine fish and mammals before returning to freshwater to spawn (Beamish 1980 and Close et al. 2002). Information on Pacific lamprey migration patterns during ocean residency remains a significant data gap for researchers and managers although recent work has been published on the relationship between the abundance of Pacific lamprey in the Columbia River and their common hosts in the marine environment (Murauskas et al. 2013).

Given the basic understanding of the species biology and ecology (in freshwater), recent work on Pacific lamprey has generally focused on topics such as developing more resolute site-specific information on the distribution and abundance of lamprey “populations”, and lamprey physiology. However, in addition to site specific distribution and abundance activities, lamprey biologists and researchers have begun to collect the information and develop the necessary tools

to address factors that may limit species persistence and recovery. Throughout the Columbia River Basin, various activities are being implemented. Monitoring activities associated with documenting key habitat related to spawning, rearing, and overwintering are being conducted annually in the Deschutes, Hood, and Umatilla rivers. In the Yakima and Umatilla watersheds, tracking adult movement patterns (via radiotelemetry) to overwintering and spawning areas and identifying passage bottlenecks is occurring. In-river and irrigation canal juvenile lamprey distribution and abundance sampling is also occurring in the Yakima basin. Multi-year juvenile distribution and abundance sampling, habitat, and larval trend monitoring is occurring in the Klickitat, Entiat, Yakima, and Methow watersheds. Surveys to assess juvenile distribution and relative abundance have also been conducted in several of the mid- and lower Columbia River reservoirs. Additional work on the general biology and ecology of Pacific lamprey includes monitoring adult harvest and escapement at Willamette Falls; translocation activities in Falls Creek and the Umatilla River; evaluating re-introduction above Pelton Round Butte Dam; assessing mercury concentrations in Lower Columbia River fine sediment; continued development of artificial propagation techniques; testing larval lamprey movements in response to dewatering events; andlamprey use of the lower Columbia River estuary(see Section 2.2: Updated Information for additional details).

2.1.2 Migration in Rivers

The upstream migration of adult Pacific lamprey in the Project area (RM 397-453) typically occurs from May through November, with peak migration occurring in August (Nass et al. 2003). In the lower Columbia River (Bonneville Dam, RM 146), this timing is shifted earlier by approximately one month (Ocker et al. 2001). Similarly, peak migration past dams upstream of Priest Rapids occur two to four weeks later. As expected, numbers of lamprey observed at successive dams decreases as fish enter tributaries or cease migration to overwinter, however the inherent challenges of counting lamprey is apparent in the years when counts at upstream facilities are higher than downstream facilities. Timing of freshwater entry is closely tied to water temperatures and somewhat with discharge. Keefer et al. (2009a) reported that few lamprey pass Bonneville Dam before water temperatures reach 15°C and half the run, on average, pass by the time water temperatures reach 19°C.

Median upstream migration rates have been estimated at 10 RM/day and 13.7 RM/day on the Columbia River (Jackson et al. 1997b and Vella et al. 2001, respectively), and 6.8 RM/day on the John Day River (Bayer et al. 2001). HDX-PIT tagged lamprey migrated at rates of 7.7 RM/day to 8.5 RM/day between Bonneville and McNary dams (~146 miles). As with timing, migration rates were correlated with water temperatures and inversely related to discharge (Keefer et al. 2009b). At Priest Rapids and Wanapum reservoirs, median upstream migration rates were 3.0 RM/day and 6.8 RM/day, respectively (Nass et al. 2003). Pacific lamprey that are migrating upstream are likely heading to holding and/or spawning areas to overwinter. Upstream migration has been documented to cease in mid-September (Beamish 1980 as cited in Close et al. 2002), and resume in mid-March of the following spring if the final spawning destination has not been reached (Bayer et al. 2001).

Spawning occurs in the summer (June and July) following the upstream migration year (Beamish 1980 as cited in Close et al. 2002). Lamprey prefer low-gradient reaches, with gravel-pebble-sand substrate for spawning (Mattson 1949 and Kan 1975 as cited in Close 1995). Further, spawning typically occurs in lotic habitat with velocities ranging from 3 to 4 feet per second (ft/sec) and in depths ranging from 1 to 3.3 feet (Kan 1975). Both sexes begin moving rocks with

their buccal funnel to create nests in excavated depressions (Pletcher 1963). Courting consists of a male approaching a female with a gliding motion to stimulate the female. A male attaches his buccal funnel to a female's head, and then wraps his body around the female to provide mixing of simultaneously released gametes. Each spawning act releases approximately 100 to 500 eggs (Pletcher 1963). Nest dimensions are approximately 12 inches wide, 1 to 2 inches deep, and oval in shape. Pacific lamprey die after spawning (Hart 1973) within 3 to 36 days (Kan 1975).

Pacific lamprey do not appear to have natal homing tendencies (return to a place of origin), but will migrate to other locations (Hatch et al. 2001). Distribution is more uncertain in the mid-Columbia area above Priest Rapids Dam compared to the lower Columbia, but since 1958 the furthest upstream extent on the Columbia River has been Chief Joseph Dam where there are no fish passage facilities.

Recent work on adult lamprey migration in rivers has used active tag technology including radio-telemetry and juvenile salmon acoustic telemetry system (JSAT) tags. These studies are occurring in reservoirs of the ACOE projects in the Lower Columbia and Snake rivers and in the Willamette River. Additional large-scale monitoring programs have also utilized half duplex (HDX) passive integrated transponder (PIT) tags in combination with multi-entity coordination to take advantage of the individual monitoring programs occurring throughout the mainstem Columbia River (see Section 2.2: Updated Information for additional details).

Information regarding juvenile migration in rivers is limited. Much of the information available has been collected anecdotally during tributary operations targeting juvenile salmonid outmigrants and is consistent with previous information regarding timing and the environmental variables associated with such movements. Juvenile lamprey have been observed using dual frequency identification sonar (DIDSON) during an evaluation of the emergency wheelgate slot exclusion screens at Priest Rapids and Wanapum dams (Wright et. al., 2010). These results suggested that downstream run timing of juvenile lamprey coincides with spring runoff upstream of the Priest Rapids Project and throughout the Columbia Basin and supports historical run timing trends of juvenile lamprey, and the size of lamprey recorded by the DIDSON also supports the distribution of recorded lamprey to be primarily juveniles (Wright et. al, 2010).

Over the past decade the lack of available tag technology has limited researchers and fish managers' ability to collect more detailed information to better understand and address challenges of juvenile lamprey movement. BioAnalysts (2000) summarized anecdotal information on the distribution of juvenile lamprey in tributaries of the mid-Columbia, which include the Wenatchee, Entiat, Chelan, and Methow rivers. Recent evidence indicates the presence of lamprey in the Similkameen River, a tributary of the Okanogan River (T. Holder, Washington Department of Fish and Wildlife, personal communication) previously thought unused by Pacific lamprey. Further, juvenile Pacific lamprey have been captured in rotary trapping operations on the Okanogan River near Malott (M. Rayton, Colville Tribes Fish & Wildlife, personal communication). Regional entities such as the Fish Passage Center have evaluated available juvenile lamprey PIT tag data in the Columbia River Basin toward improving understanding of this life stage and regularly collect data of lamprey incidentally collected at juvenile salmonid collection/bypass facilities at mainstem dams.

Given the high number of irrigation diversions in the Columbia River Basin and the recognition that poorly designed or unscreened diversions can result in fish mortality, researchers continue to evaluate the efficacy of different irrigation diversion screen panels and the effectiveness of fish

screen materials to prevent juvenile lamprey impingement and entrainment at these locations. Furthermore, to begin understanding the potential impacts of irrigation diversions on juvenile lamprey, researchers have begun conducting surveys in irrigation canals in the Yakima watershed (see Section 2.2: Updated Information for additional details).

2.1.3 Population Status

2.1.3.1 Distribution

Pacific lamprey are native to the Columbia River Basin and their spawning migration extends into many inland rivers draining Oregon, Washington and Idaho (Kan 1975; Hammond 1979; and Simpson and Wallace 1982). Collections and historic observations of Pacific lamprey are common in the Columbia River below the mouth of the Deschutes River. Areas include numerous small tributaries such as Fifteenmile Creek, Gnat Creek, Elochoman River, and larger tributaries such as the Lewis, Willamette, and Klickitat rivers. Lamprey probably used all accessible watersheds in the Lower Columbia, including mainstem and slough habitats. A comparison of counts at Bonneville Dam to harvest at Willamette Falls during the 1940s indicates that Pacific lamprey were probably more abundant in the Willamette subbasin at that time than they were anywhere upriver of the Columbia River Gorge (Kostow 2002).

Watersheds upstream of the Columbia River Gorge, specifically noted in historic collections and observations, include the Deschutes extending into the Crooked River above Pelton/Round Butte Dam, John Day, Umatilla, Walla Walla, Yakima, Entiat, Okanogan and Kootenay Lake. In the Snake River Basin, collections and historic observations have been made in the lower Palouse, Clearwater, Salmon, Grand Ronde, Imnaha, and upstream to at least the Powder River. Historic records are too sparse to determine the full extent of historic occupation of these basins; however recent work has focused on collecting more current distribution information and a report documenting the current status of Pacific lamprey in some of these river basins was published in 2011 (IDFG 2011). A study conducted by Idaho Fish and Game from 2000 to 2006 determined that Pacific lamprey currently occupy only about 25% of their historic distribution in the Snake River Basin (Hyatt et al. 2006). In the upper Columbia River Basin, distribution information is being collected in the Wenatchee, Entiat, and Methow rivers while past adult translocation activities by the Nez Perce Tribe indicated that juvenile lamprey in Asotin, Lolo, Newsome and Orofino creeks in the Snake River were primarily the progeny of translocated adults (Chris Peery, USFWS, personal communication).

The current distribution of Pacific lamprey is substantially reduced from the historic distribution. Lamprey have been lost from all areas that are blocked by impassible barriers. These barriers include the Willamette subbasin dams, and other high dams such as the Pelton/Round Butte complex (Deschutes), Dworshak (Clearwater), Hells Canyon complex (Snake), and Chief Joseph Dam (Columbia) that block upstream passage by all migratory fish. Lesser barriers that may pass salmonids also block upstream passage by lamprey, including smaller dams, small water diversion dams, culverts, tide gates and numerous other barriers. Adult Pacific lamprey are known to pass through the Project, but no radio-tagged lamprey were observed to use tributaries in the Project area (Nass et al. 2003).

2.1.3.2 Abundance

Pacific lamprey populations of the Columbia River have significantly declined in abundance in recent years as evidenced by counts at dams on the lower Columbia and Snake rivers (Close et

al. 1995; Vella et al. 1999; Close et al. 2002). Starke and Dalen (1995) reported that adult lamprey counts at Bonneville Dam that regularly exceeded 100,000 fish in the 1960s were estimated at approximately 22,000 in 1993. Specific reasons for this decline are not fully understood, but have been related to similar factors contributing to the decline of Pacific salmon. Close et al. (1995, 2002) identified several factors that may account for the decline in lamprey counts in the Columbia River Basin. This includes reduction in suitable spawning and rearing habitat from flow regulation and channelization, pollution and chemical eradication, reductions of prey in the ocean, and juvenile and adult passage problems at dams. Comparison of counts between dams and between years is complicated by variable and inconsistent sampling protocols (BioAnalysts 2000), potential over-wintering between dams, changes in personnel, and counting station passage efficiency (the ability of count station equipment to force individuals through a counting area for observation). Annual counts of adult Pacific lamprey passing select mainstem dams in the Columbia River Basin are summarized below in Table 2.

Efforts are underway to improve estimates of the number of adult lamprey passing dams using nighttime video at count stations (Clabough et al. 2009). Adding nighttime passage through count windows increased estimated escapements at Bonneville Dam by 42% in 2007, but decreased the estimated escapement to a negative value in 2008. The net downstream movement observed at Bonneville Dam in 2008 indicates that fish were passing by unmonitored routes such as through picketed leads at count stations. At The Dalles, adding nighttime counts increased estimated escapement by 42% in 2007 and by 70% in 2008.

In addition to adult dam counts, the lack of ammocoetes in surveys in the Snake River basin and limited information of juvenile use in Upper Columbia River tributaries may be an indication of the decline of Pacific lamprey.

Table 2 Annual counts (via Columbia River Data Access in Real Time [DART]) of adult Pacific lamprey at select Columbia and Snake River basin dams.

Year	McNary	Priest Rapids	Wells	Ice Harbor	Lower Granite
2000	1,281	1,468	NA	315	28
2001	2,539	1,624	261	203	27
2002	11,282	4,007	338	1,127	128
2003	13,325	4,339	1,408	1,702	282
2004	5,888	2,647	291	805	117
2005	4,158	2,598	212	461	40
2006	2,139	3,273	21	255	35
2007	3,389	3,419	32 [2]	288	34
2008	1,530	5,083	7 [2]	264	61
2009	676	2,713	9	57	12
2010	825	1,114	2	114	15
2011	868	3,868	1	269	48
2012	971	4,025	3	494	48
2013	1,570	5,968	21	328	19
2014[3]	1,813	7,586	7	721	84

Notes:

1 Ice Harbor and McNary day counts only. Wells and Priest Rapids 24-hour counts. Lower Granite counts have been conducted 24 hours a day since 2009.

2 The Pacific lamprey adult passage counts at Wells Dam are not reflective of actual run size during 2007-2008. Trapping, monitoring, and research efforts at Wells Dam artificially lowered the passage numbers for Pacific lamprey; i.e., more fish would have passed without tagging and trapping efforts.

3 Counts through December 9, 2014.

2.1.3.3 Population Structure

Genetic stock information suggests there is uncertainty among different Pacific lamprey stocks regionally. Powell and Faler (2001) determined that Pacific lamprey do not appear to have genetically different stocks, at least between some lower and mid-Columbia basins. These observations are similar to results by Goodman (2006) that found no evidence of mitochondrial DNA divergence in 81 collections of Pacific lamprey from two of the geographical regions common to the Columbia River and Klamath Mountain Province. Conversely, Lin et al. (2007; 2008) found significant differences among collections within those regions using approximately 180 amplified fragment length polymorphisms (AFLP) loci. These results detected significant genetic differences among adult Pacific lamprey returning to streams separated by as little as 54 miles (between the Deschutes River and John Day Dam). The differences between these studies may reflect the increased power of using approximately 180 AFLP loci versus a single mitochondrial DNA locus or differences in polymorphisms due to sampling of adult migrants versus ammocoetes. The geographical scale over which genetically meaningful management units (e.g., stocks, populations, or evolutionarily significant units) occur in this species could not be identified based on the results of Lin et al. Work based upon microsatellite analysis of 21 sites along the west coast of North America found low levels of genetic differentiation, providing support for a lack of natal homing in Pacific lamprey. The report noted that Pacific lamprey from most of the sites examined in this study can be managed as one unit but recommended future investigations to confirm whether this conclusion is applicable to all sites (Docker 2010). The most recent genetic analyses have continued to add uncertainty to Pacific lamprey population

structure. Spice et al. (2012) evaluated the hypothesis of natal homing in Pacific lamprey and had results that were inconsistent with philopatry, suggesting that anadromous lampreys are unusual among species with long migrations, but suggest that limited dispersal at sea precludes panmixia. Work done by Hess et al. (2012) may provide context for observed genetic divergence among collections and thus, could reconcile previous findings of population genetic heterogeneity within a species that displays extensive gene flow.

One recovery strategy for Pacific lamprey is the translocation of pre-spawn adults from downstream Columbia River locations and supplementation with hatchery spawned ammocoetes into suitable habitat upstream. Cummings (2007) found that trapping and translocating adult lamprey did not appear to affect their migration success but the implications to population structure are currently unknown. Since the late 1990's and 2006, the Umatilla and Nez Perce tribes, respectively, have been implementing Pacific lamprey translocation programs as a conservation measure to maintain some level of lamprey production in target spawning streams. In 2014, the Confederated Tribes of Grand Ronde captured lamprey at Willamette Falls and translocated them to Fall Creek (see Section 2.2: Updated Information for additional details about active efforts).

In 2009, the CRBLTWG was asked to develop a review paper on lamprey translocation and artificial propagation. Due to the uncertainty surrounding the potential implications related to unknown genetic stock structure related to translocation and differing opinions by CRBLTWG members, the CRBLTWG concluded that it would not be able endorse a position or shared opinion at this time and instead completed a literature review paper outlining the potential benefits and risks of translocation (CRBLTWG 2010, Ward et al. 2012).

2.1.4 Adult Passage at Hydroelectric Facilities

Radio-telemetry studies of adult lamprey migration patterns past dams and through reservoirs in the lower Columbia River during 1997 to 2002 provided the earliest data sets on lamprey passage timing, travel times, and passage success at hydroelectric projects (Vella et al. 2001; Ocker et al. 2001; Moser et al. 2003a; Moser et al. 2003b). While these studies have shown that 87 to 96% of the radio-tagged lamprey released migrate upstream and are detected at Bonneville Dam, less than 50% of the lamprey which encounter an entrance actually pass the dam. Passage times at lower Columbia River dams (2 to 4 days) were considerably longer compared to salmonids (1 day). Similarly, during 2005 to 2008, at McNary and Ice Harbor dams overall passage efficiencies ranged 58 to 89% and 50 to 59.1%, respectively. Median passage time from the first approach until exit into the forebay for adult lamprey ranged from 1 day to 2 days for both dams (Cummings et al. 2008). Despite different estimation techniques, HDX-PIT tag results of Daigle (2008) were generally consistent with previous study results for Bonneville, McNary and Ice Harbor dams. Recent evaluations (Keefer et al. 2009c; 2009d) indicated significantly lower passage success from release to passage of John Day Dam for radio-tagged lamprey compared to HDX-PIT-tagged lamprey (2.3 to 4.5% versus 17 to 18%), suggesting previously reported passage estimates were conservative.

Recent radio-telemetry studies at Bonneville Dam have expanded our understanding of adult lamprey behavior and passage performance in the lower Columbia River (Johnson et al. 2009a; Keefer et al 2009c; 2009d). For 2007 and 2008, 68 and 74%, respectively, of lamprey released to the tailrace were known to have returned to the dam. Of these, 32% successfully passed in both years (Johnson et al 2009a; 2009b; Keefer et al. 2009d). Entrance efficiencies (ranged 51 to

76%) were generally poorer than previous years although passage times (around 3.0 d median) was relatively good in 2007and 2008. Researchers speculated performance may have been related to smaller lamprey returning in 2007 and 2008 compared to earlier years.

In the mid-Columbia at Wanapum, Priest Rapids, Rocky Reach, and Wells dams, the results have been more varied, in part due to the use of slightly different metrics (Nass et al. 2003; Stevenson et al. 2005; LGL Limited and Douglas PUD 2008). The Net Ladder Passage Efficiency (NLPE) at Rocky Reach was 47% (Stevenson et al. 2005).

At Priest Rapids and Wanapum dams, the proportion of fish that approached the fishway that exited the ladders was 70% at Priest Rapids, and 51% at Wanapum Dam in 2002 (Nass et al. 2003). Fishway passage efficiencies (entrance to exit) were substantially higher at 87% and 82% for the same study despite substantial delays or termination of active migration near the first weir walls and old style counting stations which have subsequently been modified to include lamprey-specific crowder structures at both Priest and Wanapum dams. Design enhancements (plating and ramps at Priest Rapids Dam) installed during the 2009-2010 winter fish ladder maintenance outage, are also anticipated to address these areas and improve volitional passage efficiency. To test these design enhancements, Grant PUD, in consultation with the PRFF, has been evaluating lamprey passage behavior at the Project using an extensive HDX-PIT array (20 total receivers) at Priest Rapids and Wanapum dams since 2010. For the 2010 through 2014 migrations, Grant PUD tracked a total of 380 and 258 HDX-PIT tagged lamprey at Priest Rapids and Wanapum dams, respectively. Fishway passage efficiency for lamprey was 74% and 63% at Priest Rapids and Wanapum dams, respectively over the 2010-2014 period. However, fishway passage efficiency in 2014 was likely affected by anomoulous operations resulting from the spillway fracture at Wanapum Dam. As such, separating results in 2014 from the previous years (2010-2013) may help interpret impacts on lamprey passage metrics such as median fishway passage time, fishway passage efficiency, fallback, reservoir passage time, and overwintering behavior (Table 3). For example, fishway passage efficiency was 70% and 73% at Priest Rapids and Wanapum dams, repectively over the 2010-2013 period while in 2014, this metric at Priest Rapids and Wanapum dams was 80% and 54%, respectively. The relatively lower Wanapum Dam fishway passage efficiency was most likely related to anomalous conditions resulting from the spillway fracture.

During the 2010 migration, an additional assessment of lamprey passage was conducted using underwater video. In this study, cameras were placed to view newly installed aluminum plating on the diffusion grating, the floor through weir orifices, and on the fish count station. This monitoring activity produced observations that the plating at weir wall orifices was extensively used by lamprey and was a benefit to lamprey passage. For 19 complete passage events through an orifice, 95% of lamprey used the plating and 100% of the events demonstrated successful passage. The fish count crowder was also observed to promote guidance of lamprey through the counting chute. Of 123 events, 79% of lamprey were successfully guided by the structure to the chute and 40% of these used the plated ramp to stage below the chute.

Passage times of HDX-PIT tagged adult lamprey at Priest Rapids and Wanapum dams were relatively consistent during the 2010-2013 period. Median passage times at Priest Rapids and Wanapum right bank were less than 10 hours while passage times through the left bank fishways were greater; 76.6 hours and 24 hours at Priest Rapids left bank and Wanapum left bank fishways, repectively. This apparent delay at Priest Rapids left bank was associated with the upper fishway as fish ascended beyond the count station and past the Off Ladder Fish Trap

(OLAFT). To gain a better understanding of this phenomenon and provide increased detection resolution, two additional HDX-PIT detection stations will be installed in the Priest Rapids upper left fishway in the vicinity of the OLAFT in early 2015. Passage times of HDX-PIT tagged adult lamprey that volitionally ascended fishways in 2014 were different than previous years, possibly due to modified operations (lamprey trapping activities at both dams and change of fish ladder operation and flow variability at Wanapum). At Priest Rapids Dam the median passage time in the left bank fishway improved to 17 hours, while median passage time through the right bank remained consistent with previous years at 5 hours. At Wanapum Dam the median passage time was 55 hours in the left bank and 6 hours in the right bank.

Fallback of HDX-PIT tagged adult lamprey was relatively uncommon during the 2010-2014 period. Only one fish at each dam was detected falling back and failing to re-ascend the fishway. Median reservoir passage time through Priest Rapids reservoir for HDX-PIT tagged adult lamprey with detections at the Priest Rapids Dam exits and Wanapum Dam entrances was 4.4 days during the 2010-2013 period and 5.9 days in 2014. Finally, fish tagged in a previous study year were occasionally detected during the migration period the following year (i.e. fish tagged at Bonneville Dam in 2012 but detected at Priest Rapids Dam in 2013). These fish were assumed to have overwintered in the Columbia River then resumed migration behavior the following year. Eleven such fish were detected during the 2010-2013 period (4.5% of detected tags) and 3 in 2014 (2.1% of detected tags). The presence of these fish suggests that estimating passage efficiency for adult lamprey requires a nuanced approach.

Table 3 Passage metrics of HDX-PIT tagged adult lamprey including quantity of fish detected, median fishway passage time, combined fishway passage efficiency, (FPE), net fallback, median Priest Rapids reservoir passage time, and overwintering fish at Priest Rapids (PR) and Wanapum (WA) dams during the 2010-2013 period and for 2014.

Year	Qty Detected		Median fishway passage time (h)				FPE (%)	
	PR	WA	PR Left	PR Right	WA Left	WA Right	PR	WA
2010-2013	240	138	76.6	5	24	7.7	70	73
2014	140	120	16.8	5	54.5	6.2	80	54

Year	Qty Net Fallback		Median PR reservoir passage time (d)	Qty tags from previous year (overwintering fish)
	PR	WA		
2010-2013	1	1	4.4	11
2014	0	0	5.9	3

On February 27, 2014, a horizontal fracture was discovered in the spillway monolith No. 4 at Wanapum Dam. The fracture opened a crack on the upstream face of the structure approximately 2 inches high by 65 feet long on the spillway monolith. Grant PUD immediately initiated its EAP (level B) and began to draw the Wanapum Reservoir down in a steady controlled state. As of March 4, 2014, the Wanapum Reservoir was lowered to a safe operating elevation range between 545 feet and 541 feet. As a result of the drawdown, the fish ladder exits at Wanapum Dam were dewatered, preventing upstream migrating fish from passing Wanapum Dam. The fish ladder

entrances at Wanapum remained operational, due to the tailwater elevation. At an elevation of 560-562 feet, the Wanapum Dam fish ladders exits would be able to be operated within criteria and without modifications. Fishway Exit Passage Systems were installed at Wanapum Dam on April 15 (on left-bank) and April 26 (right-bank) and were operated throughout the fish passage season. The Wanapum Fishway Exit Passage Systems (WFEPS) successfully passed adult salmonids (spring Chinook), steelhead and other species (mountain white fish). To facilitate adult lamprey passage at the both the left and right bank fishways at Wanapum Dam, lamprey ramps were designed and incorporated into the WFEPS (Appendix C).

In order to assess the WFEPS, 28 adult lamprey were tagged with HDX PIT tags and released at dusk on July 25, 2014 into the upper Wanapum Dam left bank fishway. Within six days, 26 of the tagged fish were last detected at the left bank exit PIT reader, 1 fish moved downstream within the fishway, and 1 fish was not detected after release. It should be noted that the left bank exit PIT reader was located downstream of the WFEPS.

In addition to volitional passage, Grant PUD trapped and transported 2,263 adult Pacific lamprey collected from Priest Rapids and Wanapum dam fishways via 36 tube style traps distributed between the two dams and four mechanical weir traps at Priest Rapids (Appendix D). All trapped lamprey were scanned for a PIT tag, and previously tagged lamprey (n=45) were transported and released immediately upstream of the dam where they were trapped. Untagged lamprey were then held in a circular holding tank at Wanapum Dam until there were sufficient numbers to haul them upstream to the Kirby Billingsley Hydro Park (RM 461), approximately eight miles upstream from Rock Island Dam. Trap and transport activities occurred from July 17 to September 30, 2014, through the peak of the upstream adult lamprey migration.

During a 2008 study at Wells Dam, 18 lamprey were released into the Wells Project tailrace. Twelve of the 18 lamprey yielded sufficient data for analysis. Over the study period, 11 of 12 (91.7%) lamprey approached a fishway entrance with several lamprey making multiple approaches. Only two tailrace-released lamprey successfully entered a fishway and both failed to ascend into the forebay. Overall, 2008 study results indicate that any potential areas of impediment at Wells Dam are restricted entirely to the entrance and lower fishway, as upper fishway passage efficiency (releases in the fishway) was 100% for the two consecutive study years (LGL Limited and Douglas PUD 2008). In 2013, another fishway passage study was conducted at Wells Dam with adult lamprey translocated from Bonneville and Priest Rapids dams (due to low numbers at the dam). Results of the assessment are presented in Section 2.2; Table 4 below.

Detailed examination of detection histories for radio-tagged lamprey has concluded that there are several potential explanations for relatively low fishway passage success for adult lamprey. In general, these factors are associated with unique physical characteristics of the individual fishways and may include a lack of suitable attachment surfaces, water velocities, and channel configuration (Keefer 2008).

Experiments conducted in an experimental fishway at Bonneville Dam in 2004-2006 evaluated lamprey response to: 1) a fishway ramp and the effects of ramp flow volume, ramp angle, and attraction flow at the ramp entrance; 2) a divided fishway with differing flow velocities at each channel entrance; 3) two styles of mid-ramp lamprey “rest boxes”; and 4) three methods of attracting lampreys to the ramp entrance (water jets, air bubble streams, and waterfalls [Keefer 2008]). In the ramp tests, the majority of tagged fish ascended the ramp under all treatment

conditions but lamprey passage times differed significantly in response to flow levels. When the fishway was divided, lamprey preferentially used channels adjacent to the flume walls, and this preference increased as flow through the outside channels decreased. Lamprey passage times also increased with concentrated flow through the center channel. With the differing types of "rest boxes", there was little difference in lamprey behavior between rest boxes under various flow treatments, and fish that ascended the ramp appeared to be unaffected by either rest box type. Finally, regarding the various methods of attraction to the ramp entrance, lamprey passage efficiency was highest during the water jet treatment, but differences among tests were not statistically significant.

A potential physiological problem facing successful passage of Pacific lamprey at dams may be related to their unique method of movement as it relates to specific areas within fish ladders. Typically, lamprey move through an adult fishway in a repeated series of motions consisting of attaching to the ladder floor with their mouths, surging forward, and re-attaching. Adult lamprey have an estimated critical swimming speed of about 2.8 feet per second at 15°C (Mesa et al. 2003) and a burst swimming speed calculated at 6.9 feet per second (Bell 1990). Fishway operational criteria at Wanapum and Priest Rapids dams include average velocities over submerged weirs that are approximately 2 to 4 feet per second and 4 to 6 feet per second through the slotted entrance gates near the surface. The design of the slotted entrance gates is such that the velocity gradient will be near zero at the bottom while maintaining average water velocities to the surface of the water column (M. Nicholls, Grant PUD, personal communication). Average velocity through the orifices is approximately 6 to 7 feet per second. The physiological response of adult Pacific lamprey to exhaustive exercise may be immediate, sometimes severe, but short-lived (Mesa et al. 2003). These data suggest that lamprey may have difficulty negotiating fishways that operate according to criteria established for salmonids.

In an effort to improve monitoring of Pacific lamprey in the basin, HDX-PIT tag monitoring sites were deployed at dams beginning in 2005. HDX-PIT tags were selected for Pacific lamprey passage evaluations to avoid potential tag collisions with the full-duplex (FDX) PIT tags used to monitor salmonids in the basin. In 2005, HDX detectors were installed at Bonneville Dam to evaluate lamprey passage systems (LPS) in the Bradford Island makeup water channel and at the entrance to the Washington-shore main ladder. Detectors were also installed at McNary and Ice Harbor dams to monitor lamprey in a parallel study (Cummings 2007). In 2006, additional detectors were installed at the tops of ladders at The Dalles and John Day dams. Daigle (2008) concluded that the prototype HDX detectors used in 2005-2006 appeared to be reasonably efficient (e.g., 20-100%) at detecting tagged lamprey passing antennas. Studies comparing the use of radio-telemetry and the HDX-PIT tags were conducted in 2007-2009. Study results indicated higher escapement rates for HDX-PIT tagged fish versus radio-telemetry tagged fish at and between dams. Larger fish of both tag types were significantly more likely than smaller fish to pass through most monitored dam-to-dam reaches. The results suggest a tradeoff between tagging effects and the collection of high resolution, fine-scale data provided by the active radio telemetry system (Keefer et al. 2009a, 2009b and 2010).

Since the cumulative evidence on adult lamprey passage at dams has indicated that fishway entrances may be a major passage bottleneck, a significant effort was undertaken by the ACOE to develop and evaluate new entrance designs and operations. In 2007, a study was undertaken at Bonneville Dam to evaluate the use of reduced water velocities at entrances at night to improve entrance rates for lamprey (Johnson et al. 2009a). Lowering entrance head levels to 0.5 ft (4 feet

per second target velocity level) from 2200 to 0400 hrs at PH2 improved entrance efficiencies from 2% at normal velocity to 26% at the lowered velocity at the north-shore entrance, although the number of lamprey attracted to the entrance appeared lower during reduced velocities (i.e., net entrances may not have been different. There was also evidence that the time to enter during the lower velocity was improved. In 2008, when PH2 entrances were placed in standby mode (0 feet per second velocity) at night, entrance efficiencies were 2 and 12% at the north and south-shore entrances versus 9 and 30% during normal conditions, respectively (Johnson et al. 2009b). Lamprey were also more likely to drop out of the fishways during the standby operations. In 2009, the telescoping weir bulkheads at the Cascade Island fishway entrance at Bonneville Dam were replaced with a variable-width entrance bulkhead. Bollard structures were also added out- and inside the fishway to provide an area of low velocity along the floor as a potential route for lampreys to enter. Preliminary results from radio- and HDX-PIT tag monitoring indicated that lamprey entrance use was improved in 2009 at the Cascades Island entrance but further analyses are planned. In 2009 and 2010, Douglas PUD utilized DIDSON to evaluate lamprey entrance efficiency at the Wells Dam fishways in response to three alternative entrance flow velocities. Although number of observations were low, the data indicated that adult lamprey were able to volitionally enter fishways under reduced nighttime flows (P.N. Johnson et al. 2011). The Wells Dam 2013 passage study conducted by Douglas PUD also included a treatment with alternative entrance flow velocities (see Section 2.2: Updated Information for additional details).

In recent years, Columbia River Basin hydroelectric facilities have begun modifying fishways and fishway operations to facilitate the upstream passage of adult lamprey. ACOE and utilities with hydroelectric facilities in the basin are in various phases of design and implementation of passage improvements that include variable width weirs, bollard arrays, ¾ inch diffuser grating, lamprey passage systems LPS in various fishway locations, lamprey entrance flume systems, lamprey orifices in control section weir walls, diffuser grating plating, ramps at perched orifices, rounded edges of fishway walls, temporary velocity reductions at fishway entrances, and lifting picket leads at count stations. Researchers have also begun testing passage efficiency of an experimental vertical climbing wall and using network theory to evaluate passage behavior (see Section 2.2: Updated Information for additional details).

2.1.5 Juvenile Passage at Hydroelectric Facilities

Juvenile lamprey moving downstream may pass through a hydroelectric structure using several different routes, including the powerhouse (turbines), spillway (bottom or top discharge tainter gates), powerhouse gatewell slots (fish bypass collection area), and adult fishways. Potentially high juvenile lamprey turbine entrainment rates are likely given the tendency of juveniles to swim low in the water column (Long 1968 as cited in Moursund et al. 2000). Fyke net capture data from Wells (Douglas PUD) and Rocky Reach (Chelan PUD) further confirm that juvenile lamprey tend to pass via turbines in the lower half of the water column (BioAnalysts 2000). At the Project, turbine intake emergency wheelgate slot exclusion screen evaluations also observed small numbers of juvenile lamprey in the vicinity of turbine intake areas (Mike Clement, Grant PUD, personal communication).

The lamprey's ability to survive turbine passage, including response to changes in pressure, turbulent flow, and shear stress are not clearly understood. Another concern is how juvenile lamprey respond to diversion screens which are designed to bypass or divert fish into or toward preferred fish passage routes. For example, investigators reported large numbers of juvenile lamprey impinged between individual bars of fixed bar screens at The Dalles and McNary dams

(Hatch and Parker 1998). The effects of blade strike or sub-lethal effects, such as increased vulnerability to predation following turbine passage, are not known (Becker et. al. 2003). Although the necessary tag technology to evaluate the potential impacts to juvenile lamprey passage through hydroelectric facilities is currently unavailable (see Section 2.1.5.3), increased efforts that include synthesis of available information (e.g., juvenile bypass facilities, screw trap operations, existing reports/studies, etc.) have been implemented to provide a basin-wide perspective on juvenile lamprey passage and movements and to identify information gaps (see Section 2.2: Updated Information for additional details).

2.1.5.1 Effects of Hydrologic Pressures on Juvenile Lamprey

Moursund et al. (2000 and 2001) subjected lamprey to an abrupt pressure spike (using a hyperbaric chamber) in order to simulate turbine passage. Lamprey were examined for injuries immediately after the trial, and then again after 48 hours. Test lamprey showed no immediate or latent injuries. Juvenile lamprey hardiness likely results from their lack of swim bladder, the flexibility associated with an anguilliform body type and cartilaginous skeleton, and the reduced size of vulnerable structures, such as eyes.

To further evaluate Pacific lamprey's ability to survive turbine passage, Pacific Northwest National Laboratory (PNNL) scientists conducted laboratory tests designed to measure a juvenile Pacific lamprey's response to the absolute change in pressure or "pressure drop" during passage through a Kaplan turbine simulation (Neitzel et al. 2000). Tests conducted by PNNL used a hyperbaric chamber to test a single worst-case scenario for lamprey: bottom-acclimated with a surface return. Juvenile lamprey were acclimated to an equivalent pressure of 60-foot depth for 24 hours prior to passage. The entire pressure sequence lasted about 90 seconds (Becker et al. 2003). Results from the simulated turbine passage tests showed no immediate external injuries or mortalities for lamprey exposed to rapid changes in pressure, i.e., ~400 kPa to ~5 kPa in 0.1 second. That juvenile lamprey lack a swim bladder may be one reason for their resistance relative to bluegill sunfish (Becker et al. 2003). In 2011, continued testing by PNNL on the effects of rapid and prolonged decompression simulating hydroturbine passage were conducted on juvenile Pacific lamprey. Generally, no mortalities or barotrauma were observed for lamprey exposed to these decompression scenarios (Colotelo et al. 2012).

2.1.5.2 Effects of Bar Screens on Juvenile Lamprey

Swim trials in a laboratory flume showed that juvenile Pacific lamprey are fair to weak swimmers as compared to salmonids, with an average burst speed of 2.3 feet per second. Sustained juvenile lamprey swim speeds averaged 0.75 feet per second over a five-minute interval and 0.5 feet per second over a 15-minute interval (Moursund et al. 2000).

In laboratory conditions at PNNL in 2000, lamprey interactions with bar screens using an oval flume fitted with 1/8-inch spaced wedge-wire screen were examined. Lamprey were exposed to the screen at water velocities ranging from 0 to 2 feet per second. Observations were recorded using video cameras and infrared illuminators. At all water velocities greater than zero, the lamprey made contact with the bar screen within one minute of their entry into the water column upstream of the screen. At water velocities up to 1 foot per second, they were able to push off the screen and disperse throughout the test flume. At water velocities greater than 1.5 feet per second, all lamprey made immediate contact with the screen. Seventy percent became impinged within one minute of the exposure. After 12 hours of exposure, 97% of the lamprey were impinged on the screen (Moursund et al. 2000).

Physical model data obtained by the U.S. Army Engineer Research and Development Center suggest that the average perpendicular flow velocity at a typical turbine bypass screen is 2.4 feet per second. Field measurements directly on a screen face at John Day support the model data (Weiland and Escher 2001). They also suggest this velocity exceeds the velocities that caused impingement of juvenile lamprey during laboratory tests and was also higher than the average burst speed of the test population. On an extended-length submerged bar screen, local velocities was as high as 10 feet per second and occurred at the upper end of the screen (Weiland and Escher 2001).

As part of the series of laboratory studies conducted by PNNL in 2000, the effects of screen alignment and angles on lamprey impingement were evaluated. 1999 laboratory flume tests utilized 1/8-inch wedge-wire screen oriented perpendicular to the flow and having vertical bars. Testing in 2000 included having vertical and horizontal bars and screen orientations at 10 degrees from vertical. The angled screen provided upward sweeping velocities that were not present in the previous perpendicular tests. Trials were conducted at velocities from 2 to 5 feet per second. The findings showed lamprey were far more susceptible to become impinged on horizontal bars than on vertical ones. At water velocities of 4 feet per second, 50% of lamprey became impinged on the horizontal bars but none were stuck on the vertical bars. At 5 feet per second, 55% of the lamprey were impinged on the horizontal bars but just 25 became impinged on the vertical bars (Moursund et al. 2002). General findings showed that an increase in either water velocity or the duration of conditions favoring impingement increases the lamprey's chances of permanently becoming stuck on the screens.

Alternative screening material was also tested by PNNL. Previous testing of 1/8-inch square nylon mesh was tested against 2/29-inch bar screen. The narrower spacing was expected to reduce the amount of space for lamprey to work their tails in and become impinged. Testing results showed that while 70% of the juvenile lamprey were permanently impinged on the 1/8-inch bar screen at velocities up to 4 feet per second, none remained stuck on the bars having the smaller 2/29-inch spacing, and just 15% were permanently impinged on the 1/8-inch square mesh (Moursund et al. 2002).

2.1.5.3 Need for Active Tag Technology

A review of the most recent research addressing juvenile lamprey at hydroelectric facilities concludes that there is a current lack of methods and technology to effectively quantify survival of juvenile lamprey migrating through hydroelectric facilities (Douglas PUD and LGL 2008). Furthermore, no studies exist that determine a level of mortality attributed to a project's operations. This is due to the lack of miniaturized active tag technologies to overcome two study limitations: 1) macrophthalmia are relatively small in size and unique in body shape; and 2) migrate low in the water column resulting in the rapid attenuation of active tag signal strength. In 1999, the ACOE funded Oregon State University to assess the applicability of available tag technology to monitor juvenile lamprey macrophthalmia outmigration (Schreck et al. 2000). Results from this effort indicated that the smallest currently available radio-tag is still too large for implantation in the body cavity of a juvenile lamprey (Schreck et al. 2000). Additionally, external application was not effective as animals removed tags within the first week and fish performance and behavior were affected (Schreck et al. 2000). Internal implantation of PIT tags is currently the most viable option for tagging juvenile lamprey; however this methodology presents severe limitations due to the limited range of detection systems, and the ability to tag only the largest outmigrating juvenile lamprey (Schreck et al. 2000). Since the 1999 assessment,

there had been little development in tag technology with several studies associated with developing biological criteria for active tags and standard protocols for PIT-tagging juvenile lamprey. However, recent funding from the ACOE and Department of Energy has been made available to design, prototype and evaluate an acoustic microtransmitter that can be used to study the behavior and survival of juvenile lamprey (see Section 2.2: Updated Information).

2.1.5.4 Gatewell Exclusion Screen Evaluation

During the spring and early summer months of 2010, turbine intake emergency gatewell exclusion screens were monitored at Priest Rapids and Wanapum dams (Grant PUD 2011). Prior to the juvenile salmonid outmigration, a DIDSON camera was installed on the end of the screen that allowed 69% of the screen surface to be effectively imaged. Fishes were enumerated as they passed within the insonified area near the screen, and interactions with the screen were classified by type (contact or non-contact). A total of 18 days of data collection throughout the spring and summer salmonid migration periods were analyzed at each dam. These results showed that fishes observed had a low level of interaction with the screens and a very low level of multiple or extended contact. At Wanapum Dam, 10,632 fishes were observed near the exclusion screen with 784 (7.4%) coming in contact with the screen and at Priest Rapids Dam, 29,340 fishes were observed with 360 (1.2%) contacts with the screen (Wright et. al., 2010). Although the study was originally developed to evaluate juvenile salmonid outmigrants, small numbers of lamprey were also observed at monitored locations at both Wanapum (n=31) and Priest Rapids (n=161) dams (Wright et. al., 2010). During the study period (May 12 to July 15, 2010) no negative impacts or screen impingement events were observed at these locations (Mike Clement, Grant PUD, personal communication).

2.2 Updated Information

Pursuant to the requirements of Grant PUD's PLMP (Grant PUD 2009) and specifically for this comprehensive annual report (as described in Section 1.2 above), recent Pacific lamprey passage and survival investigations and measures undertaken in the Columbia River Basin are summarized in Table 4. For the purposes of this comprehensive annual report, the "updated" information includes activities that are either occurring or are being reported on during the current reporting period of November 1, 2013 through October 31, 2014. Worth noting is that the table only includes activities that have been implemented through the end of the reporting period. Efforts that are proposed or planned for future implementation or are proposed as a potential measure are not identified in this section. Proposed and planned efforts are, however, addressed in Section 4.0 which contains a comprehensive evaluation of all regional activities (implemented, planned and proposed) and assesses their applicability to the Project.

Information contained in the table includes the activity, project and river in which the activity occurred, results or status of activity, lead entity and information source.

Table 4 Pacific lamprey activities in the Columbia River Basin in 2014.

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
	General Biology, Ecology, and Population Status					
1.	Monitoring entrance timing, escapement, and movement patterns	No associated hydro project	Fifteenmile Creek	In 2013, abundance estimates for Pacific lamprey upstream of Cushing Falls was 1,928 (1,524 – 2,440). Out of 324 lamprey PIT tagged by CTWSRO and 1,393 tagged by UI in 2013, there were 230 detected by antenna arrays in Fifteenmile Creek between April and October, 2013 (Figure 26). In addition to those tagged and detected in 2013, there were 46 lamprey tagged in 2012 and three tagged in 2011 that were detected in 2013. Seventy percent of detections of lamprey tagged in 2013 were in May and June. Lamprey tagged in 2011 were detected in April and May and those tagged in 2012 were detected primarily in April and May (44/46) but two were detected in June. Over 90% of the lamprey detected in Fifteenmile Creek in 2013 were active between 21:00 and 03:00.	CTWSR	Evaluate Status and Limiting Factors of Pacific Lamprey in the lower Deschutes River, Fifteenmile Creek and Hood River Subbasins. Confederated Tribes of Warm Springs Reservation of Oregon, Warm Springs. (CTWSR 2014a)
2.	Adult lamprey monitoring and juvenile lamprey density and distribution surveys	No associated hydro project	Deschutes and tributaries	Since 2003, data have been collected in the lower Deschutes River Subbasin to develop population trend data and investigate local lamprey biology and ecology. In 2013, a mark-recapture study was completed to estimate the abundance of adult lamprey at Sherars Falls. In addition, a tribal creel was also completed. Escapement was calculated by subtracting tribal harvest from the abundance estimate. Adult lamprey were collected at night from late July though mid October in the Sherars Falls fish ladder (Deschutes River rkm 70.4) using a long handled dip net. Captured fish received a half duplex tag and a fin clip as a secondary mark. A total of 626 adult Pacific lamprey were marked	CTWSR	Evaluate Status and Limiting Factors of Pacific Lamprey in the lower Deschutes River, Fifteenmile Creek and Hood River Subbasins. Confederated Tribes of Warm Springs Reservation of Oregon, Warm Springs. (CTWSR 2014a)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				at Sherars Falls between July 1, 2013 and November 5, 2013. During second-event sampling, 1,540 lamprey were inspected for marks. Abundance of lamprey at Sherars Falls was estimated at 11,455 (se=1,151). Subtracting harvest, 2,058, escapement was 9,658. Lamprey implanted with half duplex (HDX) passive integrated transponder (PIT) tags at Sherars Falls were interrogated at antenna sites in Warm Springs River and Shitike Creek. Out of the 601lamprey that were PIT tagged at Sherars Falls in 2013, 48 were detected in these streams. Of the 48 detected lamprey, 32 ascended Warm Springs River and 16 passed the mouth of Shitike Creek. The highest site that lamprey were detected in Warm Springs River was just upstream of the Warm Springs National Fish Hatchery at river kilometer 17, where 8 of the 32 passed. In 2013, an ammocoete density survey was repeated in Warm Springs River and Shitike Creek that was originally conducted in 2009. Since then, an extensive floodplain restoration project in lower Shitike Creek had been completed, which included adding habitat complexity in the primary stream channel. In 2013, Beaver Creek had highest ammocoete densities of Reservation streams sampled, also including Warm Springs River, Badger and Shitike creeks. There was no difference in median ammocoete densities in restoration and non-restoration reaches in Shitike Creek. The habitat restoration project in Shitike Creek was completed in 2009. The goal was to restore hydrologic connectivity to the floodplain and enhance in-stream habitat complexity by installing log and rock fish-structures, for use by juvenile salmonids. Ammocoete densities in the restoration area in 2013 were back up to the level before construction took place. The slow water		

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				floodplain habitats did not have high ammocoete densities most likely because ammocoetes need flowing water to transport food for them to filter and highest densities were found along stream margins on the main stem in substrate dominated by silt and organic matter. Very small larvae (<20 mm) are described and presumed to be young-of-the-year. They are not part of the estimated densities because they go through the dip net and are translucent and therefore difficult to see but represent recent spawning. Young-of-the-year larvae were present in all Reservation streams except for Badger Creek where only larger ammocoetes were captured. It is expected that a barrier to adult passage may exist in lower Badger Creek.		
3.	Conduct adult lamprey movement study using radio telemetry	BOR projects in Yakima	Yakima	In 2014, the Mid-Columbia River Fishery Resource Office continued a radio telemetry study of Pacific lamprey movements in the Yakima River. Eighty-nine radio-tagged adult Pacific lamprey were released into the Yakima River to assess passage at irrigation diversion dams, movement patterns, overwintering and spawning areas. The 2014 annual report will be available on April 1, 2015.	USFWS	Personal communication with RD Nelle, USFWS (12/10/14)
4.	Determining adult escapement and adult harvest monitoring	Willamette Falls	Willamette	Pacific lamprey escapement through the fish ladder at Willamette Falls was 109,372 in 2012 and 55,460 in 2013. Total estimated lamprey present at the Falls in 2012 was 245,352 and 173,792 in 2013. In 2012, an estimated 6,523 lamprey were harvested between June 20 and July 27. This was 2.7% of total lamprey abundance present at the Falls in 2012. In 2013, an estimated 7,552 lamprey were harvested between June 14 and July 28. This was 4.3% of total lamprey abundance at the Falls in 2013. Escapement estimates of lamprey at Willamette Falls, 2010 –	CTWSR	Willamette Falls Lamprey Study. Annual Report to BPA (CTWSR 2014b)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				2013, corresponded with day and night counts of lamprey at Bonneville Dam (r^2=0.98). Estimated abundance of lamprey that failed to return to the fish ladder at Willamette Falls were correlated with harvest of lamprey at Willamette Falls, 2010 – 2013 (r^2=0.85). The proportion of lamprey that failed to return to the fish ladder was 55.4% in 2012, consistent with 2011 (54.3%), however the rate increased in 2013 to 68.1%. Annual differences in flow characteristics at the Falls likely had an effect on the number of PIT tagged lamprey that returned to the fish ladder. The proportion of PIT tagged fish that returned to the fish ladder were used to estimate total abundance of lamprey at Willamette Falls. However, improvements in quantifying the number that ascends the Falls by alternate passageways, such as lamprey ramps over the temporary flow-control structure that Portland General Electric Company installs every summer and PGE's West Side Lamprey Structure through the old fishway, is needed to avoid underestimating escapement. Total number of lamprey counted over both lamprey ramps in 2012 was 575 and 2,132 were counted climbing over ramps in 2013. The proportion of lamprey enumerated passing ramps in 2012 was 0.5% of the escapement estimate and in 2013 it was 3.8% of estimated escapement through the fish ladders. During both years, 50% of the passage occurred during the first week and 90% of lamprey had passed within four weeks. Equipment failures prevented video capture of lamprey at the West Side Lamprey Structure in 2013 and HDX antenna detection of PIT tags in 2012. In 2013, a high water event swept HDX antenna away at lamprey ramps and data were not recovered. The Confederated Tribes of Warm Springs Reservation of Oregon Fisheries staff is working toward applying advancements in		

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				technological devices that allow observation, detection, and enumeration lamprey to improve estimates.		
5.	Evaluation of larval Pacific lamprey rearing	The Dalles	Columbia River	A generalized random tessellation-stratified approach was used to select sampling quadrats (30 m X 30 m) in a random, spatially-balanced order to evaluate larval lamprey occupancy in Columbia River mainstem pools (i.e., reservoirs) at three strata: within pools as a whole, within shallow-water strata of the pools, and in tributary mouth habitats within the pools. Larval lamprey occupancy was evaluated in Bonneville, The Dalles, John Day, and McNary pools, shallow water strata within Bonneville Pool, and tributary mouths occurring within the respective pools including the Wind, Little White Salmon, White Salmon, Hood, Klickitat, Deschutes, John Day, and Umatilla River mouths. Larval lampreys were found to occupy Bonneville Pool as a whole, Bonneville pool shallow water strata, McNary Pool, as well as all of the above tributary mouth habitats in the Columbia River mainstem.	USFWS	Personal communication with Greg Silver, USFWS (11/6/14)
6.	Evaluation of Portland Harbor Superfund Area Restoration: Larval Pacific Lamprey	No associated hydro project	Willamette River	We initiated an evaluation of the effects of restoration actions in the Portland Harbor Superfund area on larval lamprey occupancy in the lower Willamette River. Mainstem river areas of interest associated with the Alder Point restoration site and one reference site near Ross Island were sampled for larval lamprey occupancy with a deepwater electrofisher. A generalized, random tessellation-stratified approach was used to delineate 30 m x 30 m quadrats in a random, spatially-balanced manner throughout the lower Willamette River. A subsample of the quadrats	USFWS	Personal communication with Greg Silver, USFWS (11/6/14)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				occurring within 100 m of the restoration and reference site locations were sampled to evaluate larval lamprey occupancy. Both the Alder Point restoration site and the Ross Island reference site were occupied by larval lampreys.		
7.	Pacific lamprey assisted recolonization of Tryon Creek	No associated hydro project	Tryon Creek	Pacific lamprey, thought to historically inhabit Tryon Creek, OR, no longer occur in the watershed. Following restoration activities to improve fish passage at the Highway 43 culvert in 2008, assisted recolonization of Tryon was begun in 2013. To help reestablish a spawning population of Pacific lamprey in Tryon Creek, 1046 larval Pacific lampreys collected in Eagle Creek and North Fork Eagle Creek (Clackamas R basin) were released in Tryon Creek. Spawning ground surveys and backpack electrofishing surveys to monitor adult and larval lamprey activity within Tryon Creek are ongoing.	USFWS	Tryon Creek Restoration Monitoring Report (Silver et al. 2014)
8.	Lamprey monitoring	No associated hydro project	Hood River	In 2013, 11 sites in Hood River were sampled, including two in the mainstem, two in the Middle and West forks of the Hood River, and three in the East Fork Hood River. Sites sampled in tributaries included two in Neal Creek and one in Odell and Indian creeks. Ammocoetes were present in the Hood River up to the confluence with the East and West Fork Hood River (rkm 0 – 19.3). Ammocoete distribution extended 5.6 km up into East Fork Hood River. Total distribution in the Hood River Subbasin for larval Pacific lamprey was 24.9 rkm. Out of six sites sampled in Hood River and two in East Fork Hood River with ammocoetes present, four sites had ammocoetes large enough to sample. Lamprey captured upstream of the former	CTWSR	Evaluate Status and Limiting Factors of Pacific Lamprey in the lower Deschutes River, Fifteenmile Creek and Hood River Subbasins. Confederated Tribes of Warm Springs Reservation of Oregon, Warm Springs. (CTWSR 2014a)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				Powerdale dam site (rkm 6.5) in 2013 were the first large enough to measure, which averaged 53.3 mm (range 39 – 82, n=18). There was no significant difference in mean lengths of ammocoetes upstream or downstream of the former dam site (t=-1.17, p- value=0.26, α=0.05), 50.9 and 57.1 mm, respectively. Densities in the four sites ranged from 2.1 to 17.8 ammocoetes/m^2. About 100 small (< 20 mm) ammocoetes were observed at every sample site throughout the mainstem and East Fork Hood River.		
9.	Adult lamprey monitoring	No associated hydro project	Umatilla	In 2014, the Confederated Tribes of the Umatilla Reservation (CTUIR), continued monitoring of adult lamprey in the Umatilla River via radio-telemetry. The objective of the monitoring is to identify passage bottlenecks within the watershed and passage efficiency at low-elevation dams in the drainage. In total, 30 fish were tagged and monitoring consisted of both fixed stations and mobile surveys. Final reporting of this activity will become available soon.	CTUIR	Personal communication with Aaron Jackson, CTUIR (11/5/14)
10.	Re-introduction evaluation	Pelton Round Butte	Deschutes	As part of relicensing the Pelton Round Butte Hydroelectric Project (PRB), the licensees, Portland General Electric and CTWSR, developed a Fish Passage Plan approved by the Federal Energy Regulatory Commission. A component of the Fish Passage Plan is the Pacific Lamprey Passage Evaluation and Mitigation Plan (PLEMP). To re-establish lamprey upstream of PRB, a series of assessments is called for in the PLEMP. The first step was to study habitats currently occupied downstream of PRB, then identify potential habitat	CTWSR	Personal communication with Cyndi Baker, CTWSR (10/24/14)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				upstream of PRB. Both juvenile and adult lamprey downstream of PRB were studied to ascertain: 1) timing and locations of spawning and overwintering, 2) spawning and rearing distribution, and 3) habitat associations. The culmination of this assessment was a theoretical abundance estimate of Pacific lamprey ammocoetes (larval lamprey) in habitat that may be re-colonized upstream of PRB. The extent of potential ammocoete rearing habitat upstream of PRB includes the Metolius River from the mouth to Camp Creek (rkm 13.8), the Deschutes River from the head of Lake Billy Chinook (rkm 193) to Big Falls (rkm 213), Whychus Creek from the confluence with the Deschutes River to Alder Springs (rkm 2.4) and the Crooked River from the head of Lake Billy Chinook to Opal Springs (rkm 6.9). Two models; a capture efficiency (CE) model and an ammocoete abundance model (AAM) were developed and used in conjunction with water temperature and habitat data upstream of PRB, which resulted in an estimate of 4.8 million ammocoetes (95% prediction interval = 3.7 to 7.5 million ammocoetes) for the identified habitat. The evaluation to determine whether lamprey can be re-established upstream of the PRB Hydrologic Complex (rkm 161) in the Deschutes River is complete, however a management decision on reintroduction is still pending.		
11.	Conduct juvenile distribution and abundance sampling	No associated hydro project	Umatilla	In 2014, index sites were surveyed using backpack electrofishing to assess juvenile lamprey distribution and abundance in the Umatilla watershed. These sites were established in the late 1998 as a research, monitoring and evaluation tool for Tribal translocation activities. Forty sites are surveyed from river mile (RM) 0 to 70. Survey results show that Pacific lamprey are present	CTUIR	Personal communication with Aaron Jackson, CTUIR (11/5/14)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				throughout the Umatilla River and Meacham Creek and juvenile densities remain elevated compared to pre-translocation levels. Final reporting of this activity will become available soon.		
12.	Larval lamprey surveys for status and trend, distribution, relative abundance, and habitat availability	No associated hydro project	Yakima, Entiat, Methow, and Klickitat	Sampling in 2014 for all subbasins focused on index sites (for long-term status and trend) with a mix of new sites to examine various questions, such as distribution, habitat availability, entrainment rates into irrigation diversion, genetic analysis, and translocation potential or success. In Yakima Basin, no larval Pacific lamprey have been found above Roza Dam and very few are found upstream of Naches River confluence consistent with very low recent adult counts at Prosser Dam. Some of the young of the year lamprey captured near supplementation release sites (potential offspring of translocated adults) were preserved for species identification and parentage analysis. In Entiat Subbasin, upper distribution of larval Pacific lamprey was pursued as well as relative abundance and habitat availability throughout the subbasin. In Methow Subbasin, most time was spent assisting the Methow sampling lead by John Crandal (see Activity #16), but a few new sites were examined in Chewuch, Twisp, and Methow rivers for potential future supplementation activities. In Klickitat, weather conditions were not favorable to conduct whole watershed surveys as planned, but key sites in lower and mid reaches were surveyed to primarily collect tissue and fine sediment samples for mercury anlaysis (see Activity #13). 2013 Reports are available upon request (2014 Reports available in 2015).	Yakama Nation	Appendices in "Yakama Nation Pacific Lamprey Project, 2013 Annual Report, Project No. 2008-470-00" (Lampman et al. 2014). Personal communication with Ralph Lampman, Yakama Nation (10/7/14)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
13.	Mercury study on larval lamprey and fine sediment in Lower Columbia River	No associated hydro project	Lower Columbia & tributaries (including Klickitat, White Salmon, Rock, Wind)	Since 2013, PNNL with assistance from the Yakama Nation has collected larval lamprey tissue and fine sediment (rearing habitat) from select locations in Lower Columbia River and its tributaries to compare and contrast the level of mercury concentrations. A draft report is available upon request, which indicates that mercury levels were high near the Lower Columbia River as well as in some of the tributaries (such as Klickitat River). A similar study was conducted in 2014.	PNNL and Yakama Nation	Mercury concentrations in Pacific lamprey (Entosphenus tridentatus) and sediments in the Lower Columbi River Basin, Draft Preliminary Report (Linley et al. 2014). Personal communication with Ralph Lampman, Yakama Nation (10/7/2014)
14.	Larval / juvenile lamprey surveys in irrigation diversions	No associated hydro project	Yakima	The Yakama Nation Pacific Lamprey Project has been active in October/November surveying dewatered irrigation canals within the Yakima River subbasin for larval / juvenile lamprey within these diversions. There seems to be a strong correlation between the amount of fine sediment collected in diversions and the number of larvae found at these facilities. Lamprey of various sizes (sometimes in the thousands) were found behind screens. A new report summarizing this sampling from 2013 is available now. Multiple other reports were also made available in 2014, which focused on conducting monitoring 1) in the head gate area prior to irrigation season, 2) in diversions during irrigation season using rotary screw traps, tailor made sediment traps, transported larvae, and video monitoring.	Yakama Nation	Appendices in "Yakama Nation Pacific Lamprey Project, BPA 2013 Annual Report, Project No. 2008-470-00" (Lampman et al. 2014). Appendices in "Evaluation and Coordination of Pacific Lamprey Activities in the Yakima River Subbasin, BOR 2013 Annual Progress Report" (Lampman et al. 2014). Personal communication

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
						with Ralph Lampman, Yakama Nation (10/7/14)
15.	Conduct status and trend larval monitoring program	No associated hydro project	Methow	In August 2013, as part of continuing lamprey activities in the Methow watershed (which began in 2008), on-going status and trend monitoring of larval lamprey continued with surveys of the three sites on both the Chewuch and Methow rivers. Several sites in the upper Methow and Twisp River were also sampled but no larvae have been observed in these areas since monitoring began in 2008. Electrofishing was conducted to determine larval presence and relative abundance and all type 1 larval habitat was GIS mapped to determine larval density as well as persistence of larval habitat over time. A project status report that will include all lamprey specific work conducted in the Methow since 2009 will be completed in early 2014.	Methow Salmon Recovery Foundation, Wild Fish Conservancy, USFS, Yakama Nation and USFWS	Personal communication with John Crandall, Methow Salmon Recovery Foundation (10/15/14)
16.	Habitat restoration and effectiveness monitoring	No associated hydro project	Methow (Chewuch River)	A salmonid-based habitat restoration action on the Chewuch River at RM 10 is being assessed to determine its effects on 1) the distribution of larval lamprey rearing habitat, 2) the distribution and relative abundance of ammocoetes. The restoration project was initiated by the Yakama Nation and the monitoring component is being coordinated by John Crandall. Pre-treatment data was collected in 2010 and post-treatment data has been collected in subsequent years including 2013.	Wild Fish Conservancy, Methow Salmon Recovery Foundation, and Yakama Nation	Personal communication with John Crandall, Methow Salmon Recovery Foundation (10/15/14)
17.	Distribution and relative abundance monitoring of spawning and larval lamprey	No associated hydro project	Willamette	Spawning surveys of adult lamprey and backpack electrofishing for larval lamprey were conducted throughout the Willamette River Basin, 2011-2013. Lamprey redds were detected in all survey segments visited, including reaches on Ritner Creek (~4m average channel width) and the Santiam River (~70-100m average channel width), but more redds were detected in reaches composed of alluvial underlying sediments. Spawning habitat	Oregon Cooperative Fish and Wildlife Research Unit at OSU	Personal communication with Luke Schultz, OSU (09/29/14) Using Spatial Resampling to Assess Redd Count Survey Length

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				was similar to that used by salmonids and results suggest that ongoing habitat restoration will be mutually beneficial for these species of concern. The attached manuscript details our findings related to developing monitoring plans for lamprey spawning. Larval lamprey were also collected throughout the Basin, but appeared to be limited by small anthropogenic barriers. In areas with adult access, we did not detect any differences in relative abundance across the basin, but larvae were strongly associated with low velocity burrowing habitats and, in particular, off channel areas (backwaters, side channels). Finally, we used length information to estimate mortality rates for larval lamprey. Results indicate that survival was fairly high during the larval portion of the life cycle. Similar to adults, findings suggest habitat restoration strategies that increase the complexity of stream channels will be beneficial to Pacific lamprey juveniles.		Requirements for Pacific Lamprey (Mayfield et al. 2014) The distribution and relative abundance of spawning and larval Pacific lamprey in the Willamette River Basin (Schultz et al. 2014)
18.	Presence/Absence, habitat use, and relative abundance of juvenile lamprey	Priest Rapids and Wanapum	Columbia	On March 4 – 7 and 13-14, 2014 a field crew used ABP-2 backpack electrofishers to assess presence/absence of juvenile Pacific lamprey in areas affected by the abnormal drawdown of Wanapum Reservoir. Generally, sampling was difficult and at times not feasible due to deep mud exposed by low pool elevation (543.3-544.0 at the Wanapum forebay). Three ammocoetes were captured and another was observed during sampling on March 4 in the vicinity of Sunland Estates (RM 431). Small numbers of dead juvenile Pacific lamprey were observed in the vicinity of Walling Canyon (RM 449), Crescent Bar (RM 441), and Sunland Estates. Additional sampling in the Wanapum reservoir at low operational elevations is planned for 2015 after the pool returns to normal operating levels.	Grant PUD	Personal communication with Rod O'Connor Blue Leaf Environmental (10/9/14)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
19.	Lamprey artificial propagation	N/A	N/A	Pacific lamprey adults were collected in summer 2012 and held over winter at ambient water conditions. On 9 May 2013 a single ripe male and female were anaesthetized and stripped of gametes. The eggs and milt were held separately on ice for the 4 h transport to Walla Walla. They were then mixed for 2 min, exposed to culture water for 3 min, rinsed three times and installed in two upwelling jars at 14°C and 0.1-0.2 L/min flow. We recorded 100% fertilization success to the morula stage. For the second test, gametes were stripped from two females and three males on 20 May and transported on ice to Mukilteo. Gametes were held on ice for 6, 18, 24, and 42 h before mixing using the method described above. Fertilization success was 93% for the 6 h treatment, but only 20% at 18 h. For the 24 and 42 h treatments, no eggs developed to the morula stage. A third test was conducted on 5 June using gametes from three males and three females. These gametes was fertilized at Prosser within 2 h of stripping using twelve treatment combinations: a) gametes combined and mixed for 2 min before addition of culture water and then exposed for 3, 6, or 12 min, and b) gametes combined and mixed with culture water and then exposed for 3, 6 and 12 min. Half of the fertilized gametes from each treatment were rinsed three times with culture water before installation in individual Heath trays. The others were not rinsed. Two observers scored fertilization to the morula stage and successful development to day 12 (near hatching) for three subsamples of 50 embryos from each treatment at each stage of development. The results indicated that fertilization is enhanced slightly by mixing gametes before addition of culture water, but that eggs are easily damaged by “dry” mixing. However, neither effect was statistically significant. For both treatments, the lowest	NOAA Fisheries, CTUIR, Yakama Nation	Personal communication with Mary Moser, NOAA Fisheries (11/10/14)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				exposure times had highest fertilization rates and survival to day 12. Contrary to expectation, rinsing the fertilized eggs resulted in significantly lower fertilization success and greater rates of egg damage. However, survival to day 12 was significantly higher in rinsed treatments.		
20.	Lamprey artificial propagation	N/A	N/A	The YNPLP have conducted artificial propagation and rearing of Pacific lamprey since 2012. This work was accomplished in close coordination with the CTUIR (Aaron Jackson), NOAA (Mary Moser) and USGS (Matt Mesa) who are also conducting similar research activities. Over 365,000 larvae were successfully hatched and produced. Rearing experiments, using various tank sizes, density, and feeds are ongoing to learn how to best feed and care for these larvae throughout the year. Maximum density for YOY larvae were approximately 3000 fish / m2 while that for 1+ larvae were approximately 1000 fish / m2. Although there is a wide variation in individual size and growth, on average 12 month old larvae typically reached 30-60 mm in length (largest larvae was 81 mm). 2013 Report is available upon request.	Yakama Nation	Evaluation and Coordination of Pacific Lamprey Activities in the Yakima River Subbasin, BOR 2013 Annual Progress Report (Lampman et al. 2014).
21.	Reservoir fluctuation impacts on larval lamprey	Bonneville	Columbia	A depth averaged numerical hydraulic model (MASS2) which was developed at PNNL was used to quantify the extent of dewatered sediments near the delta regions of four major tributaries in the Bonneville pool. These included the Little White Salmon, Wind, White Salmon, Hood and Klickitat rivers. Inundation changes were examined at four different forebay elevations. From the modeled water-surface elevation output we determined that the overall change in affected area is less sensitive to elevation changes during higher river discharges. Changing the forebay elevation at Bonneville Dam and the resulting	PNNL	Bob Mueller, PNNL, Presentation at AFEP Review, Portland, OR (12/11/14)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				impact on total dewatered regions was greater at the lowest modeled river flow (97 kcfs) and showed the greatest variation at the White Salmon/Hood River delta regions followed by the Wind, Klickitat, and the Little White Salmon rivers. The unsteady model output showed that water-surface elevation in the reservoir closely follows that of the Bonneville Dam forebay with rapid changes of 1 to 2 ft possible. A 2.5-ft variation in water-surface elevation occurred during a 2-week period in February in 2002 and a 3.7-ft change occurred in the same period in 2014. The durations of these changes were highly variable and generally did not stay constant for more than a 5-hr period.		
22.	Lamprey translocation project including juvenile surveys and radio-telemetry studies.	No associated hydro project	Willamette	In 2014, the CTGR collected 240 adult pacific lamprey from Willamette Falls and translocated them to Fall Creek above the Fall Creek Dam. 40 were fitted with tags and tracked using radio telemetry. Electrofishing is also being conducted to determine the presence and distribution of juvenile lamprey both above and below the Fall Creek Dam. The study is ongoing with no formal reports or data available at this time.	CTGR	Personal communication with Bryan Fendall, CTGR (10/07/14)
23.	Collection of adult lamprey for translocation, artificial propagation and radio-telemetry studies	No associated hydro project	Umatilla	In 2014, the CTUIR collected adult lamprey from lower Columbia River mainstem dams. In total, 910 adults were captured and transported to the South Fork Walla Walla lamprey holding facility throughout the fall and then moved to Minthorn Springs to over-winter. These fish will be used for translocation programs in the Umatilla and Grande Ronde basins; to support radio-telemetry assessments (releases in the lower Umatilla River); and to support artificial propagation research occurring at the Walla Walla Community College, Water Environmental Center lab.	CTUIR	Personal communication with Aaron Jackson, CTUIR (11/5/14)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				Final reporting of this activity will become available soon.		
24.	Collection of adult lamprey for translocation, artificial propagation and radio-telemetry studies	No associated hydro project	Yakima	In 2014, the Yakama Nation collected adult lamprey from Lower Columbia River mainstem dams. In total, 882 adults were captured and transported to the Prosser Fish Hatchery (Prosser, WA). These fish will be used for translocation programs in the Yakima subbasin; to support radio-telemetry assessments (releases in the Yakima River); and to support artificial propagation research. In addition to the 882 adults, 22 adults were taken directly by Grant PUD to test passage at Wanapum Dam.	Yakama Nation	Yakama Nation Pacific Lamprey Project, BPA 2013 Annual Report, Project No. 2008-470-00 (Lampman et al. 2014). Personal communication with Ralph Lampman, Yakama Nation (10/7/2014)
25.	Pacific lamprey in the Columbia River Estuary	No associated hydro project	Lower Columbia Estuary	A manuscript describing the timing, abundance, and size of both juvenile and adult Pacific lamprey in the lower Columbia estuary (below Rkm 60) is being prepared. The work is based on historic (1980-81) and current (2001-2012) sampling in the estuary. The paper (Weitkamp, L.A., S. A. Hinton, and P. J. Bentley. In press. Seasonal abundance, size, and host selection of Pacific (Entosphenus tridentatus) and River (Lampetra ayresii) Lamprey in the Columbia River estuary. Fishery Bulletin) was just accepted. The date for publication is to be determined.	NOAA Fisheries	Personal communication with Laurie Weitkamp, NOAA Fisheries (09/22/14)
	Lamprey Migration in Rivers					
26.	General migration and upstream passage patterns	Bonneville, The Dalles, John Day, McNary, Priest Rapids, Wanapum, Rock Island,	Columbia and Snake	Monitoring adult Pacific lamprey migration in the Columbia River Basin is an important part of understanding how dams and environmental factors affect lamprey behavior, dam passage success, and distribution among spawning areas. In 2014, we conducted several concurrent radio		Matthew Keefer, University of Idaho, Presentation at AFEP Review, Portland, OR (12/11/14)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
		Rocky Reach, and all four lower Snake River dams		and HD-PIT studies. At Bonneville Dam, we collected and radio-tagged 600 lamprey from 23 May to 12 September. All were released downstream from the dam and all had an HD PIT tag as a secondary tag. We also tagged 900 adult lampreys at Bonneville Dam with HD PIT tags only: 599 were released downstream from the dam from 15 May to 23 September for full-migration monitoring; another 299 were used in the experimental flume at Bonneville Dam and were then released into the Bonneville forebay. A third group of 100 lampreys was collected from the new lamprey passage structure (LPS) at John Day Dam. This group was HD PIT-tagged and then released upstream from John Day Dam during a three-week period in July. The radio-tagged group was monitored at the four lower Columbia River dams, Priest Rapids Dam, at the four lower Snake River dams, and at major tributaries. HD PIT antennas were also located at all of these dams plus public utility districts monitored PIT tagged lamprey passage at Wanapum, Rock Island, and Rocky Reach dams. The Confederated Tribes of Warm Springs monitored some tributary sites with instream HD PIT antennas. A new (late summer 2013) HD/FD PIT antenna at the mouth of the Deschutes River also collected data for all the 2014 tag groups. Monitoring is ongoing.		
27.	Evaluate movement and fate of adult Pacific lamprey in Bonneville Reservoir and Lower Columbia River	Bonneville	Columbia	Between 2011 and 2013, we tagged 761 adult lampreys with 400-day duration JSAT tags and 23 with 60-day duration JSATS tags. All fish were trapped at Bonneville Dam (rkm 235) in the Adult Fish Facility. A total of 411 fish were released upstream from Bonneville Dam at Stevenson, WA or Cascade Locks Marina. The remaining 373 fish were released into the Bonneville Dam tailrace at	University of Idaho Cooperative Fish and Wildlife Research Unit	Christopher Noyes, Presentation at AFEP Review, Portland, OR (12/11/14)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				Hamilton Island or Tanner Creek. Telemetry monitoring increased each year as we added and adjusted receiver sites. The behavior and final distributions of lamprey were similar across all years. A strong majority (~80%) of tagged fish entering Bonneville Reservoir each year rapidly moved upstream to the head of the reservoir by the end of fall and most of these had last fall detections in the The Dalles Dam tailrace. The 400-d duration JSATS tags allowed continued monitoring of tagged lamprey in spring. Springtime detections of lamprey directly indicated or suggested that many fish entered monitored spawning tributaries of Bonneville Reservoir (including Klickitat, Wind, and Hood rivers, and Fifteen Mile Creek). These fish represented 12% (2011), 13% (2012), and 6% (2013) of lamprey that had previously been last detected in Bonneville Reservoir with unknown final fates. Dam-to-dam escapement of (JSATS+HD-PIT)-tagged adults was similar between all years and was comparable to lamprey tagged only with HD-PIT tags. Lamprey consistently exhibited high within-reservoir migration rates (km/d) through all study years. Overall, the multi-year study results indicate that: 1) most adults entering reservoirs rapidly and successfully move upstream during summer and fall, indicating high survival and low predation in reservoirs; 2) most lamprey overwintering in the mainstem do so in tailraces; 3) a proportion of adult lamprey move downstream into tributaries of the overwintering reservoir during spring; and 4) that considerably uncertainty remains about the fate of a large proportion of adults overwintering in tailraces, with potential fates that include successful movement into unmonitored tributaries,		

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				mortality in tailraces/headsof- reservoirs, or spawning in tailrace environments.		
28.	Design and construction of flume to test irrigation diversion screening	No associated hydro project	N/A	In 2012, the USGS began the design and construction of a large, oval flume to test the effects of irrigation diversion screens on juvenile lampreys. In 2013-2014, ammocoetes were exposed to a 2.5-m-wide screen panels with flows up to 10 cfs, a sweeping velocity (SV) component, and a simulated bypass channel. The addition of a SV modestly improved protection of lamprey ammocoetes for all materials tested (woven wire (WW), perforated plate (PP), profile bar (PB), or Intralox® (IL) material). A SV of 35 cm/s with an approach velocity (AV) of 12 cm/s protected fish about 5 – 15 mm smaller than the same AV with no SV. The best performing screen panels (PP, IL, and PB) provided almost complete protection from entrainment for fish greater than 50 mm, but the WW material only protected fish greater than 100 mm. Decreasing the AV and SV by half expanded the size range of protected lampreys by about 10–15 mm for those exposed to IL and WW screens, and it decreased protection of PP screens by about 10 mm. Much of the improvement for IL and WW screens was due to an increase in the number of lampreys swimming away from the screen. Fish of all sizes became impinged (i.e., stuck on the screen surface for more than 1 s) on the screens, with the rate of impingement highest on PP (39-72%) and lowest on WW (7-22%). Although impingements were common, injuries were rare and 24-h posttest survival was over 99%. Our results refined the level of protection provided by these screen materials when both an AV and SV are present and confirmed our earlier recommendation that WW	USGS	Personal communication with Marty Liedtke, USGS (11/20/14)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				screens be replaced with more effective materials. A manuscript for the study is currently in review.		
29.	Vulnerability of larval lampreys to hydrosystem operations: Effects of dewatering on movements and survival	No associated hydro project	Columbia	A dewatering tank was designed and built to test the movement of larval lampreys in response to dewatering of their habitat relative to fish size and ramping rates. Trials at two ramping rates are ongoing. Trials to document the survival of larval lampreys in substrates that have been dewatered relative to fish size and duration of exposure are also ongoing. Testing will continue for the next couple months.	USGS	Personal communication with Marty Liedtke, USGS (11/20/14)
30.	Juvenile lamprey outmigration monitoring	No associated hydro project	Umatilla	In 2013-14, the CTUIR continue to operate a rotary screw trap at RM 2.5 of the Umatilla River to document juvenile lamprey outmigration timing. The trap is run from November to May of each year. Status and trend monitoring shows continued increases since initiating translocation. Final reporting of this activity will become available soon.	CTUIR	Personal communication with Aaron Jackson, CTUIR (11/5/14)
31.	Upstream migration and dam passage	Ice Harbor, Lower Monumental, Little Goose, and Lower Granite	Snake	During 2014, 254 adult lamprey were captured at John Day Dam on the Columbia main stem, surgically outfitted with radio transmitters and transported for release to Ice Harbor Dam on the lower Snake River. Approximately 75% of the fish were released downstream of the Ice Harbor Dam while the remaining 25% were released above the dam to increase the sample of fish available to evaluate passage at upstream dams. Monitoring for the radio-tagged sample is on-going. Through 23 Oct 2014, one-hundred, sixty-nine of these fish were subsequently detected at Ice Harbor Dam (87%; 169/194), 52 were detected at Lower Monumental (20%; 52/254), 19 were detected at Little Goose (7%; 19/254) and 8 were	USFWS	Chris Peery, Presentation at AFEP Review, Portland, OR (12/11/14)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				detected at Lower Granite dams (3%; 8/254). Preliminary passage efficiency rates by project are 53% (41/78) for Ice Harbor dam, 62% (29/47) for Lower Monumental dam, 56% (10/18) for Little Goose dam and 63% (5/8) for Lower Granite dam. Preliminary passage rate for all four dams combined is 3% (5/151). Data from these detections will be used to calculate additional passage metrics including percent approach, relative entrance and fishway use, entrance and fishway passage success and passage times for each passage zone within a given dam. These metrics will be used to identify primary entrances, fishways, and turn around zones used by fish that do not successfully pass each dam. Additionally, overall dam passage (conversion) and fallback rates will be calculated for dam where sample sizes permit. Results from 2014 will be used to determine numbers of lamprey to be tagged and release locations to be used in 2015. The results from this project will be used to identify potential passage impediments and opportunities for future fishway improvements in the Snake River.		
32.	Juvenile lamprey data synthesis	Lower Granite, Little Goose, Lower Monumental, Rock Island, McNary, John Day and Bonneville	Columbia and Snake	Most available data on migration, passage, and other characteristics of juvenile lampreys in the Columbia River basin (CRB) was summarized. This included counts of fish from juvenile bypass facilities at several dams, incidental catches of juvenile lampreys in turbine cooling water strainers, a summary of previously published fyke net studies, catches of lampreys from various screw trap operations in tributaries of CRB, and a brief summary of juvenile lampreys found in the diet of piscine and avian predators. Collectively, this information has provided a unique, basin-wide perspective on juvenile lamprey passage and movements and suggests several areas where information is limited and research should be targeted. Although most of this information was	USGS	Synthesis of Juvenile Lamprey Migration and Passage Research and Monitoring at Columbia and Snake River Dams (Mesa et al. 2014)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				readily available elsewhere, this document gets everything in one place and should be a valuable resource for managers charged with conserving and protecting lamprey populations.		
33.	Predictive model to prioritize barrier removal	No associated hydro project	Santiam	Mark-recapture population estimates at ~100 sites were conducted throughout wade-able habitats in the Santiam River to assess how reach scale habitat features and segment-scale geomorphic characteristics influence lamprey capture probability and abundance, respectively. This information will be used to develop a predictive map for lamprey abundance that can be combined with a barrier layer within a GIS framework to prioritize barrier removal in stream reaches with the greatest potential to increase availability of suitable lamprey habitat.	Oregon Cooperative Fish and Wildlife Research Unit at OSU	Personal communication with Luke Schultz, OSU (09/29/14)
	Adult Passage at Hydroelectric Facilities					
	Structural and Operational Fishway Modifications					
34.	Ladder tours	Bonneville, McNary, Lower Monumental, Lower Granite	Columbia and Snake	Completed a tour of fish ladders with regional fish managers and researchers to identify potential minor fishway modification opportunities. Tours in 2014 were confirmed for Snake River projects but information was not available for Lower Columbia River projects at time of reporting.	ACOE	Personal communication with Sean Tackley, ACOE (11/14/13) and Steve Juhnke, ACOE (09/25/14)
35.	Inspect fishway at Priest Rapids and Wanapum dams and identify areas that could represent passage problems for adult Pacific lamprey	Priest Rapids, Wanapum	Columbia	In January 2013, Grant PUD conducted tours during scheduled maintenance outages with the PRFF members to evaluate the modifications to the fish ladders to improve adult lamprey passage (i.e., plating installation, adult lamprey collection facilities, newly designed count stations, and ramps downstream of perched orifices) and to identify any potential passage problem areas.	Grant PUD	Personal communication with Mike Clement, Grant PUD (09/23/14)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
36.	Improving adult lamprey passage using lamprey passage structures (LPS) and refuges	Bonneville	Columbia	This project is part of a multi-year effort to understand and improve the passage performance of adult Pacific lamprey at lower Columbia River dams. Efforts to increase adult Pacific lamprey passage in 2014 included structural and operational changes to improve lamprey access to and passage through LPSs at Bonneville Dam. Lamprey use of these structures was assessed with lamprey-activated counters and passive integrated transponder (PIT) detections. Adult Pacific lamprey (n=1,199) were tagged with a PIT tag and released downstream from Bonneville Dam. Movements of PIT tagged lamprey were monitored by antenna arrays at traditional fishways and lamprey passage strucures (LPS) at Columbia and Snake River Dams. Adult Pacific lamprey (n=1,327 as of October 1, 2014) were collected from an auxiliary water supply channel that has no outlet to the forebay at Bonneville Dam. These lamprey were transported and released untagged approximately 1 km upstream from the dam. Using PIT detections, we tested whether lamprey use refuge boxes installed along the bottom of the Washington-shore AWS channel placed in an effort to improve lamprey retention in this area.	ACOE (prepared by NOAA Fisheries)	Personal communication with Steve Corbett, NOAA Fisheries (11/12/14)
37.	Design LPS for Westland Diversion	Westland diversions	Umatilla	In 2012, the Umatilla Tribe continued design of the LPS for the Westland Diversion. The diversion dam is located in the Umatilla River watershed. A 2013 update to this activity was unavailable at the time of report publication.	CTUIR	Personal communication with Aaron Jackson, CTUIR (11/5/14)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
38.	Passage improvement design	McNary	Columbia	A prototype adult lamprey passage structure was installed in Oregon shore ladder (SFE2) in February 2014. Structure usage and passage success are being monitored using DIDSON, optical video and HDX PIT-tags. Evaluation is ongoing.	ACOE	Personal communication with Steve Juhnke, ACOE (09/25/14)
39.	Installation and/or utilization of slotted "keyhole" fishway entrance at Project	Priest Rapids, Wanapum	Columbia	Grant PUD currently utilizes the "keyhole" fishway entrance at Priest Rapids and Wanapum dams.	Grant PUD	Personal communication with Mike Clement, Grant PUD (09/23/14)
40.	Modify dewatering procedures	All ACOE projects	Columbia and Snake	Modifications to dewatering procedures to reduce stranding and mortalities have occurred over the past several years. These include: managing dewatering to better flush fish down to the tailrace; to keep fish remaining in the ladder in standing water while dewatering to reduce the efforts by lamprey to move through gratings when stranded; and adequate personnel and equipment to ensure timely salvage. This is an ongoing action.	ACOE	Personal communication with Sean Tackley, ACOE (11/14/13)
41.	Modify dewatering procedures	Wells	Columbia	Pursuant to the Wells Habitat Conservation Plan (HCP; Douglas PUD 2002), a dewatering protocol is in place.	Douglas PUD	Personal communication with Chas Kyger, Douglas PUD (10/21/14)
42.	Modify dewatering procedures	Rocky Reach, Rock Island	Columbia	Pursuant to the Rocky Reach Unwatering/Waterup Job Plan 1402 and Rock Island Standard Operating Procedures (SOP), fishway, dewatering protocols and fish recovery operations for all species are followed during annual winter fishway maintenance and dewatering activities..	Chelan PUD	Personal communication with Steve Hemstrom, Chelan PUD (10/14/14)
43.	Modify dewatering procedures	Priest Rapids, Wanapum	Columbia	Pursuant to the Project Fishway Operation Plan, dewatering protocols are followed annually during winter maintenance and dewatering activities.	Grant PUD	Personal communication with Mike Clement, Grant PUD (9/23/14)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
44.	Operation of old fishway for lamprey passage	Willamette Falls	Willamette	Based upon past lamprey evaluations conducted at Willamette Falls, activities to restore portions of the existing "old fishway" to operability were completed in 2011 with the completion of a 52m linear curb and an adjustable headgate. The facility began operation in early spring 2012 when flows decrease below a river elevation (upstream of the falls) of 54'. Current information indicated that lamprey congregate in an area of this fishway early in the migration season. Operations of this fishway allow lamprey volitional passage to the forebay of the project. In 2014, Portland General Electric (PGE) continued to operate the "old fishway" and install lamprey ramps to facilitate adult lamprey passage at Willamette Falls Dam. High numbers of lamprey are observed using the facilities and the CTWSR has been evaluating the structures using cameras and PIT tags.	PGE	Personal communication with Tim Shibahara, PGE (09/24/14)
45.	Initiated design work for fishway modifications	Little Goose, Lower Granite	Snake	Initiated design work and awarded contract for minor modifications to fishway. Lamprey orifices in control section weir walls, and diffuser grating landing plates will be installed during the winter outage period. Work was completed at Little Goose Dam in 2013. Monitoring of modifications was complete at that site. Installation of lamprey orifices is on-going during the dewatered ladder period in Jan-Feb 2014. Monitoring of the passage route will be discontinued after 2013, as no negative impacts were found in 2013 monitoring.	ACOE	Personal communication with Steve Juhnke, ACOE (09/25/14)
46.	Fishway modifications	Rocky Reach	Columbia	Based upon a literature review and site visit conducted in spring of 2010, Chelan PUD made modifications to the Rocky Reach fishway during the 2010-2011 and 2011-2012 fishway maintenance periods to improve adult lamprey passage at the Project. These improvements include installation of plating at diffuser gratings	Chelan PUD	Personal communication with Steve Hemstrom, Chelan PUD (10/14/14)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				throughout the ladder, plating at orifices in the lower fish ladder sections where overflow weirs are located, ramps at perched orifices in the upper ladder, and an HDX PIT tag detection system at key locations within the fishway and have been evaluated since 2013. The Rocky Reach fishway passage assessment continued in 2014. Between 31 July and 19 September, Chelan PUD PIT tagged (32mm half-duplex) **276** adult lampreys at the Rocky Reach tag facility. Source of adult lamprey was Grant PUD's trap and haul effort. Tagged lampreys were re-released in the mainstem just upstream of the Wenatchee River, approximately 5 miles below Rocky Reach Dam. Between 2 August and 24 September, 227 unique tags were detected at the Rocky Reach fishway forebay exit; 212 of these were released by Chelan PUD, 15 were tagged and/or detected at Wanapum Dam by Grant PUD. Preliminary, ongoing detections of tagged adults passing Rocky Reach indicate a preliminary passage rate of approximately 80% and an overall passage success greatly improved.		

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
47.	Passage design elements for new fishway construction	Trail Bridge Dam	McKenzie	As part of the implementation of the Carmen-Smith Project FERC license (currently awaiting issuance), the Eugene Water and Electric Board (EWEB) has included several design elements in the Trail Bridge Dam fish ladder that will assist in the upstream passage of Pacific Lamprey. • The auxiliary water comes into the entrance pool through a wall diffuser rather than a floor diffuser. • A 3"W x 4"H orifice through the dog-leg wall, on the floor and against the side wall. • A rounded instead of square end on the dog-leg • All lips, floor bumps and width changes (e.g. to and from pool and transport channels) have 4" radius corners. • In 2014, engineering design was on hold. All of the above elements remain in place.	EWEB	Personal communication with Andy Talabere, EWEB (10/6/14)
48.	Reduced water velocities at fishway entrances	Bonneville	Columbia	In 2013, continued reduced nighttime flow operations at the Washington Shore Fish Ladder to improve lamprey passage efficiency. Updated information was not available at time of reporting.	ACOE	Personal communication with Sean Tackley, ACOE (11/14/13)
49.	Reduced water velocities at fishway entrances	McNary	Columbia	In 2013, continued reduced nighttime flow operations were implemented at the Oregon Shore Fish Ladder entrances, to improve lamprey passage efficiency. In 2014, reduced nighttime flow operation occurred only at SFE1. An adult lamprey passage structure was installed in SFE2, and normal flow operations were maintained. This is an ongoing action.	ACOE	Personal communication with Steve Juhnke, ACOE (09/25/14)
50.	Reduce water velocities at fishway entrances	Wells	Columbia	Water velocities were reduced at the Wells fishway entrances in late 2013 as a component of a passage study.	Douglas PUD	Personal communication with Chas Kyger Douglas PUD (10/21/14)
51.	Lift picket leads at count station	Bonneville	Columbia	In 2011, lifted picket leads by 1 inch at Bradford Island Fish Ladder count station to improve access to AWS channel LPS. The 1 inch spacers were	ACOE	Personal communication with Sean Tackley,

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				removed mid-passage season (June 29) due to an incident in which dozens of sockeye salmon were found milling behind picket leads. During an emergency dewatering on June 30, it appeared that the sockeye were able to get behind the picket leads via inconsistencies in the floor surface at the base of the picket leads (some gaps were up to 3 inches). ACOE modified picket leads at Bradford Island during winter 2011-12 to allow lifting picket leads by 1 inch while ensuring a contiguous floor surface. University of Idaho monitored these picket leads in summer 2012. Results suggest that adult salmonids, including relatively small-bodied sockeye salmon, jack Chinook salmon, and steelhead, did not attempt to or successfully enter the AWS channel at Bradford Island during the viewing period. Observations from project biologists at Bonneville Dam also did not see sockeye milling behind picket leads, despite the record-sized run. Accordingly, ACOE modified the Washington Shore Fish Ladder count station picket leads in winter 2012-13 to improve access to the AWS channel LPS in that fishway. Updated information was not available at the time of reporting.		ACOE (11/14/13)
52.	Lift picket leads at count station	The Dalles	Columbia	Lifted picket leads at East and North Fish Ladder count stations by 1.5 inches to provide alternative passage routes for Pacific lamprey.	ACOE	Personal communication with Sean Tackley, ACOE (11/14/13)
53.	Lift picket leads at count station	John Day	Columbia	Lifted picket leads at South Fish Ladder (already lifted at North) count station by 1.5 inches to provide alternative passage routes for Pacific lamprey. Updated information was not available at the time of reporting.	ACOE	Personal communication with Sean Tackley, ACOE (11/14/13)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
54.	Lift picket leads at count station	McNary, Ice Harbor, Lower Monumental, Little Goose, Lower Granite	Columbia and Snake	Lifted picket leads at fish ladder count stations by 1.5 inches to provide alternative passage routes for Pacific lamprey. This is an ongoing ladder operation.	ACOE	Personal communication with Steve Juhnke, ACOE (09/25/14)
55.	Maintain fishway operations criteria	Rock Island	Columbia	Pursuant to the Rocky Reach and Rock Island Fish Passage Plan (Chelan PUD 2012), fishway operations criteria are in place. In 2014, fish passage operations continued with Denil extensions to all three Rock Island Dam fishways in response to the Wanapum emergency drawdown.	Chelan PUD	Personal communication with Steve Hemstrom, Chelan PUD (10/14/14)
56.	Maintain fishway operations criteria	Priest Rapids, Wanapum	Columbia	Pursuant to the Project Fishway Operation Plan (Grant PUD 2009), fishway operations criteria are routinely maintained.	Grant PUD	Personal communication with Mike Clement, Grant PUD (09/23/14)
57.	Minor fishway modifications	The Dalles and John Day	Columbia	Designed and awarded construction contract to install lamprey diffuser plating immediately upstream and downstream of all overflow weir orifices in the lower sections of The Dalles East Fish Ladder and John Day South Fish Ladder. Installation will be completed in Winter 2013-2014. Updated information was not available at the time of reporting.	ACOE	Personal communication with Sean Tackley, ACOE (11/14/13)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
58.	Fishway modifications to facilitate lamprey collection and counting	John Day	Columbia	Modified count station area behind picket leads at John Day South Fish Ladder to facilitate (1) trapping for research or translocation activities; (2) improved escapement estimates. Picket lead spacing was reduced to ¾ inches, except near the bottom, where openings allow lamprey to enter a small flume system leading to a trap and videocounting mechanism still in development. When not in collection mode, the system will allow lamprey to continue moving up the fishway. Evaluation in 2013 was limited to monitoring the number of lamprey collected in the trap box. In total, 100 were collected by tribal researchers in 2013. Minor modifications to the system will be completed in Winter 2013-14 to improve functionality. Updated information was not available at the time of reporting.	ACOE	Personal communication with Sean Tackley, ACOE (11/14/13)
59.	Design, construction and testing of lamprey vertical climbing structure (wetted wall) for passage	Bonneville	Columbia	An experimental vertical climbing structure intended as a mechanism of passing lamprey out of a serpentine weir section of a fish ladder into an AWS containing an LPS was tested in the FERL facility at Bonneville Dam in 2014. Lamprey climbing success was measured against three flow levels and three ways of supplying water to the structure. Lamprey passage was 100% under all experimental conditions for fish that interacted with the structure.	NOAA Fisheries	Personal communication with Kinsey Frick, NOAA (11/12/14)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
60.	Swimming behavior and performance in relation to passage barrier velocity, distance, and turbulence	Bonneville	Columbia	The hydraulic and structural environment within the serpentine weir sections at Bonneville Dam are associated with both high turbulence flow regimes and relatively long sections of high velocity that may act as a deterrent or barrier for lamprey passage. The study objective was to simulate the hydraulic conditions observed in the serpentine weirs under an experimental setting to evaluate why lamprey passage is so poor through this section. Velocity levels (1.2 m/s, 1.8 m/s, 2.4 m/s), weir lengths (0.33 m, 0.66 m, 1.00 m), and turbulence presence were manipulated. The overall experimental design consisted of 18 total treatment combinations (3 ×3 × 2) where each treatment combination consisted of three replicates with ten lamprey each. Overall, passage efficiency of the weir was high under all treatments. There was no significant effect of velocity, turbulence, or weir distance on lamprey success rates. The only significant effect on lamprey success was a turbulence (high) × distance (long) interaction though the magnitude of the effect was relatively small. There was no indication of size-selective processes under the test conditions. Video observations from deployments within the serpentine weirs section of the Bonneville Bradford Island fishway revealed slightly different lamprey behaviors, which included a lower propensity for attachment behaviors. Ongoing analyses are evaluating more detailed elements of behavior in relation to details of hydraulic conditions in both the flume and BI serpentine weirs and analysis of the potential cumulative consequences of passing the 15 weirs at Bonneville Dam.	University of Idaho Cooperative Fish and Wildlife Research Unit	Mark Kirk, Presentation at AFEP Review, Portland, OR (12/11/14)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
61.	Redesign of diffuser plating	Bonneville	Columbia	In 2014, ACOE re-designed diffuser plating that is to be installed at the Washington Shore Ladder at Bonneville Dam. The current diffuser design is too large given the abnormally high diffuser velocities in this ladder. Hydraulic analysis suggests that the plating would drive average floor diffuser velocities to over 2 times the NOAA criteria of 0.5 ft/sec and would increase risk of diffuser grating blowouts. An acceptable alternative design was identified and will be installed during the 2014-2015 IWW period	ACOE	Personal communication with Sean Tackley, ACOE (8/5/14)
	Project Passage Effectiveness					
62.	Using network theory to evaluate passage behavior	Bonneville	Columbia	Network theory is a component of graph theory, which is a body of mathematics and computer science that characterizes the connectivity of spatial systems. We used network analyses to reconstruct the passage histories of 255 adult Pacific lamprey and 240 Chinook salmon at Bonneville Dam from a 2010 radiotelemetry study. The first specific objective of this study was to examine the utility of network metrics for describing individual elements of passage and migration behavior. The second objective was to expand those analyses to the population-level to test for differences in network structure both between and within these two species. Network analyses revealed higher variation in network metrics for lamprey compared with salmon, which was largely due to the difference in passage success between the two species (46% vs. 98%, respectively). Lamprey that did not pass Bonneville exhibited a wide range of movement patterns, from approaching only one fishway entrance to visiting every fishway site. Lamprey that passed Bonneville Dam had networks consisting of more direct paths with fewer	University of Idaho Cooperative Fish and Wildlife Research Unit	Mark Kirk, Presentation at AFEP Review, Portland, OR (12/11/14)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				movements between fishway sites than lamprey that did not pass, but longer paths and larger networks than salmon that passed. We demonstrate the importance of accounting for time in the network on the estimation of passage metrics. Network metrics did not show clear relationships with body size for either lamprey or salmon. There was an interesting positive relationship between network metrics and migration date for salmon, with more movements between fishway sites for summer than spring Chinook. Network analyses provided a novel approach for evaluating differences in route patterns, path length, and milling behaviors between lamprey and salmon. Similar analyses have the potential to be applied in a wide range of fish movement studies, including monitoring the effect of environmental conditions on fish passage and testing effectiveness of fish passage modifications.		
63.	Underwater Video Monitoring of Adult Fish Ladder Modifications to Improve Pacific Lamprey Passage at McNary, Ice Harbor, Little Goose, and Lower Granite Dams, 2013.	McNary, Ice Harbor, Little Goose, and Lower Granite dams	Columbia and Snake rivers	This study was a continuation of monitoring efforts at fishway modifications; specifically:1) enumerate adult passage at dams using video technology, 2) evaluate adult lamprey behavior at picketed leads and at lamprey orifices using non-invasive observation methods, 3) evaluate adult salmonid behavior near lamprey orifices, and 4) complete development of video image analysis software and package the software for general use. These data provide rigorous quantitative estimates of adult Pacific lamprey escapement at McNary and Ice Harbor dams, ensure that ladder modifications for lamprey at Lower Granite and Little Goose dams do not impede adult salmonid passage, and improve our understanding of lamprey passage behavior and success at Walla Walla District USACE hydroelectric projects.	UC Davis and University of Idaho	Underwater Video Monitoring of Adult Fish Ladder Modifications to Improve Pacific Lamprey Passage at McNary, Ice Harbor, Little Goose, and Lower Granite Dams, 2013 (Thompson et al. 2014).

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
64.	Evaluation of Adult Fish Ladder Modifications to Improve Pacific Lamprey Passage at McNary and Ice Harbor Dams, 2014	McNary, Ice Harbor	Columbia and Snake	Continuation of picketed lead video monitoring in 2014 at McNary and Ice Harbor dams. Additional activities included using a combination of optical video cameras and DIDSON sonar cameras to evaluate the behavior of lamprey in the immediate vicinity of the prototype lamprey entrance structure installed in the MCN South Shore Fishway entrance (SFE 2); enumerating adult lamprey entering and exiting the structure; and estimating passage efficiency and passage time using HD-PIT tag technology. Work is continuing with a draft report due Feb 28, 2015.	UC Davis and University of Idaho	Evaluation of Adult Fish Ladder Modifications to Improve Pacific Lamprey Passage at McNary and Ice Harbor Dams, 2014 (Loge 2013).
65.	Evaluate fishway modifications	Priest Rapids, Wanapum	Columbia	Grant PUD implemented a comprehensive adult passage evaluation study plan, titled "Assessment of Pacific lamprey behavior and passage efficiency at Priest Rapids and Wanapum dams" (Nass et al. 2009). The goal was to collect data in support of determining whether proposed modifications (plating, ramps at perched orifices, and lamprey-specific crowders at fish count stations) improved adult passage. HDX-PIT system were used to collect data from fish tagged downstream of Priest Rapids Dam. Pacific lamprey tagged at lower river facilities were passively monitored at PRP facilities as directed by the PRFF. Preliminary cummulative data analysis will be completed as part of 2014 activities and included in the 2014 annual report (see Table 5, Line #7). Final results will be included in Grant PUD's 2015 Comprehensive Annual Report.	Grant PUD	Personal communication with Mike Clement, Grant PUD (9/23/14)
66.	Evaluate passage at LPS structures	Threemile Falls Dam, Maxwell and Feed	Umatilla	In the Umatilla River watershed, lamprey passage structures (LPS) have been completed and are operational at Threemile Falls Dam (July 2009), Feed Diversion (October 2010), and Dillon	CTUIR	Personal communication with Aaron Jackson, CTUIR

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
		diversions		Diversion (2011). A flat plate was installed to aid upstream lamprey movement at Maxwell Diversion (August 2010). Radio-telemetry monitoring at these structures was conducted in 2012. Preliminary results indicated that 38 lamprey were detected using the LPS while 55 lamprey were detected passing through the traditional ladder at Threemile Dam. A number of fish had undocumented passage at this location so monitoring of the entire facility is planned for 2013. Information to date indicates no detections higher in the watershed however, complete monitoring results are not yet available. A 2013 update to this activity was unavailable at the time of report publication.		(11/5/14)
67.	Project passage evaluation	Clackamas	Clackamas	In 2013, an active/passive tag evaluation using RT and HDX tags to evaluate passage success through the project was implemented. All fish were tagged at the trap in River Mill Fish ladder and released ~1 mile downstream to evaluate re-assent back through this facility and remaining NF ladder upstream. A total of 47 fish were active/HDX tagged and 45 HDX tagged. The evaluation started last spring and is still ongoing. Preliminary results indicate high ladder passage success at River Mill Dam ladder (~86%). No fish were observed passing the NF Ladder. This is confounded by historical fish facility features that prevented migration through this facility. A final report will be available in 2015.	PGE	Personal communication with Tim Shibahara, PGE (09/24/14)
68.	Development and use of LPS structures	Bonneville, John Day	Columbia	We assessed lamprey use of the Bonneville Dam Lamprey Flume System-Lamprey Passage Structure (LFS-LPS) and John Day LPS by enumerating adults collected at the upstream of	University of Idaho	Chris Caudill, Presentation at AFEP, Portland, OR (12/11/14)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				each terminus daily, including those previously tagged with half-duplex (HD) PIT tags. HD PIT antennas were integrated into the construction of the Bonneville LFS-LPS and became operational during 2014. Several modifications to the LFS-LPS were completed during winter 2013-2014 to improve passage and operations. During 2014, 600 lamprey were radio tagged and released below Bonneville Dam and movements at Bonneville Dam Powerhouse 2 (PH2) were monitored in relation to the LFS-LPS entrance. At the John Day Dam North Fishway Entrance (NFE) LPS lamprey were collected and transported to the forebay and a subsample of 100 were tagged with HD-PIT tags prior to release to evaluate postrelease movements and final distribution. The Bonneville Dam LFS-LPS was operated 20 May – 30 September 2014, though entrained air in the LFS water supply prevented operation at high flow rates due to concerns for salmon passage. A total of 545 adults were collected from the LFS-LPS (0.42% of the total (day+night+LPS) counted passing Bonneville Dam), with the majority of these adults collected during the first fifteen days of operations, compared to a total of 27 adults collected during seven weeks in 2013. During 2014, daily collection rate ranged from 0 to 56 lamprey per day, representing 0-12.7% of the total (day+night+LPS) daily counted passing Bonneville Dam. We are currently assessing potential operational changes to reduce entrained air and increase attraction flow rate of the LFS, and the potential effects of tailwater elevation on guidance and attraction flow to NDE and the LFS entrances. Few HD-PIT tagged lamprey were detected on LFS-LPS antennas and analyses of radiotelemetry data are ongoing.		

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				During 2014, the John Day LPS was operated continuously from 25 June through 30 September. A total of 1,228 lampreys were collected (4.45% of the totalday+night+LPS counted). Daily collection rate ranged from 0-91 lamprey per day (0-36% of the total (day+night+LPS counted) and daily collection rate was also highest during the first third of the operation season. Lampreys were released to the forebay or used for a radiotelemetry study in the Snake River (N = 254; see Table 4 Line 31) A total of 111 adults were collected during a similar period in 2013 and the increase during the second year of operation at both sites is consistent with previous installations of LPSs at Bonneville Dam.		
69.	Passage structure evaluations	Bonneville Dam	Columbia River	In 2014, NOAA Fisheries continued a multi-year study to evaluate and improve adult Pacific lamprey passage at Bonneville Dam. As in previous years, modifications and improvements to lamprey passage structures (LPSs) were made prior to the adult lamprey migration period. During the migration period, NOAA evaluated LPSs and modifications with the following objectives: 1) Determine use of LPSs located at the auxiliary water supply (AWS) channels 2) Assess the effects of providing refuge areas in AWS channels 3) Determine lamprey use of the LPS located at the Cascades Island fishway entrance To achieve the monitoring objectives, NOAA used two approaches. First, we counted individual river-run lamprey passage. Using lamprey-activated counters in the Washington Shore, Bradford Island, and Cascades Island LPSs. Second, NOAA marked lamprey with passive integrated transponder (PIT) tags, released them below Bonneville Dam, and monitored their upstream	NOAA Fisheries	Personal communication with Steve Corbett, NOAA Fisheries (11/8/14)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				movements within the LPSs. In 2014, NOAA tagged 1,199 migrating adult lamprey with a PIT tag (600 of these fish were also tagged with a radio tag for a separate study Antennas to detect PIT tags were integrated into all of the lamprey passage structures.		
70.	Evaluate entrance efficiency at reduced fishway head differential and evaluate count station modifications to improve lamprey enumeration accuracy.	Wells	Columbia	Radiotelemetry was used to study upstream passage behavior and enumeration in the Wells Project fishways. Specific objectives of the study include*:* Evaluate passage efficiency of radio-tagged adult Pacific lamprey through Wells Dam fishways; with an emphasis in the lower fishway section. Evaluate travel time of radio-tagged adult Pacific lamprey through Wells Dam fishways; with an emphasis in the lower fishway section. Evaluate radio-tagged adult lamprey behavior through Wells Dam fishways; with an emphasis in the lower fishway section. Compare adult Pacific lamprey entrance efficiency under reduced Wells Project fishway entrance velocities to entrance efficiencies at non-reduced velocities. Evaluate enumeration efficiency of adult lamprey at the fish count station at Wells Dam using new, 11/16th inch picketed leads and compare adult lamprey behavior at the fish count station with old picketed leads to behavior at count windows with new, 11/16th inch picketed leads. In December 2012, modifications were made to the fish count station areas of the fishways. Modifications included the addition of smaller 11/16th inch grating to exclude lamprey from a count window bypass area and attachment ramps leading to the count windows. 106 lamprey collected at Bonneville Dam and 9 collected at Priest Rapids dam radio and PIT tagged and released in the Wells tailrace with a subset released directly into the fishways. Radio telemetry antennas were placed in multiple locations throughout both the east and west	Douglas PUD	Personal communication with Chas Kyger, Douglas PUD (10/21/14)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				fishways and also at the mouth of the Methow and Okanogan Rivers. Results of the study will be available in spring 2013.		
	Lamprey Counts at Dams					
71.	Conduct 24-hour lamprey counts	Bonneville, The Dalles, John Day, McNary, Lower Granite	Columbia and Snake	Counts include nighttime video window counts. Nighttime counting was expanded in 2012 to include The Dalles and John Day dams. Updated information was not available at the time of reporting.	ACOE	Personal communication with Sean Tackley, ACOE (11/14/13)
72.	Conduct 24-hour lamprey counts	Wells	Columbia	On-going 24-hour fishway monitoring since the 1990's.	Douglas PUD	Personal communication with Chas Kyger Douglas PUD (10/21/14)
73.	Conduct 24-hour lamprey counts	Rocky Reach, Rock Island	Columbia	On-going 24-hour fishway monitoring since the late 1980's.	Chelan PUD	Personal communication with Steve Hemstrom, Chelan PUD (10/14/14)
74.	Conduct 24-hour lamprey counts	Priest Rapids, Wanapum	Columbia	On-going 24-hour fishway monitoring since the mid 1990's; however, due to the Wanapum fracture, 24-hour video and fish counts for Wanapum Dam were not conducted during 2014 (see Section 5.0).	Grant PUD	Personal communication with Mike Clement, Grant PUD (09/23/14)
75.	Structural modifications to count station	Bonneville Dam	Columbia	Improvements to the remotely-accessed LPS counting system occurred in 2014. Additionally an alternate counting method was tested at the WA shore LPS.	NOAA Fisheries	Personal communication with Kinsey Frick, NOAA Fisheries (11/12/14)
76.	Estimate adult lamprey upstream passage success rates, ladder passage times, entrance slot preference and fallback rates at Snake River dams.	Ice Harbor, Lower Monumental, Little Goose, and Lower Granite	Snake	In 2014, ACOE contracted with Cramer Fish Sciences, to conduct an adult lamprey migration behavior and passage success evaluation in the Lower Snake River. Adult Lamprey were captured at the JDA north	ACOE	Personal communication with Steve Juhnke, ACOE (09/25/14)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				ladder LPS, and the JDA South ladder lamprey trap, tagged onsite, and transported for release into Ice Harbor dam tailrace or forebay. Opportunistically, test fish included lamprey previously radio- and/or PIT-tagged for lower Columbia River lamprey modification evaluations, if detected migrating up the Snake River. Specific objectives are: 1. Determine which ladder entrances slots (multiple entrance slots per ladder entrance) attract the majority of migrating adult lamprey to aid in developing future entrance design modifications. 2. Estimate adult lamprey upstream passage success rates, relative fishway route use, passage times, turnaround/ladder fallout, and forebay fallback at IHR, LMN, LGO, LGR using radio-telemetry, HDX-PIT technology, and visual counts. 3. Determine conversion rates of migrating adult lamprey between Snake River dams based on a combination of RT and PIT-tag detections.		
	Predation					
77.	Establish predation control measures (sea lions)	Bonneville	Columbia	Ongoing implementation of predation control measures, such as sea lion removal efforts - although planned for salmon, are also expected to benefit adult Pacific lamprey. Efforts are being made to be sure to include concerns for lamprey and adequate monitoring of lamprey predation in future efforts.	ACOE	ACOE Pacific lamprey passage improvements implementation plan, 2008-2018 (ACOE 2009)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
	Juvenile Passage at Hydroelectric Facilities					
	Structural and Operational Fishway Modifications					
78.	Delayed deployment of extended length screen during outmigration	McNary	Columbia	Installation of extended screens was delayed in the spring of 2013 to reduce impacts to juvenile lamprey migrating out early. Updated information was not available at the time of reporting.	ACOE	Personal communication with Sean Tackley, ACOE (11/14/13)
79.	JBS modifications	McNary	Columbia	Extended the JBS raceway waste water outfall pipe and altered JBS raceway screen mesh size to allow juvenile lamprey to volitionally pass from the raceway back to the river. This is the current configuration and an ongoing action.	ACOE	Personal communication with Steve Juhnke, ACOE (09/25/14)
80.	JBS outfall relocation	McNary, Lower Monumental	Columbia / Snake	JBS outfalls were relocated downriver from existing locations. The outfall relocations were done to improve salmonid survival, but juvenile lamprey will benefit from the new locations as well. This is the current configuration and an ongoing action.	ACOE	Personal communication with Steve Juhnke, ACOE (09/25/14)
81.	Continue salvage activities during ladder maintenance de-watering	All ACOE projects	Columbia / Snake	Modifications to dewatering procedures to reduce stranding and mortalities have occurred over the past several years. These include: managing dewatering to better flush fish down to the tailrace; to keep fish remaining in the ladder in standing water while dewatering to reduce the efforts by lamprey to move through gratings when stranded; and adequate personnel and equipment to ensure timely salvage. Updated information was not available for Columbia River projects at the time of reporting.	ACOE	Personal communication with Sean Tackley, ACOE (11/14/13) and Steve Juhnke, ACOE (9/25/14)
82.	Continue salvage activities during ladder maintenance de-watering	Wells	Columbia	Pursuant to the Wells Habitat Conservation Plan (HCP; Douglas PUD 2002), a dewatering protocol is in place. Any adult lamprey captured during salvage activities are released upstream of Wells Dam, juveniles downstream per the Wells Pacific	Douglas PUD	Personal communication with Chas Kyger Douglas PUD (10/21/14)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				Lamprey Management Plan.		
83.	Continue recovery activities during ladder maintenance de-watering	Rocky Reach, Rock Island	Columbia	Pursuant to the Rocky Reach Unwatering/Waterup Job Plan 1402 and Rock Island SOP, fishway dewatering protocols and fish recovery operations for all species are followed during annual winter fishway maintenance and dewatering activities.	Chelan PUD	Personal communication with Steve Hemstrom, Chelan PUD (10/14/14)
84.	Continue salvage activities during ladder maintenance de-watering	Priest Rapids, Wanapum	Columbia	Consistent with its Fishery Operations Plan (Grant PUD 2010), Grant PUD conducts salvage operations for all fish species during annual ladder maintenance activities.	Grant PUD	Personal communication with Mike Clement (09/23/14)
85.	Maintain bypass operations criteria	Rock Island	Columbia	Pursuant to the Rocky Reach and Rock Island Fish Passage Plan (Chelan PUD 2012), bypass operations criteria are in place.	Chelan PUD	Personal communication with Steve Hemstrom, Chelan PUD (10/14/14)
86.	Maintain bypass operations criteria	Priest Rapids, Wanapum	Columbia	Grant PUD has existing bypass systems, which includes gatewells, spillways, the WFUFB, and Priest Rapids Top-Spill Bypass.	Grant PUD	Personal communication with Mike Clement, Grant PUD (09/23/14)
	Project Passage Effectiveness					
87.	Monitor passage timing, number, and mortalities of juvenile lamprey collected at projects with juvenile fish bypass facilities	Bonneville, McNary, Lower Monumental, Little Goose, Lower Granite	Columbia and Snake	Monitoring is occurring at all of the identified projects. Updated information was not available at Columbia River projects at the time of reporting.	ACOE	Personal communication with Sean Tackley, ACOE (11/14/13) and Steve Juhnke, ACOE (9/25/14)
88.	Juvenile lamprey monitoring	Bonneville, John Day, McNary, Lower Monumental, Little Goose, Lower Granite, and Rock	Columbia and Snake	The Fish Passage Center (FPC), per request of the FWS reviewed PIT-tag data for juvenile lamprey in the Columbia River Basin. • To date a total of 14,053 lamprey have been PIT-tagged and released, of which 3,647 (26%) were determined to have been tagged and released as juveniles.	FPC	Memo: Review of PIT-tag data for juvenile lamprey in the Columbia River Basin (FPC 2014)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
		Island		• Approximately 81% were tagged and released at a dam for specific studies. Many of these fish were collected from downstream projects and transported upstream to the release site for these studies. Therefore, any downstream detections of these fish would not be useful in assessing passage, travel, survival, etc. • Based upon the review, the following are recommended 1) researchers should clearly distinguish between adults and juveniles 2) an increase in marking of juvenile lamprey is needed to better inform passage timing, travel times, diel passage, and survival. • Limited downstream detection data limits estimates of downstream passage and survival metrics.		
89.	Lower Granite Dam Juvenile Fish Collection Channel Prototype Overflow Weir and Enlarge Orifice Biological Evaluation	Lower Granite	Snake	As part of a study in 2014 to evaluate passage of juvenile fishes through prototype fish passage structures in a gatewell at Lower Granite Dam (LGR), juvenile Pacific lamprey were collected, PIT-tagged, and released. The study was undertaken as part of a broader effort to assess the effectiveness of traditional juvenile bypass systems prescribed by the NOAA Biological Opinion (NOAA 2008, 2010) RPA 54.2. The objectives addressed in the study were: (1) determine how the overflow weir and/or larger orifices affected orifice passage efficiency (OPE) and gatewell residence times compared to current orifice configuration for juvenile lamprey, (2) determine effective collection methods for juvenile lamprey at LGR, Little Goose (LGS), and Lower Monumental (LMN) dams, (3) determine collection efficiency for juvenile lamprey designated for recollection at the Sort by Code (SxC) system at LGR, and (4) evaluate PIT tag	ACOE (prepared by Blue Leaf Environmental)	Personal communication with Rod O'Connor, Blue Leaf Environmental (10/9/14)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				retention using two different tagging techniques: surgical methods described by Mesa et al. (2011) and injecting PIT tags with a 16-gauge needle. PIT-tagged lamprey (n=753) were released at night during the period of May 10, 2014 through June 5, 2014. Fish were released into one of four locations. Statistical tests were used to detect significant differences in travel time between release locations. Collection efficiency, tag retention, and travel times for different release locations were also evaluated. A final report is currently being developed and will be available in the future.		
90.	JSATS Tag Development	No associated hydro project	N/A	With co-funding from the ACOE and DOE, a project has been implemented to design, prototype, and evaluate an acoustic microtransmitter that can be used to study the behavior and survival of juvenile eel and lamprey. Laboratory research will be used to guide the design of the transmitter and provide guidance for field deployment.	PNNL	Daniel Deng, Presentation at AFEP, Portland, OR (12/10/14)
	Predation					
91.	Establish predation control measures (pike minnows and birds)	All ACOE projects	Columbia	Ongoing implementation of predation control measures such as harassment, avian lines, avian colony management, and the pikeminnow bounty program, although planned for salmon, are also expected to benefit juvenile Pacific lamprey. Efforts are being made to be sure to include concerns for lamprey and adequate monitoring of lamprey predation in future efforts.	BPA	ACOE Pacific lamprey passage improvements implementation plan, 2008-2018 (ACOE 2009)
92.	Predation control measures	Rocky Reach, Rock Island	Columbia	As part of its HCP obligations, Chelan PUD implements predation control activities. Controlling predators of juvenile salmonids, both fish and birds, is a tool Chelan PUD has used to achieve HCP survival standards for juvenile fish. HCP Combined Adult and Juvenile Passage	Chelan PUD	Personal communication with Steve Hemstrom, Chelan PUD (10/14/14)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				Survival Standards were achieved by Chelan PUD in 2011 for both the Rocky Reach and Rock Island HCPs. Chelan PUD's predator control program for Northern pikeminnow has reduced the number of pikeminnow known to consume large numbers of outmigrating juveniles. The program includes a sport fishing derby, a U.S. Department of Agriculture (USDA) catch-and-remove program, Chelan PUD personnel catch-and-remove program, and a Chelan PUD funded long-lining program. Chelan PUD will also continue working with the USDA and other parties to identify and implement the best methods for deterring predatory birds. Since 2003, Chelan PUD has removed an average of 66,256 Northern pikeminnow annually from Rocky Reach and Rock Island Project areas combined, and a total of 662,563 Northern pikeminnow from 2003 to 2012. In 2013, total program catch was 72,365 pikeminnow from Rocky Reach and Rock Island reservoirs combined. In 2014, pikeminnow control programs continue in both Rock Island and Reach; Programs utilize long-line and rod-reel angling in tailrace and main reservoirs by Chelan PUD contractors and Chelan PUD fish crews.		
93.	Predation control measures	Priest Rapids, Wanapum	Columbia	Grant PUD implements predation control measures (avian and aquatic) to protect outmigrating, anadromous salmonids as a requirement of Grant PUD's NOAA Biological Opinion (NOAA Fisheries 2004). These measures include use of lethal and non-lethal control and monitoring presence and absence of juvenile lamprey through dietary sub sampling. It would be expected that these predation control activities will indirectly benefit outmigrating juvenile lamprey throughout the project.	Grant PUD	Personal communication with Mike Clement, Grant PUD (09/23/14)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
	Policy/Recovery Activities					
94.	Develop/implement implementation plan for Pacific lamprey restoration	All ACOE projects	Columbia and Snake	In May 2009, the Nez Perce, Umatilla, Yakama and Warm Springs tribes ("tribes") developed a Tribal Pacific Lamprey Restoration Plan for the Columbia River Basin. A final draft of the Plan was completed in December 2011. The tribes propose the plan for restoration of the species to numbers adequate for tribal use and ecological health of the region. Activities to support the objectives identified in the plan were implemented in 2014 (see other categories in Table 4).	Nez Perce, Umatilla, Yakama and Warm Springs tribes	Tribal Pacific lamprey restoration plan for the Columbia River basin (Nez Perce, Umatilla, Yakama, and Warm Springs Tribes 2011)
95.	Implementation of Pacific lamprey restoration plan	All ACOE projects	Columbia and Snake	In May 2009, the Nez Perce, Umatilla, Yakama and Warm Springs tribes ("tribes") developed a Tribal Pacific Lamprey Restoration Plan for the Columbia River Basin. A final draft of the Plan was completed in December 2011. The tribes propose the plan for restoration of the species to numbers adequate for tribal use and ecological health of the region. Activities to support the objectives identified in the plan were implemented in 2013 (see other categories in Table 4).	ACOE	ACOE Pacific lamprey passage improvements implementation plan, 2008-2018 (ACOE 2009)
96.	Develop/implement management plan for Pacific lamprey restoration	Wells	Columbia	In 2010, a PLMP was filed as part of the Wells Hydroelectric Project FERC License Application. In addition to fishway evaluations and activities to improve adult lamprey passage and juvenile passage and survival (when technology exists), management plan activities also include implementation of adult fishway and juvenile bypass operations criteria at the Project, regional data sharing, protocol development, and participation in regional conservation and recovery activities.	Douglas PUD	Personal communication with Chas Kyger, Douglas PUD (10/21/14)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
				Implementation of some management plan activities is underway and includes a passage and enumeration study in 2013.		
97.	Develop/implement management plan for Pacific lamprey passage monitoring and improvement	Rocky Reach	Columbia	On-going implementation of the PLMP that was developed and finalized in 2005. In addition to fishway evaluations and activities to improve adult lamprey passage and juvenile passage and survival (when technology exists), management plan activities also include implementation of adult fishway and juvenile bypass operations criteria at the Project, regional data sharing and protocol development, and participation in regional conservation and recovery activities.	Chelan PUD	Rocky Reach Pacific Lamprey Management Plan (Chelan PUD 2005)
98.	Develop/implement management plan for Pacific lamprey restoration	Priest Rapids, Wanapum	Columbia	On-going implementation of the PLMP that was developed, finalized, and approved by the PRFF, Ecology, and FERC in 2009. In addition to fishway evaluations and activities to improve adult lamprey passage and juvenile passage and survival (when technology exists), management plan activities also include, regional data sharing, protocol development, and participation in regional conservation and recovery activities.	Grant PUD	Priest Rapids PLMP (Grant PUD 2009)
99.	Lamprey Technical Work Group • Supplementation Subgroup • Passage Engineering Subgroup • NPCC lamprey synthesis Subgroup • FPC smolt monitoring	All ACOE projects, Wells, Rocky Reach, Rock Island, Priest Rapids	Columbia and Snake	The purpose of the Columbia River Basin Lamprey Technical Work Group (CRBLTWG) is to provide technical review, guidance, and recommendations for activities related to lamprey conservation and restoration. The CRBLTWG accomplishes this by: 1) identifying and prioritizing critical uncertainties regarding lamprey conservation; 2) providing a forum for discussion regarding lamprey-related concerns; and 3) disseminating technical information. In 2014, the CRBLTWG did not meet. Subgroup	USFWS	Personal communication with Christina Wang, USFWS (12/8/14)

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
	program assistance			meetings were convened during the year to discuss lamprey, supplementation framework, passage engineering, smolt monitoring program, Northwest Power and Conservation Council (NPCC) synthesis reporting, standardized sampling techniques, revision of the critical uncertainties and writing of a new charter for the workgroup. In 2014, the Supplementation Subgroup worked on the framework for Pacific lamprey artificial propagation and supplementation. The framework will be presented to the whole workgroup for review. In 2014, the Passage Engineering Subgroup continued to work on developing a paper on known engineering fixes to aid lamprey passage at dams and other barriers. In 2014, the NPCC synthesis subgroup continued working on the lamprey synthesis report. In 2014, the CRBLTWG continued to assist the Fish Passage Center with the smolt monitoring program for lamprey at FCRPS projects. In 2014 the CRBLTWG started the transition from CBFWA to the Pacific Lamprey Conservation Initiative Conservation Team. The CRBLTWG will be expanded outside of the Columbia Basin and include coastal Washington and Oregon and California.		

	Activity	Hydroelectric Project	Waterbody	Results / Description of Activity	Lead Entity(ies)	Source
100.	Pacific Lamprey Conservation Initiative	All ACOE projects	Columbia and Snake	The USFWS with signatories to the Pacific Lamprey Conservation Agreement and other partners continued to work on regional implementation plans for all regional management units in the Columbia and Snake rivers including the mainstem Columbia and Snake. A Conservation Team was formed to facilitate review and potential funding of conservation actions and RM&E. The Conservation Team met on August 27, 2014.	USFWS	Personal communication with Christina Wang, USFWS (12/8/14)

Notes:

AAM = ammocoete abundance model
ACOE = Army Corps of Engineers
AWS = auxiliary water supply
BOR = U.S. Bureau of Reclamation
BPA = Bonneville Power Administration
CE = capture efficiency
CRBLTWG = Columbia River Basin Lamprey Technical Work Group
CRITFC = Columbia River Inter-Tribal Fish Commission
CTGR= Confederated Tribes of Grand Ronde
CTUIR = Confederated Tribes of the Umatilla Indian Reservation
CTWSR = Confederated Tribes of the Warm Springs Reservation
DDR = design documentation report
DIDSON = Dual-frequency Identification Sonar
EWEB = Eugene Water and Electric Board
FCRPS = Federal Columbia River Power System
FPC = Fish Passage Center
HCP = Habitat Conservation Plan
HDX = half duplex
ISRP = Independent Scientific Review Panel
JSATS = juvenile acoustic telemetry system
LPS = lamprey passage system
mm = millimeters
MRC = mark-recapture methods
MUK = Mukilteo Research Station
N/A = not applicable
NOAA = National Oceanic and Atmospheric Administration
NPCC = Northwest Power and Conservation Council
ODFW = Oregon Department of Fish and Wildlife
OSU = Oregon State University
PGE = Portland General Electric
PIT = Passive Integrated Transponder
PLEMP = Pacific Lamprey Passage Evaluation and Mitigation Plan
PLMP = Pacific Lamprey Management Plan
PNNL = Pacific Northwest National Laboratory, Battelle
PRB = Pelton Round Butte Project
PRFF = Priest Rapids Fish Forum
PUD = Public Utility District
RM = river mile
RRFF = Rocky Reach Fish Forum
SMP = Smolt Monitoring Program
SNP = single nucleotide polymorphism
SOP = Standard Operating Procedure
USDA = U.S. Department of Agriculture
USFWS = U.S. Fish and Wildlife Service
USGS = U.S. Geological Survey
YNPLP = Yakama Nation Pacific Lamprey Project

3.0 Status of Pacific lamprey Activities at the Priest Rapids Project

Pursuant to the requirements of Grant PUD's PLMP (Grant PUD 2009) and specifically for this comprehensive annual report (as described in Section 1.2 above), activities at the Project related to Pacific lamprey are described in Table 5. The information is organized by the protection, mitigation and enhancement (PM&E) measures for each of the four objectives set forth in the Project's PLMP. Included for each PM&E is the timeframe for implementation/completion of the measure, the action taken by Grant PUD in 2014, and any variations in schedule. In general, measures are currently on or ahead of schedule.

Table 5 Schedule and status of Pacific Lamprey Management Plan implementation measures at the Priest Rapids Project.

	Implementation Measure	Evaluation Timeframe	Relevant to Current Reporting Period	Action Taken in 2014	Variation from Schedule (if applicable)
Objective 1: Identify, address, and fully mitigate Project effects to the extent reasonable and feasible to achieve NNI					
	Provide an annual report summarizing activities undertaken to identify and address Project impacts.	Annually (by March 31), starting 2010	Yes	Yes, report will be filed on or before March 31, 2015.	No
Objective 2: Provide safe, effective, and timely volitional passage for adult upstream and downstream migration					
	Maintain adult fishways.	Annually for the period 2009-2015	Yes	Grant PUD continues to maintain fishways at the Project in accordance with the NOAA Fisheries Fishway Operations and Criteria Guidelines for salmon (NOAA Fisheries 2008). The plan includes operational criteria for dewatering and the recovery of all fish.	No
	Develop adult Pacific lamprey passage criteria.	To be determined by the PRFF Annual passage detection monitoring initiated in July 2010, 2011, 2012, 2013, and 2014	Yes	Grant PUD installed HDX-PIT tag arrays in the fish ladders at Wanapum and Priest Rapids dams to measure adult Pacific lamprey passage. Passage metrics will be determined when a sufficient sample size has been achieved. Presently, Grant PUD has tracked a total of 380 unique PIT tags at Priest Rapids and 258 at Wanapum since 2010. Fish passage efficiency (FPE) and passage times are being calculated, although the sample size is insufficient for statistical comparisons.	No

	Implementation Measure	Evaluation Timeframe	Relevant to Current Reporting Period	Action Taken in 2014	Variation from Schedule (if applicable)
	Continue to operate and maintain fish count systems at the Project (upgrade count systems as new technology becomes available).	Annually for the period 2009-2015	Yes	Grant PUD maintains video stations at the Project to count fish in accordance with the PLMP, NOAA Fisheries Biological Opinion and agreements included in the FERC License. Newly designed and fabricated fish crowder facilities were installed and operated at both Priest Rapids and Wanapum dams prior to April 2010. Fish counts are for all species including adult lamprey are expected to be extremely accurate and are available at www.gcpud.org for review.	No

	Implementation Measure	Evaluation Timeframe	Relevant to Current Reporting Period	Action Taken in 2014	Variation from Schedule (if applicable)
	Develop and implement a comprehensive evaluation of adult lamprey passage at the Project.	Develop / implement: Within one year of license issuance (2009)	Yes	This annual report includes a comprehensive evaluation on adult lamprey passage in the Project area by addressing each measure in the PLMP. PRFF members conducted an on-site inspection of the Priest Rapids and Wanapum left bank fishway facilities during the 2013-2014 winter fish ladder maintenance outage.	No
		Determination of whether proposed modifications improve adult passage: Within four years of license issuance	Yes	Grant PUD implemented components of a comprehensive adult passage evaluation study plan, titled "Assessment of Pacific lamprey behavior and passage efficiency at Priest Rapids and Wanapum dams" (Nass et al. 2009). The goal of the evaluation was to collect data in support of determining whether the modifications improved adult passage. The assessment of plating and count station use in 2010 documented the effective use of these structures by migrating lamprey. FPE and passage times are being calculated, although the sample size is insufficient for statistical comparisons. Data analyses have been conducted annually since 2010 and are ongoing.	No
	Implement improvements to the junction pool and the diffusion gratings at the Priest Rapids Dam as identified in the FLA.	Within two years of license issuance (2010)	No	None. Grant PUD completed improvements proposed in the FLA and included in the FERC License in 2010.	No

	Implementation Measure	Evaluation Timeframe	Relevant to Current Reporting Period	Action Taken in 2014	Variation from Schedule (if applicable)
	Implement an evaluation program to assess the effectiveness of fishway modifications on adult lamprey.	Within one year of completion of fishway modifications at Priest Rapids Dam (2011)	Yes	Grant PUD implemented an evaluation program in coordination with the PRFF to determine and assess the effectiveness of fish ladder modifications. HDX-PIT system were used to collect data from fish tagged downstream of Priest Rapids Dam. Pacific lamprey tagged at lower river facilities were passively monitored at PRP facilities as directed by the PRFF. The assessment of plating and count station use in 2010 documented the effective use of these structures by migrating lamprey. FPE and passage times are being calculated, although the sample size is insufficient for statistical comparisons. Based on five years of monitoring (2010 through 2014), estimated FPE for Priest Rapids Dam is 74% and estimated FPE for Wanapum Dam is 63%.	Yes, ahead of schedule. An evaluation program was implemented in 2010 and was continued in 2011.
	Implement all modifications identified for adult fishways at the Project as identified in the FLA or as amended by the PRFF.	Within seven years of license issuance (2015)	Yes	Grant PUD has implemented improvements proposed in the FLA and included in the FERC License (see #6 above). Grant PUD will consider additional modifications based on the evaluation of the effectiveness of fishway modifications.	No

	Implementation Measure	Evaluation Timeframe	Relevant to Current Reporting Period	Action Taken in 2014	Variation from Schedule (if applicable)
	Begin investigation of the efficacy and advisability of reducing fishway flows at night during peak lamprey migration periods.	Following implementation and evaluation of identified fishway modifications	No	Grant PUD began to investigate the efficacy and advisability of reducing fishway flows at night and had incorporated this objective into the 2010 study plan. However, after consideration by the PRFF and NOAA Fisheries, this objective of the study plan was determined to be considered after evaluation of existing fishway modifications (see PRFF meeting minutes for May 5, 2010).	No
	Complete a biological objectives status report for WDOE 401 water quality certification.	Every 5th year of the license term (Aug. 2013, 2018, 2023, etc)	Yes	Biological objectives status report update for 2013 was included in last year's annual report.	Yes.
	Conduct a monitoring and evaluation study of adult Pacific lamprey passage at Project; if based on the 10-year status report, Ecology concludes that a Pacific Lamprey Biological Objective has not been met; Grant PUD shall continue to implement the Adaptive Management process.	Every 10th year of the license term (2018, 2028, 2038, 2048, 2058) or as recommended by the PRFF	No	None	No
	Participate in regional studies, forums and measures and cooperate with other entities performing those activities when useful information may be obtained about Project impacts on adult Pacific lamprey. Forums will include (but not limited to) the CRBLTWG.	Annually for the life of the license	Yes	Grant PUD currently participates in regional forums such as the Columbia River Basin Pacific Lamprey Technical Workgroup, the Lamprey Conservation Initiative (USFWS), and the Tribal Restoration Plan activities (CRITFC). Refer to Section 2.2 for specific activities.	No
	Continue to operate and maintain the adult PIT-tag detection system (full-duplex) at the Priest Rapids Dam fishway.	Annually for the life of the license	Yes	Grant PUD continues to maintain the adult PIT-tag detection system (full-duplex) at Priest Rapids Dam.	No

	Implementation Measure	Evaluation Timeframe	Relevant to Current Reporting Period	Action Taken in 2014	Variation from Schedule (if applicable)
Objective 3: Provide safe, effective and timely volitional passage for juvenile migration					
	Identify and mitigate for Project effects on juvenile Pacific lamprey	No later than 10 years following license issuance (2018)	Yes	Currently, options for measuring Project effects on juvenile Pacific lamprey are under consideration by the PRFF.	No
	Develop juvenile Pacific lamprey passage criteria	No later than 10 years following license issuance (2018)	No	None. At this time, technology does not exist to measure juvenile Pacific lamprey passage.	No
	Participate in regional studies, forums and measures and cooperate with other entities performing those activities when useful information may be obtained about Project impacts on juvenile Pacific lamprey. Forums will include (but not limited to) the CRBLTWG.	Annually for the life of the license	Yes	Grant PUD currently participates in regional forums such as the Columbia River Basin Pacific Lamprey Technical Workgroup, the Lamprey Conservation Initiative (USFWS), and the Tribal Restoration Plan activities (CRITFC). Refer to Section 2.2 for specific activities.	No
Objective 4: Avoid and mitigate Project impacts on rearing habitat					
	Determine juvenile lamprey presence / absence, habitat use, and relative abundance in the Project area. If significant ongoing effects are identified, Grant PUD shall develop a plan and implement reasonable and feasible measures to address such effects.	No later than 10 years following license issuance (2018)	Yes	Grant PUD implemented a PRFF approved study plan to determine juvenile lamprey presence / absence, habitat use, and relative abundance in the Project area in 2012 and 2013. Addional sampling was completed in the Wanapum Reservoir in 2014, although the reservoir elevations were well below normal operations due to the fracture in the Wanapum Dam spillway. The preliminary results of these activities are presented in the Results section.	No

Notes:

CRBLTWG = Columbia River Basin Lamprey Technical Work Group
CRITFC = Columbia River Inter-Tribal Fish Commission
FERC = Federal Energy Regulatory Commission
FLA = Final License Application

FPE = Fish Passage Efficiency
NOAA = National Oceanic and Atmospheric Administration
PIT = Passive Integrated Transponder
PLMP = Pacific Lamprey Management Plan
PRFF = Priest Rapids Fish Forum
PUD = Public Utility District
USFWS = U.S. Fish and Wildlife Services

4.0 Evaluation of Activities in the Columbia River Basin Relative to the Priest Rapids Project

This section provides a comprehensive assessment of activities occurring in the Columbia River Basin and their applicability to the Project. Table 6 is designed to meet the requirement of the comprehensive annual report (described in Section 1.2 above) to determine whether measures being investigated and/or implemented in the Columbia River Basin are: (i) consistent with similar measures taken at other projects; (ii) appropriate to implement at the Project; and (iii) cost effective to implement at the Project.

For purposes of this evaluation, the definitions used for the three stated elements above are as follows:

- "Consistent with similar measures taken at other projects" is "Yes" for an activity that has been implemented by a hydroelectric facility operator in a hydroelectric project area other than Grant PUD's Priest Rapids Project.
- "Appropriate to implement at the Priest Rapids Project" is "Yes" for an activity that is a requirement of Grant PUD's PLMP (Grant PUD 2009) or is an activity subsequently agreed to by Grant PUD as a result of implementation of the PLMP.
- "Cost-effective to implement at the Priest Rapids Project" is "Yes" for an activity where resource benefits are commensurate with the level of effort and cost to implement, and in a manner not inconsistent with anadromous fish passage criteria and habitat requirements. If a measure is "appropriate to implement", then it is also considered cost effective and the specific action being taken by Grant PUD is described. If a measure is not "appropriate to implement," then cost effectiveness is considered not applicable.

The activities identified in the table include both those that have been implemented (as identified and described in Table 4 of Section 2.2: Updated Information above), or planned or proposed pursuant to an existing and approved implementation, restoration, or management plan of another utility, the ACOE, or tribal entities. As such, for each activity, details include the project(s) where the activity has been implemented, planned or proposed, river of each project, and in the case of implemented items, a cross reference to Table 4. For planned or proposed efforts (which are not identified as current activities in Table 4) the source of the information is noted at the end of Table 6.

Table 6 Pacific lamprey activities in the Columbia River basin and applicability to the Priest Rapid Project.

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P or Proposed = PR[1]	River(s)	Table 4 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost-Effective for Priest Rapids Project
	General Biology, Ecology, and Population Status						
1.	Identify spawning areas or determine the extent of adult spawning	BOR projects in Yakima (I)	Yakima	#3	Yes.	No. This activity is not required by Grant PUD's PLMP. Radio-telemetry studies conducted in 2001-2002 did not show use of any tributaries in the PRPA (Nass et al. 2003).	N/A
2.	Develop measures to protect spawning habitat	Wells (P)	Columbia	N/A[2]	No.	No. This activity is not required by Grant PUD's PLMP.	N/A
		Rocky Reach (P)	Columbia	N/A[3]			
3.	Monitor adult population status and trends (unrelated to counting at hydroelectric projects)	BOR projects in Yakima (I)	Yakima	#3	No.	No. This activity is not required by Grant PUD's PLMP.	N/A
		Willamette Falls (I)	Willamette	#4			
		No associated hydro project (I)	Fifteenmile Creek,	#1			
			Deschutes, and tributaries	#2			
			Hood	#8			
			Umatilla	#9			
			Lower Columbia Estuary	#25			

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P or Proposed = PR[1]	River(s)	Table 4 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost-Effective for Priest Rapids Project
4.	Determine the extent of juvenile rearing habitat	Priest Rapids and Wanapum (I)	Columbia	#18	Yes.	Yes. PLMP Objective 4 requires quantification of lamprey habitat in the Project area.	Yes. Stratified sampling habitat surveys were implemented in 2012 to detect presence/absence of juvenile lamprey within the Project operational zone. Required to be conducted within the PRPA within 10 years of license issuance. This activity is ongoing and will likely be completed by 2016.
		The Dalles (I)	Columbia	#5			
		No associated hydro project (I)	Fifteenmile Creek	#1			
			Deschutes and tributaries	#2			
		Wells (P)	Columbia	N/A[2]			
5.	Develop measures to protect juvenile rearing habitat	No associated hydro project (I)	Fifteenmile Creek	#1	No.	No. This activity is not required by Grant PUD's PLMP.	N/A
			Columbia	#29			
		Wells (P)	Columbia	N/A[2]			
		Rocky Reach (P)	Columbia	N/A[3]			

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P or Proposed = PR[1]	River(s)	Table 4 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost-Effective for Priest Rapids Project
6.	Monitor juvenile population status and trends (unrelated to counting at hydroelectric projects)	Priest Rapids and Wanapum (I)	Columbia	#18	No.	Yes. PLMP Objective 4 requires the assessment of juvenile presence / absence and relative abundance.	Yes. Stratified sampling habitat surveys were implemented in 2012 to detect presence/absence and Project operational zone. Required to be conducted within the PRPA within 10 years of license issuance.
		No associated hydro project (I)	Willamette	#6, 17			
			Deschutes and other tributaries	#2			
			Hood	#8			
			Umatilla	#11			
			Yakima, Entiat, Methow, and Klickitat	#12			
			Lower Columbia & tributaries (including Klickitat, White Salmon, Rock, Wind)	#13			
			Yakima	#14			
			Methow	#15			
			Methow (Chewuch)	#16			
			Willamette	#17			
		Wells (P)	Columbia	N/A[2]			

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P or Proposed = PR[1]	River(s)	Table 4 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost-Effective for Priest Rapids Project
7.	Evaluate lamprey physiology, energy use, swimming performance	No associated hydro project	N/A	N/A	No.	No. This activity is not required by the PLMP. Evaluating lamprey physiology, energy use, and swimming performance are not objectives, goals, or measures outlined in the PLMP.	N/A
8.	Evaluate, implement and/or monitor translocation, supplementation, and artificial propagation programs	No associated hydro project (I)	Umatilla	#23	Yes.	No. This activity is not required by Grant PUD's PLMP. However, trap and transport is being evaluated by the PRFF as a potential implementation measure in fulfillment of an ongoing conceptual NNI agreement. Grant PUD successfully trap and transported 2,269 adult Pacific lamprey above Rock Island Dam during 2014 as a result of fish passage activities in support of the Wanapum Dam fracture.	N/A
			Tryon Creek	#7			
			Yakima	#24			
			N/A	#19, 20			
		Pelton Round Butte (I)	Deschutes	#10			
9.	Develop and test new technologies / methodologies / protocols	The Dalles(I)	Columbia	#5	No.	No. This activity is not required by the PLMP. Developing technologies for	N/A
		No associated hydro project (I)	Willamette River	#6, 22			

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P or Proposed = PR[1]	River(s)	Table 4 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost-Effective for Priest Rapids Project
	for lamprey		N/A	#19, 20		sampling juvenile lamprey in deep water are not objectives, goals, or measures outlined in the PLMP. However, Grant PUD will determine juvenile lamprey presence / absence, habitat use, and relative abundance in the Project area, in coordination with the PRFF no later than 10 years following license issuance.	

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P or Proposed = PR[1]	River(s)	Table 4 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost-Effective for Priest Rapids Project
10.	Determine genetic structure and maintain genetic integrity	No associated hydro project (I)	N/A Santiam	N/A[1] #33	No.	No. This activity is not required by the PLMP. Determining genetic structure and maintaining genetic integrity are not objectives, goals, or measures outlined in the PLMP.	N/A
11.	Determine water quality impacts of hydropower projects on lamprey and implement actions to mitigate these impacts	PR (as identified in the Tribal Pacific Lamprey Restoration Plan for the Columbia River)	N/A	N/A[1]	No.	No. This activity is not required by the PLMP. Grant PUD monitors and maintains water quality in compliance with freshwater designated uses and criteria for the Project as required by the Ecology 401 Certification; therefore, no further actions are required.	N/A
12.	Evaluate the need for a lamprey aquaculture facility based upon a limiting factor analysis	No associated hydro project	N/A	N/A	No.	No. This activity is not required by the PLMP. However, lamprey aquaculture is being evaluated by the PRFF as a potential implementation measure in fulfillment of an ongoing conceptual NNI agreement.	N/A
13.	Restore tributary habitat and passage	PR (as identified in the Tribal Pacific Lamprey Restoration Plan for the Columbia River)	N/A	N/A[1]	No.	No. This activity is not required by the PLMP. Radio-telemetry studies conducted in 2001-2002 did not show use of any tributaries in the PRPA (Nass et al. 2003).	N/A

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P or Proposed = PR[1]	River(s)	Table 4 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost-Effective for Priest Rapids Project
	Lamprey Migration in Rivers						
14.	Evaluate adult migration in rivers and reservoirs	Bonneville (I)	Columbia	#26, 27, 32	Yes.	Yes. The PLMP does not include a specific PM&E related to this activity; however, Grant PUD has committed to collect and evaluate data on the passage of adult lamprey through the Project reservoirs as part of a telemetry evaluation (Objective 2). Grant PUD conducted this activity as part of its 2001-2002 radio-telemetry studies on adult lamprey (Nass et al. 2003).	Yes. Monitoring of lamprey through the Project reservoirs was conducted using HDX-PIT tags in 2010 through 2014 for fish detected at both Priest Rapids and Wanapum dams. Where detection systems are present at upstream projects, the additional data will be evaluated during future adult Pacific lamprey fishway evaluations.
		The Dalles (I)	Columbia	#26			
		John Day (I)	Columbia	#26, 32			
		McNary (I)	Columbia	#26			
		Ice Harbor (I)	Snake	#26, 31			
		Lower Monumental (I)	Snake	#26, 31, 32			
		Little Goose (I)	Snake	#26, 31, 32			
		Lower Granite (I)	Snake	#26, 31, 32			
		Priest Rapids and Wanapum (I)	Columbia	#26			
		Rock Island (I)	Columbia	#26, 32			
		Rocky Reach (I)	Columbia	#26			
		McNary (I)	Columbia	#32			
15.	Assess impacts of irrigation water withdrawal structures on juvenile passage/habitat	No associated hydro project (I)	N/A	#28	No.	No. This activity is not required by the PLMP. Assessing the impacts of irrigation water withdrawal are not objectives, goals, or measures outlined in the PLMP.	N/A
16.	Assessing juvenile lamprey outmigration	No associated hydro project (I)	Umatilla	#30	No.	No. This activity is not required by the PLMP. Assessing the impacts of irrigation water withdrawal are not objectives, goals, or measures outlined in the PLMP.	N/A

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P or Proposed = PR[1]	River(s)	Table 4 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost-Effective for Priest Rapids Project
	<u>Adult Passage at Hydroelectric Facilities</u>						
	Structural and Operational Fishway Modifications						
17.	Inspect / inventory / document / assess structural improvements for fishway	Bonneville (I)	Columbia	#34	Yes.	Yes. PLMP Objectives 1 and 2 specifically identify methods and reporting requirements for assessing and improving passage conditions for adult lamprey. These activities are a continuation of efforts started in 2001.	Yes. Grant PUD implemented an evaluation program in coordination with the PRFF to determine and assess the effectiveness of fish ladder modifications. HDX-PIT system were used to collect data from fish tagged downstream of Priest Rapids Dam. Pacific lamprey tagged at lower river facilities were passively monitored at Project facilities as directed by the PRFF. The assessment of plating and count station use in 2010 documented the effective use of these structures by migrating lamprey. Fish passage efficiency (FPE) and passage times are being calculated, although the sample size is insufficient for statistical comparisons.
		McNary (I)	Columbia	#34			
		Lower Monumental(I)	Snake	#34			
		Lower Granite (I)	Snake	#34			
		Priest Rapids and Wanapum	Columbia	#35			
		Wells (P)	Columbia	N/A[2]			

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P or Proposed = PR[1]	River(s)	Table 4 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost-Effective for Priest Rapids Project
18.	Conduct a literature review of upstream passage improvements	Rocky Reach (I)	Columbia	#46	Yes.	Yes. PLMP Objective 1 requires compilation of measures taken in the Columbia River basin and an assessment of their applicability to the Project.	Yes. This activity is documented in this PLMP Comprehensive Annual Report (see Section 2.2: Updated Information).
		Wells (I)	Columbia	#99			
19.	Design / install / evaluate lamprey passage system (LPS) and entrance structures	Bonneville (I)	Columbia	#36, 60	Yes.	No. The LPS has been evaluated with respect to application in the Project (2001-2002 radio-telemetry study; Nass et al. 2003) and determined that because there are no areas where lamprey concentrate at either facility, this method would not be appropriate to implement.	N/A
		McNary (I)	Columbia	#38			
		Westland diversions (I)	Umatilla	#37			
20.	Install / evaluate / operate slotted "keyhole" fishway entrances	Priest Rapids and Wanapum (I)	Columbia	#39	Yes.	Yes. Keyhole entrances are currently utilized at both Wanapum and Priest Rapids dams.	Yes. See adjacent response.
		John Day (P)	Columbia	N/A[5]			
		McNary (P)	Columbia	N/A[6]			
21.	Develop / implement / evaluate ladder dewatering procedures	All ACOE projects[7] (I)	Columbia / Snake	#40	Yes.	Yes. Dewatering procedures were identified as existing at the Project in the PLMP.	Yes. Grant PUD operates its fishways according to the NOAA Fisheries Fishway Operations and Criteria Guidelines for salmon (NOAA Fisheries 2008). The plan includes operational criteria for dewatering and the recovery of all fish.
		Wells (I)	Columbia	#41			
		Rocky Reach (I)	Columbia	#42			
		Rock Island (I)	Columbia	#42			
		Priest Rapids and Wanapum (I)	Columbia	#43			

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P or Proposed = PR[1]	River(s)	Table 4 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost-Effective for Priest Rapids Project
22.	Rehabilitate and/or operate old or existing fishway for lamprey passage	Willamette Falls (I)	Willamette	#44	No.	Yes. Subsequent to fishway modifications completed in 2009-2010 outage at Priest Rapids and Wanapum dams, Grant PUD and the PRFF will continue to assess the applicability, feasibility, and appropriateness of other potential modifications.	Yes, as determined by Grant PUD and the PRFF.
23.	Address issues with diffuser gratings and picket leads, e.g., replace gratings with material of ¾-inch spacing (and replace other related structures: e.g., track rack cleaning system and grating support system)	John Day (I)	Columbia	#58	No.	No. These issues have not been identified in the Project fishways. Members of the PRFF toured the fish ladders at Priest Rapids and Wanapum dams and did not identify that these issues existed at either dam. However, Grant PUD replaced the fish count stations at both dams in 2010 with picket-lead gratings that is 11/16-inch gap to ensure accurate adult counts.	N/A
		Other ACOE projects (exact ones unspecified) (P)	Columbia / Snake	N/A[5]			
		Wells (P)	Columbia	N/A[2]			

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P or Proposed = PR[1]	River(s)	Table 4 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost-Effective for Priest Rapids Project
24.	Install/evaluate plates over diffuser along the bases of walls and weir	Little Goose (I)	Snake	#45	Yes.	Yes. PLMP Objective 2 requires installation of plating along the edges and through the orifices in the pools with diffusion chambers at Priest Rapids Dam.	Yes. Grant PUD installed aluminum plating on diffuser grates at Priest Rapids during the 2009-2010 winter fish ladder maintenance outage. The effectiveness of the plating was evaluated through the use of underwater video as part of the 2010 assessment of Pacific lamprey behavior and passage efficiency at Priest Rapids and Wanapum dams (Nass et al. 2009). This study showed that lamprey effectively used the plating to move through a weir orifice or past the counting station.
		Lower Granite (I)	Snake	#45			
		Rocky Reach (I)	Columbia	#46			
		Bonneville (I)	Columbia	#61			
25.	Install lamprey orifices	Little Goose (I)	Snake	#45	Yes.	No. The PLMP does not include a specific PM&E measure related to this activity, nor has it been identified by Grant PUD and the PRFF as an appropriate measure to implement at Priest Rapids and Wanapum dams.	N/A
		Lower Granite (I)	Snake	#45			
26.	Install/evaluate ramps at sills and lips	The Dalles (I)	Columbia	#57	Yes.	Yes. The PLMP does not include a specific PM&E related to this activity; however, Grant PUD has committed to this activity as part of its ladder modification plan.	Yes. Grant PUD installed aluminum ramps during the 2009-2010 winter fish ladder outage at every perched orifice in the Priest Rapids Dam fishways.
		John Day (I)	Columbia	#57			
		Little Goose (I)	Snake	#45			
		Lower Granite (I)	Snake	#45			
		Rocky Reach (I)	Columbia	#46			

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P or Proposed = PR[1]	River(s)	Table 4 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost-Effective for Priest Rapids Project
27.	Round sharp corners	Rocky Reach (I)	Columbia	#46	Yes.	No. Sharp corners have not been identified in the Project fishways. Members of the PRFF toured the fish ladders at Priest Rapids and Wanapum dams and did not identify that sharp corners were an issue at either dam.	N/A
		Trail Bridge Dam (I)	McKenzie	#47			
		Ice Harbor (P)	Snake	N/A[6]			
28.	Installed permanent monitoring technology (e.g., HDX-PIT arrays)	Rocky Reach (I)	Columbia	#46	Yes.	Yes. Grant PUD committed to the installation of a monitoring technology in their PLMP.	Yes. Grant PUD installed HDX-PIT systems during the 2009-2010 fishway outage. The arrays were operated during the 2010 through 2014 migration seasons.
29.	Design / install water supply or auxillary water supply systems	Trail Bridge Dam (I)	McKenzie	#48	No.	No. This activity is not required by the PLMP.	N/A

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P or Proposed = PR[1]	River(s)	Table 4 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost-Effective for Priest Rapids Project
30.	Reduce/evaluate ladder entrance flow velocities at night	Bonneville (I)	Columbia	#48	Yes.	Yes. PLMP Objective 2 requires that Grant PUD and the PRFF evaluate the efficacy of reducing fishway flows at night.	Yes. Grant PUD developed a PRFF-approved comprehensive study plan to evaluate improvements and modifications to the fish ladders at Priest Rapids and Wanapum dams in 2010. Grant PUD began to investigate the efficacy and advisability of reducing fishway flows at night and had incorporated this objective into the 2010 study plan. However, after consideration by the PRFF and NOAA Fisheries, this objective of the study plan was considered to be unnecessary (see PRFF meeting minutes for May 5, 2010).
		McNary (I)	Columbia	#49			
		Wells (I)	Columbia	#50			
		Priest Rapids (P)	Columbia	N/A[8]			
		Ice Harbor (P)	Snake	N/A[5]			
31.	Modify/evaluate weir head differentials	PR (as identified in the Tribal Pacific Lamprey Restoration Plan for the Columbia River)	N/A	N/A[1]	No.	No. Fishway operational procedures were identified as existing at the Project in the PLMP.	N/A. Grant PUD operates its fishways according to the NOAA Fisheries Fishway Operations and Criteria Guidelines for salmon (NOAA Fisheries 2008). The plan includes operational criteria for weir head differentials.

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P or Proposed = PR[1]	River(s)	Table 4 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost-Effective for Priest Rapids Project
32.	Manage flows to a peaking hydrograph	PR (as identified in the Tribal Pacific Lamprey Restoration Plan for the Columbia River)	N/A	N/A[1]	No.	No. Grant PUD operates its facilities as part of a seven dam coordination schedule of flows. The proposed activity is not consistent with operations for power generation, flood control and recreational activities.	N/A
33.	Establish protocol for formal inspection of passage facilities	Priest Rapids and Wanapum (I)	Columbia	#99	No.	Yes. PLMP Objective 2 requires inspection of passage facilities by PRFF members.	Yes. Inspection by the PRFF is coordinated with annual winter fish ladder maintenance outages.
34.	Establish protocol for annual lamprey passage reporting	Priest Rapids and Wanapum (I)	Columbia	#99	No.	Yes. PLMP Objective 1 requires an annual report summarizing all PLMP activities.	Yes. Lamprey activities at the Project are documented in this PLMP Comprehensive Annual Report.
35.	Develop and/or maintain fishway operations criteria	Bonneville (I)	Columbia	#51	Yes.	Yes. PLMP Objective 2 requires Grant PUD to maintain its fishways in a manner that is consistent with the NOAA Fisheries Fishway Operations and Criteria Guidelines for salmon (NOAA Fisheries 2008). In 2011, Grant PUD implemented a Standard Operating Procedure (SOP) for operation of the OLAFT vertical orifice gate to remain open when the OLAFT is not operating.	Yes. Specific operations criteria are presented in Grant PUD's Project Adult Fishways Operational Plan (Grant PUD 2008).
		The Dalles (I)	Columbia	#52			
		John Day (I)	Columbia	#53			
		McNary (I)	Columbia	#54			
		Ice Harbor (I)	Snake	#54			
		Lower Monumental (I)	Snake	#54			
		Little Goose (I)	Snake	#54			
		Lower Granite (I)	Snake	#54			
		Wells (I)	Columbia	#99			
		Rocky Reach (I)	Columbia	#99			
		Rock Island (I)	Columbia	#55			
		Priest Rapids and Wanapum (I)	Columbia	#56			

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P or Proposed = PR[1]	River(s)	Table 4 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost-Effective for Priest Rapids Project
	Project Passage Effectiveness						
36.	Develop adult lamprey passage criteria	Rocky Reach (P)	Columbia	N/A[3]	No.	Yes. PLMP Objective 2 requires the development of adult lamprey passage criteria that are not inconsistent with the Fishery Operations Plan (Grant PUD 2010).	Yes. Grant PUD and the PRFF will consider success achieved at other Columbia River basin projects and site specific conditions related to Priest Rapids and Wanapum dams.
		Priest Rapids and Wanapum (P)	Columbia	N/A[4]			

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P or Proposed = PR[1]	River(s)	Table 4 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost-Effective for Priest Rapids Project
37.	Evaluate effectiveness of dam passage	Bonneville (I)	Columbia	#27, 68, 69	Yes.	Yes. PLMP Objective 2 requires a comprehensive passage evaluation.	Yes. Grant PUD implemented an evaluation program in coordination with the PRFF to determine and assess the effectiveness of fish ladder modifications. HDX-PIT systems were used to collect data from fish tagged downstream of Priest Rapids Dam. Pacific lamprey tagged at lower river facilities were passively monitored at PRP facilities as directed by the PRFF. The assessment of plating and count station use in 2010 documented the effective use of these
		John Day (I)	Columbia	#69			
		McNary (I)	Columbia	#28, 64			
		Ice Harbor (I)	Snake	#76			
		Lower Monumental (I)	Snake	#76			
		Little Goose (I)	Snake	#76			
		Lower Granite (I)	Snake	#76			
		Priest Rapids (I)	Columbia	#65			
		Wanapum (I)	Columbia	#65			
		Wells (I)	Columbia	#70			
		Threemile Falls Dam, Maxwell and Feed diversions (I)	Umatilla	#66			
		Clackamas	Clackamas	#67			

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P or Proposed = PR[1]	River(s)	Table 4 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost-Effective for Priest Rapids Project
		Rocky Reach (P)	Columbia	N/A[3]			structures by migrating lamprey. Fish passage efficiency (FPE) and passage times are being calculated, although the sample size is insufficient for statistical comparisons. Through 2014, Grant PUD has tracked a total of 380 unique PIT tags at Priest Rapids and 258 at Wanapum since 2010. Estimated FPE for 2010-2014 for Priest Rapids Dam is 74% and estimated FPE for Wanapum Dam is 63%. Median passage times at Priest Rapids Dam are 58 h at the left bank and 5 h at the right bank. Median passage times at Wanapum Dam are 24 h at the left bank and 9 h at the right bank.

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P or Proposed = PR[1]	River(s)	Table 4 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost-Effective for Priest Rapids Project
38.	Evaluate upstream passage modifications	Priest Rapids and Wanapum(I) [Note: evaluations performed on existing structural / operational improvements at ACOE dams are identified earlier in this table, under the heading, Structual and Operational Fishway Modifications.]	Columbia	#65	No.	Yes. PLMP Objective 2 requires a comprehensive passage evaluation of modifications to fishways as required per the FERC License Order and PLMP.	Yes. Grant PUD conducted an adult passage evaluation to determine the effectiveness of fish ladder modifications made during the 2009-2010 winter fish ladder maintenance outage (Nass et al. 2009). Specific modifications included diffusion grate plating and new fish crowder structures. HDX-PIT systems were used to collect data from fish tagged downstream of Priest Rapids Dam. Pacific

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P or Proposed = PR[1]	River(s)	Table 4 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost-Effective for Priest Rapids Project
		Rocky Reach (P)	Columbia	N/A[3]			lamprey tagged at lower river facilities were passively monitored at PRP facilities as directed by the PRFF. The assessment of plating and count station use in 2010 documented the effective use of these structures by migrating lamprey. Estimated FPE for 2010-2014 for Priest Rapids Dam is 74% and estimated FPE for Wanapum Dam is 63%. Median passage times at Priest Rapids Dam are 58 h at the left bank and 5 h at the right bank. Median passage times at Wanapum Dam are 24 h at the left bank and 9 h at the right bank.

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P or Proposed = PR[1]	River(s)	Table 4 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost-Effective for Priest Rapids Project
	Lamprey Counts at Dams						
39.	Develop feasibility, techniques, and protocols to improve 24-hour counting / conduct counts	McNary (I)	Columbia	#71	Yes.	Yes. PLMP Objective 2 requires maintenance and feasible improvements to adult fish counting systems.	Yes. Grant PUD currently provides counts of all fishes 24 hours per day, 7 days per week for the period April 15 – November 15, annually.
		Lower Granite (I)	Snake	#71			
		Bonneville (I)	Columbia	#60			
		Wells (I)	Columbia	#72			
		Rocky Reach (I)	Columbia	#73			
		Rock Island (I)	Columbia	#73			
		Priest Rapids and Wanapum (I)	Columbia	#75			
40.	Develop/evaluate passage alternatives related to count facilities	Bonneville (I)	Columbia	#75	Yes.	Yes. PLMP Objective 2 requires maintenance and feasible improvements to adult fish counting systems.	Yes. Grant PUD installed newly designed, lamprey-specific fish crowder structures for all count stations at Priest Rapids and Wanapum dams during the 2009-2010 winter fish ladder maintenance outage. Based on design criteria for the new video fish count crowders (picketed lead gap of 11/16 inches). Grant PUD expects fish count accuracy to be at or near 100% for adult lamprey and other fishes passing through all count stations.
		Wells (I)	Columbia	#70			

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P or Proposed = PR[1]	River(s)	Table 4 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost-Effective for Priest Rapids Project
	Predation						
41.	Establish predation control measures (sea lions)	Bonneville (I)	Columbia	#77	Yes.	No. Sea lions are not present in the PRPA.	N/A
	Juvenile Passage at Hydroelectric Facilities						
	Structural and Operational Fishway Modifications						
42.	Conduct a literature review of juvenile Pacific lamprey passage and survival	Priest Rapids and Wanapum (I)	Columbia	N/A	No.	Yes. PLMP Objective 1 requires compilation of measures taken in the Columbia River basin and an assessment of their applicability to the Project.	Yes. This activity is documented in this PLMP Comprehensive Annual Report.
		Wells (P)	Columbia	N/A[2]			
43.	Replace turbine intake screens with smaller spacing	All ACOE projects (P)	Columbia / Snake	N/A[6]	No.	No. Grant PUD dams are not equipped with turbine intake or diversion screens.	N/A
44.	Lift/remove extended length screens during outmigration	McNary (I)	Columbia	#78	Yes.	No. Grant PUD has existing turbines bypass systems, gatewells and spill, but does not have a system into which a separator could be installed.	N/A
45.	Manage flows to a peaking hydrograph	PR (as identified in the Tribal Pacific Lamprey Restoration Plan for the Columbia River)	N/A	N/A[1]	No.	No. Grant PUD operates its facilities as part of the seven dam coordinated system. The proposed activity is not consistent with operations for power generation, fish protection, flood control and recreational activities.	N/A

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P or Proposed = PR[1]	River(s)	Table 4 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost-Effective for Priest Rapids Project
46.	JBS modifications	McNary (I)	Columbia	#78, 79, 80	Yes.	No. Grant PUD has existing bypass systems, which includes gatewells, spillways, the WFUFB, and Priest Rapids Top-Spill Bypass. The WFUFB and experimental Priest Rapids Top-Spill Bypass are operated to achieve safe passage of out-migrating salmonids. It would be expected that juvenile lamprey would also benefit as a result of these operations.	N/A
		Lower Monumental (I)	Snake	#80			
47.	Establish/continue salvage activities during ladder maintenance de-watering	All ACOE projects (I)	Columbia / Snake	#81	Yes.	Yes. Dewatering procedures were identified as existing at the Project in the PLMP.	Yes. Grant PUD operates its fishways according to the NOAA Fisheries Fishway Operations and Criteria Guidelines for salmon (NOAA Fisheries 2008). The plan includes operational criteria for dewatering and the recovery of all fish during all maintenance activities.
		Wells (I)	Columbia	#82			
		Rocky Reach (I)	Columbia	#83			
		Rock Island (I)	Columbia	#83, 85			
		Priest Rapids and Wanapum (I)	Columbia	#84			
48.	Develop and/or maintain bypass operations criteria	Wells (I)	Columbia	#82	Yes.	Yes. Grant PUD has existing bypass systems, which includes gatewells, spillways, the WFUFB, and Priest Rapids Top-Spill Bypass.	Yes. The WFUFB and experimental Priest Rapids Top-Spill Bypass are operated to achieve safe passage of out-migrating salmonids. It would be expected that juvenile lamprey would also benefit as a result of these operations.
		Rocky Reach (I)	Columbia	#83			
		Rock Island (I)	Columbia	#83, 85			
		Priest Rapids and Wanapum (I)	Columbia	#84, 86			

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P or Proposed = PR[1]	River(s)	Table 4 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost-Effective for Priest Rapids Project
	Project Passage Effectiveness						
49.	Evaluate tagging and development of miniature tags	No associated hydro project (I)	N/A	N/A	No.	No. This activity is not required by the PLMP. Evaluation and development of tags are not objectives, goals, or measures outlined in the PLMP.	N/A
50.	Develop juvenile lamprey passage criteria	Priest Rapids and Wanapum (P)	Columbia	N/A[4]	No.	Yes. PLMP Objective 3 requires the development of juvenile lamprey passage criteria.	Yes. Grant PUD and the PRFF will include consideration of success achieved at other Columbia River basin projects and site specific conditions when the technology exists to measure juvenile lamprey passage.
51.	Evaluate downstream passage and survival when technology available	Wells (P)	Columbia	N/A[2]	No.	Yes. The PLMP does not include a specific PM&E related to this activity; however, Grant PUD has committed to providing safe, effective and timely passage which could be evaluated when adequate technology exists.	Yes.
		Rocky Reach (P)	Columbia	N/A[3]			
		Priest Rapids and Wanapum (P)	Columbia	N/A[4]			
		No associated hydro project (I)	N/A	#93			
52.	Laboratory passage evaluation	No associated hydro project (I)	N/A	N/A	No.	No. This activity is not required by the PLMP. Lab passage evaluations are not objectives, goals, or measures outlined in the PLMP.	N/A

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P or Proposed = PR[1]	River(s)	Table 4 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost-Effective for Priest Rapids Project
53.	Monitor passage timing, number, and mortalities of juvenile lamprey collected at projects with juvenile fish bypass facilities	Bonneville (I)	Columbia	#87, 88	Yes.	No. Grant PUD does not have juvenile collection facilities at either Priest Rapids or Wanapum dams that could be used for this purpose.	N/A
		John Day (I)	Columbia	#88			
		McNary (I)	Columbia	#87, 88			
		Rock Island (I)	Columbia	#88			
		Lower Monumental (I)	Snake	#87, 88			
		Little Goose (I)	Snake	#87, 88			
		Lower Granite (I)	Snake	#87, 88, 89			
54.	Monitor and report on juvenile impingement	Rocky Reach (I)	Columbia	#99	Yes.	No. Priest Rapids and Wanapum dams are not equipped with turbine intake or diversion screens.	N/A
	Predation						
55.	Continue predation control measures (Northern pikeminnow and birds)	Pikeminnow only All ACOE projects (I)	Columbia / Snake	#91	Yes.	Yes. The PLMP does not include a specific PM&E related to this activity. However, Grant PUD maintains predator control programs for piscivorous birds and Northern pikeminnow in the PRPA.	Yes. Grant PUD maintains both avian and Northern pikeminnow control programs to minimize the effects of predation to salmonids which would also be expected to provide a benefit to lamprey.
		Pikeminnow and birds Rocky Reach (I)	Columbia	#92			
		Pikeminnow and birds Rock Island (I)	Columbia	#92			
		Pikeminnow and birds Priest Rapids and Wanapum (I)	Columbia	#93			

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P or Proposed = PR[1]	River(s)	Table 4 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost-Effective for Priest Rapids Project
	Policy and Recovery Activities						
56.	Develop/implement Pacific Lamprey Management Plans	All ACOE projects (I)	Columbia / Snake	#94, , 95, 99, 100	Yes.	Yes. Grant PUD is required by FERC to develop and implement a PLMP.	Yes. Grant PUD has a FERC-approved PLMP (Grant PUD 2009). Implementation of that plan is in progress.
		Wells (I)	Columbia	#96			
		Rocky Reach (I)	Columbia	#97			
		Priest Rapids and Wanapum (I)	Columbia	#98			
57.	Establish regional data protocols for collection, storage and analysis; develop means to widely access and share information	All ACOE projects (I)	Columbia / Snake	#94, 95, 96, 99, 100	Yes.	Yes. PLMP Objectives 2 and 3 require "Regional Studies" which includes participation and cooperation in studies where useful information may be obtained about project impacts to lamprey.	Yes. Grant PUD participates in regional forums such as the CRBLTWG the USFWS Lamprey Conservation Initiative and the CRITFC Pacific Lamprey Recovery Plan planning processes.
		Wells (I)	Columbia	#96			
		Rocky Reach (I)	Columbia	#97			
		Priest Rapids and Wanapum (I)	Columbia	#98			
58.	Establish coordinated public education and other outreach programs	Priest Rapids and Wanapum (I)	Columbia	#98	No.	Yes. The PLMP does not include a specific PM&E related to this activity; however, Grant PUD participates in education programs regarding lamprey.	Yes. Grant PUD participates in the annual Wanapum Indian Archeological Days program and provides technical support and displays regarding the importance of lampreys.
59.	Participate in regional lamprey activities	All ACOE projects (I)	Columbia / Snake	#94, 95, 99, 100	Yes.	Yes. PLMP Objectives 2 and 3 require "Regional Studies" which includes participation and cooperation in studies where useful information may be obtained about Project impacts to lamprey.	Yes. Grant PUD participates in regional forums such as the CRBLTWG the USFWS Lamprey Conservation Initiative and the CRITFC Pacific Lamprey Recovery Plan planning processes.
		Wells (I)	Columbia	#96			
		Rocky Reach (I)	Columbia	#97			
		Priest Rapids and Wanapum (I)	Columbia	#98			

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P or Proposed = PR[1]	River(s)	Table 4 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost-Effective for Priest Rapids Project
60.	Environmental analysis and feasibility investigations	All ACOE projects (I)	Columbia / Snake	#99, 100	No.	No. This activity is not required by the PLMP. Environmental analysis and feasibility investigations related to public transportation and lamprey propagation are not objectives, goals, or measures outlined in the PLMP.	N/A

ACOE = Army Corps of Engineers
BOR = Bureau of Reclamation
CRBLTWG = Columbia River Basin Lamprey Technical Work Group
CRITFC = Columbia River Inter-Tribal Fish Commission
FERC = Federal Energy Regulatory Commission
FPE = Fish Passage Efficiency
HDX-PIT = Half-duplex Passive Integrated Transponder
LPS = lamprey passage system
N/A = Not applicable
NOAA = National Oceanic and Atmospheric Administration
PLMP = Pacific Lamprey Management Plan
PM&E = protection, mitigation and enhancement
PRFF = Priest Rapids Fish Forum
PRPA = Priest Rapids Project area
PUD = Public Utility District
SOP = Standard Operating Procedure
USFWS = U.S. Fish and Wildlife Service
WFUFB = Wanapum Future Unit Fish Bypass

5.0 Summary

One of the goals of Grant PUD's PLMP is to improve Pacific lamprey passage efficiency through the implementation of structural and, potentially, operational modifications to the Project fishways. In the sixth year of PLMP implementation, several planned activities were conducted on schedule. Grant PUD continued to conduct components of a PRFF-approved study plan titled, "Assessment of Pacific Lamprey Behavior and Passage Efficiency at Priest Rapids and Wanapum Dams" (Nass et al. 2009). The study was conducted to evaluate the effectiveness of structural modifications to Priest Rapids Project fishways that are intended to facilitate lamprey passage.

The study plan objectives were to:

1). Determine the fishway passage efficiency for adult lamprey at Priest Rapids and Wanapum dams; and
2). Evaluate the passage of adult lamprey through sections of the Priest Rapids fishways where new structures have been installed to facilitate upstream movement.

In 2014, Grant PUD, in consultation with the PRFF, continued to passively monitor Pacific lamprey tagged at downstream facilities and added valuable information to the cumulative Project data set. The intent of the PIT data collection program is to provide sufficient sample size over time to calculate relevant passage metrics. Analysis of the data available from 2010 – 2014 was completed as part of 2014 reporting activities. During this time period, data available indicates that fishway passage efficiency for lamprey was 74% and 63% at Priest Rapids and Wanapum dams, respectively. However, fishway passage efficiency at Wanapum Dam in 2014 was likely affected by emergency operations resulting from the spillway fracture. As such, separating results in 2014 from the previous years (2010-2013) may help interpret impacts on lamprey passage metrics such as median fishway passage time, fishway passage efficiency, fallback, reservoir passage time, and overwintering behavior (see section 2.1.4, Table 3). For example, fishway passage efficiency was 70% and 73% at Priest Rapids and Wanapum dams, repectively over the 2010-2013 period. Interpretation of fishway passage efficiency should include consideration of fish that overwintered during migration (fish tagged in the previous study year). Such fish made up 4.5% of detected tags during the 2010-2013 period. These detections indicate the complexity of adult lamprey migration behavior.

Upon receiving HDX-PIT data from Rock Island Dam (not available at the time of reporting), preliminary passage efficiency results will be updated as appropriate in the 2015 Annual Report.

Lamprey passage data from 2010 through 2013 showed a continuing trend of increased median travel time for adult lamprey ascending the upper fishway on Priest Rapids left bank compared to the other fishways at Priest Rapids and Wanapum dams (median passage time of 43.2 hours for the Priest Rapids left bank upper fishway versus 3.5 hours for the other upper fishways at Priest Rapids and Wanapum dams). The only feature in the Priest Rapids left bank upper fishway that is unique compared with the other fishways is the OLAFT.

In order to investigate the possibility that the OLAFT in the Priest Rapids left bank fishway is associated with this observed delay, two new HDX-PIT stations will be installed in the vicinity of the OLAFT during the 2014-2015 fishway maintenance period. Installation of one new station downstream of the OLAFT and one upstream will provide insight into lamprey behavior in the

Priest Rapids left bank upper fishway and increase the detection resolution within the upper fishway.

In 2014, Grant PUD also continued its regional approach to monitoring lamprey by coordinating among utilities, participating in forums, and the sharing of PIT data with other researchers.

In 2015, Grant PUD plans to complete PLMP-required activities and study planning/implementation efforts including:

PRFF on-site inspection of Priest Rapids and Wanapum fish facilities during the 2014-2015 winter fish ladder maintenance outage.

3). Pre-season testing and calibration of HDX-PIT arrays, and maintenance of arrays during the migration season.
4). Tracking lamprey enumeration statistics for the Priest Rapids Project and lower Columbia River dams.
5). Continuing to survey the distribution and relative abundance of juvenile lamprey in the operations zone of the PRPA as based on the results of activities conducted in 2012. Results from the 2015 surveys completed by October 31, 2015 will be presented in the next annual report.
6). Continuing to operate HDX-PIT arrays to assess passage metrics (passage efficiency, etc.) and coordinate detection of tagged fish with regional monitoring efforts to evaluate Pacific lamprey passage; both downstream and upstream of the Priest Rapids Project.

Grant PUD will continue to conduct surveys to determine the distribution and relative abundance of juvenile lamprey in the operational zone of the Project area, as appropriate, and modify sampling based on the cumulative results of surveys conducted in 2014 during the drawdown of Wanapum Reservoir. More specifically, desk-top assessments and field surveys determining juvenile lamprey presence and habitat use will be conducted for biologically appropriate locations within elevations consistent with the low and high water levels as a result of Project operations. The main purpose of these juvenile surveys is to collect baseline data for identifying potential Project effects on rearing juvenile lamprey.

Pursuant to the requirements identified in the PLMP, Grant PUD will continue to monitor lamprey-related efforts occurring throughout the Columbia River Basin, will actively participate in regional research and forums, and will assess opportunities for lamprey restoration at the Project.

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Appendix A:
Summary of PRFF Comments and Grant PUD Response

Summary Table of Agency/Tribal Comment and Grant PUD Responses for 2014 PLMP Annual Comprehensive Report

Submitting Entity	Date Received	Section/Page	Agency Comment	Grant PUD Response
WADOE	2/27/15	1	Ecology has reviewed the *2014 Pacific Lamprey Management Plan Comprehensive Annual Report* that was e-mailed to Ecology on January 29, 2015. Ecology has no comments on the *2014 Pacific Lamprey Management Plan Comprehensive Annual Report* as submitted. The report is a requirement of Section 6.2(5)(c) for the Pacific Lamprey Management Plan and Section 6.2(5)(c) of the 401 certification.	Comment noted.
CRITFC	3/2/15	1.2/pg. 3 Appendix C	Consider adding information about the Yakama Nation efforts to recover lamprey or determine presence/absence. Are these juvenile or larval lamprey? Was there an attempt to differentiate between the two.	Comment noted. Appendix C has been modified; however, the June 2012 sampling only categorized lamprey as juveniles although the two captured were only measured.
CRITFC	3/2/15	2.1.3/pg. 13	With regard to the discussion regarding translocation, please update the citation with Ward et al. 2012.	The citation was added into section 2.1.3/pg. 13 and included in the references cited section.
CRITFC	3/2/15	2.1.4/pg.16	Consider making the Wanapum Fracture information a separate paragraph given its importance.	Comment noted. Details regarding the Wanapum Fracture have been modified in more detail; specifically section 1.1. Section 2.1.4 is focused on "Adult Passage at Hydroelectric Facilities."
CRITFC	3/2/15	2.1.4/pg. 16	With regard to the WFEPS assessment, it should be noted that the left bank exit PIT reader was located downstream of the WFEPS so we cannot determine true fish passage efficiency for Wanapum Dam at this location.	Comment noted. Section 2.1.4 has been modified to reflect this suggestion.
CRITFC	3/2/15	2.1.4/pg. 16	These efforts were encouraged by the PRFF.	Comment noted.
CRITFC	3/2/15	2.1.4/pg. 16	With regard to the Wells Dam study, the paragraph seems out of place.	Section 2.1.4 Adult Passage at Hydroelectric Facilities is intended to summarize the body of work for all Columbia River Basin hydroelectric project. This section includes studies conducted at other Columbia River dams including Bonneville, The Dalles, John Day, Rocky Reach, Ice Harbor, and McNary dams. Wells Dam is an additional project where information is reported.

Submitting Entity	Date Received	Section/Page	Agency Comment	Grant PUD Response
CRITFC	3/2/15	Appendix C	Why were two of the 30 tagged lamprey removed?	These two fish appeared lethargic comparative to the other fish and later expired.
CRITFC	3/2/15	Appendix C	Note that the exit was not necessarily PIT monitored although limited fallback of lamprey were observed.	Comment noted. Appendix C has been modified to reflect this suggestion.
CRITFC	3/2/15	Appendix C/Table 1	Implies that the fish was detected exiting the fishway which is misleading. Suggest word changing. "Last detected downstream of false weir" or “final weir”. Could add a fallback % which would help cite the assumption that fish passed the structure.	Comment noted. Appendix C has been modified to reflect this suggestion.
CRITFC	3/2/15	Appendix C	Appendix D, paragraph 2- -- Although GCPUD did act proactively on many issues related to the Wanapum dam crack, a majority of the structural modifications and subsequent monitoring for Pacific lamprey were initially recommended by the Priest Rapids Fish Forum and then implemented by GCPUD (e.g. PIT monitoring of false weird, video monitoring at false weir during nighttime passage, aggressive trap/haul program). It should read more like "in close coordination and guidance from the Priest Rapids Fish Forum, GCPUD implemented many structural changes and subsequent monitoring programs for Pacific lamprey."	Comment noted. Appendix C has been modified to include this recommendation.
CRITFC	3/2/15	Appendix D	Please explain the adjustment factor.	Comment noted. Appendix D has been modified to provide additional clarification.
CRITFC	3/2/15	Appendix D	Total of 2,269 lamprey in Table 1 is not consistent with the total in Table 2 (n=2,463).	Text added to show that these were approximations. Appendix D has been modified to provide additional clarification.
CRITFC	3/2/15	Appendix D	With the corrected PR passage numbers, conversion to RI is about 31%.	Comment noted.
CRITFC	3/2/15	General	In general -- If information related to the Wanapum crack is going to included as an appendix (D), suggest citing the appendix within the main body of the report. The Wanapum crack work is important to highlight and the appendix should be referenced more in the main body. This comment goes for information contained in Appendix C and E as well.	Section 1.2 History of Pacific Lamprey related Activities at the Project” introduces the Wanapum Fracture in detail and describes the measures implemented for Pacific lamprey. All relevant appendices are cited in this section of the report. Additional reference to appendices were also added to Section 2.1.4 Adult Passage, where appropriate.

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
4601 N Monroe Street • Spokane, Washington 99205-1295 • (509)329-3400

February 23, 2015

Mr. Mike Clement
Senior Biologist
Grant County PUD
PO Box 878
Ephrata, WA 98823

RE: Request for Ecology Review and Comment –*2014 Pacific Lamprey Management Plan Comprehensive Annual Report.* Priest Rapids Hydroelectric Project No. 2114

Dear Mr. Clement:

Ecology has reviewed the *2014 Pacific Lamprey Management Plan Comprehensive Annual Report* that was e-mailed to Ecology on January 29, 2015.

Ecology has no comments on the *2014 Pacific Lamprey Management Plan Comprehensive Annual Report* as submitted. The report is a requirement of Section 6.2(5)(c) for the *Pacific Lamprey Management Plan* and Section 6.2(5)(d) of the 401 certification.

Please contact me at (509) 329-3567 or pmcg461@ecy.wa.gov if you have any questions for Ecology.

Sincerely,

Patrick McGuire
Eastern Region FERC License Coordinator
Water Quality Program

PDM:jab

From:	Debbie Firestone
To:	Debbie Firestone
Subject:	FW: 2014 Pacific Lamprey Management Plan Comprehensive Annual Report
Date:	Tuesday, March 10, 2015 10:50:30 AM
Attachments:	GCPUD PRP 2114 LA 401(a)(12) 2014 PLMP Annual Comprehensive_ Report Master_ts comments.pdf GCPUD PRP 2114 LA 401(a)(12) 2014PLMP Annual Comprehensiv bmac CRITFC 03022015.pdf

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From: Tom Skiles [mailto:skit@critfc.org]
Sent: Monday, March 02, 2015 8:27 PM
To: Mike Clement
Cc: Mike Matylewich; Brian McIlraith; rosb@yakamafish-nsn.gov
Subject: 2014 Pacific Lamprey Management Plan Comprehensive Annual Report

Hi Mike-
Brian McIlraith and I had some comments on the 2014 Pacific Lamprey Management Plan Comprehensive Annual Report. I attached two pdf copies of the report: one with Brian's comments and one with my comments. You have my apologies for not consolidating our comments on one document. My comments are restricted Appendices D and E. Below, you'll find some additional comments from Brian.

I hope all is going well. If you'd like to discuss anything, feel free to give me a call, as per usual.

Tom

Pages 16-17 -- Paragraphs related to the Wanapum Dam crack are buried within the adult passage at hydroelectric facilities. It seems to me that these efforts should be separated and not sandwiched in between historical passage info from throughout the region. Suggest adding a subheading for 2014 passage issues within section 2.1.4 perhaps before 2.1.5 begins. Also, the Appendix D should be cited within this section.

Page 17, paragraph 2 -- It should be noted that the left bank exit PIT reader was immediately downstream of the WFEPS so GCPUD cannot determine true passage efficiency for the Wanapum Dam left bank fishway and the WFEPS. There was no PIT monitoring at the fishway exit (i.e. upstream of the false weir WFEPS). However, GCPUD did not obverse fallback of PIT lamprey through the fish ladder which suggests that PIT tagged adults did indeed exit the fishway. Regardless, descriptions of these data should include some information about PIT monitoring locations.

In general -- If information related to the Wanapum crack is going to included as an appendix (D), suggest citing the appendix within the main body of the report. The Wanapum crack work is important to highlight and the appendix should be referenced more in the main body. This comment goes for information contained in Appendix C and E as well.

Appendix C -- Suggest adding some information from parallel monitoring by the YN.

Appendix D, paragraph 2- -- Although GCPUD did act proactively on many issues related to the Wanapum dam crack, a majority of the structural modifications and subsequent monitoring for Pacific lamprey were initially recommended by the Priest Rapids Fish Forum and then implemented by GCPUD (e.g. PIT monitoring of false weird, video monitoring at false weir during nighttime passage, aggressive trap/haul program). It should read more like "in close coordination and guidance from the Priest Rapids Fish Forum, GCPUD implemented many structural changes and subsequent monitoring programs for Pacific lamprey…".

Appendix D, paragraph 5 -- It should be noted that the left bank exit PIT reader was immediately downstream of the WFEPS so GCPUD cannot determine true passage efficiency for the Wanapum Dam left bank fishway and the WFEPS. There was no PIT monitoring at the fishway exit (i.e. upstream of the false weir WFEPS). However, GCPUD did not obverse fallback of PIT lamprey through the fish ladder which suggests

that PIT tagged adults did indeed exit the fishway. Regardless, descriptions of these data should include some information about PIT monitoring locations.

Appendix E -- Further explanation of the "adjustment factor" is recommended.

Tom D. Skiles
Fish Passage Specialist
Columbia River Inter-Tribal Fish Commission
700 NE Multnomah Street, Suite 1200
Portland, OR 97232
Office: (503)731-1289
Fax: (503)235-4228
Skit@critfc.org
critfc.org

Appendix B:
March 2014 Juvenile Lamprey Surveying

WANAPUM FRACTURE JUVENILE LAMPREY SURVEYING MARCH 2014

Introduction and Methods

Within normal operating conditions the Wanapum Reservoir is maintained at a minimum pool elevation of 560-562 feet above mean sea level. Due to the fracture in the spillway monolith #4 of Wanapum Dam that was detected in February 2014, the pool elevation was drawn down well below the normal minimum operational level to 541-545 feet per Emergency Action Plan (EAP) requirements. As such, potential benthic habitat for juvenile lamprey was exposed that would otherwise be protected under normal reservoir operations.

Grant PUD's Pacific Lamprey Management Plan (PLMP) requires that Grant PUD "determine juvenile lamprey presence/absence, habitat use, and relative abundance in the Project area". Shoreline surveys using ABP-2 Backpack Electrofishers were implemented in 2012 and 2013 to fulfill this requirement. However, the drawdown of Wanapum Reservoir in 2014 exposed areas for sampling outside the normal operating range (i.e., normally protected and outside required sampling areas) and thus provided an opportunity to supplement the existing PLMP requirement by exploring areas that were otherwise not available for shoreline sampling. In 2015, reservoir elevations are expected to return to normal operating levels and shoreline surveys are planned to continue per the PLMP requirement.

During the Wanapum Reservoir drawdown, a juvenile lamprey survey was completed March 4-14, 2014 by Grant PUD and Blue Leaf Environmental staff. Sampling sites were selected based on Grant PUD's prior juvenile lamprey sampling sites and criteria. Of those sites, eight locations that were accessible by land and five tributary mouths accessible by boat were selected. Of the eight land-accessible sampling sites selected, only four were accessible for electrofishing. The other sites were excluded from sampling due to deep soft mud and steep banks. All the sites selected were between Rock Island (RM 453) and Wanapum (RM 415) dams, as far upstream as just below Rock Island Dam and downstream to McCumber Beach just south of Sand Hollow Creek (Figure 1; RM 418). Elevations at Wanapum Dam forebay were 544.0, 543.3, and 543.9 feet, respectively for the first three days of sampling (March 4-6).

Access to sampling sites was completed either by walking in from roads or using a boat to reach shoreline areas. The use of the boat was at the boat operator's discretion with respect to safe operating conditions. As such, a boat was used to access sampling sites only on March 13. If sites were deemed unsafe to sample, observations of stranded or dead fish and invertebrates were limited to areas where the crew could physically approach the area. Therefore results reported in this document are from sites accessible to the crew with safe conditions for sampling.

Sampling was conducted using an ABP-2 Backpack Electrofisher set to 125 volts at 3 pulses/second. Sampling occurred in 20 minute increments using a sweeping pattern along the shoreline in 0-1 meter depths at a slow walking pace. Sampling was completed with a team of three people; one to operate the backpack electrofisher and two additional crew members with long handled dip nets to capture any lamprey observed. Lamprey collected during sampling were measured and returned to the river. Due to the considerable drop in water elevation, all of the areas sampled were well below the habitat boundaries that were previously mapped out as Type-1, Type-2, or Type-3 habitats.

Results

A variety of fish species and crayfish were found stranded along the shorelines in the selected juvenile lamprey sampling sites. Redside shiner (*Richardsonius balteatus*), three-spine stickleback (*Gasterosteus*

aculeatus), Pacific lamprey (*Lampetra tridentata*) and various sculpin and crayfish of family Cottidae and Cambaridae respectively. Some of these stranded fish and crustaceans were found in pools along the shorelines, however the majority were found in patches of milfoil along the banks. An abundance of tracks from raccoons and large birds were observed in areas where stranded fishes and invertebrates occurred. The presence of these scavengers could have biased observations by altering the quantities and variety of aquatic life that was stranded by the drawdown.

Of the few stranding pools observed, pools on the left bank between Vantage Bridge (RM 420) and Sand Hollow (RM 419) measured approximately 50 to 100 feet in diameter on March 4, 2014. The area around Crescent Bar (RM 441) also had some large stranding pools around the primary boat launch area and extending back around to the eastern side of Crescent Bar. The likelihood of surviving fish in the Sand Hollow pools was low since they appeared to be draining quickly. The more likely stranding locations for surviving fish were around the Crescent Bar boat launch or any pools that may have been near Sunland Estates (RM 431), however, it was difficult to ascertain from the areas approachable on foot.

Live juvenile lamprey (three ammocoetes) were sampled when electrofishing near the Sunland Estates area at RM 431 (Figure 2; lengths 110 to 120mm). Dead juvenile lamprey (lengths 114 to 120mm) were observed near Walling Canyon (RM 449), Crescent Bar (RM 441), and upstream of Sunland Estates (Figure 3). Lamprey mortalities ("morts") were generally found in a band of dried aquatic plant life on the shore often with crayfish and various small fish such as sculpin and stickleback. Raccoon and heron tracks were observed in areas where lamprey morts were found. All lamprey observed were identified as Pacific Lamprey using a standard key.

Notes of the comprehensive field survey effort are provided in Appendix A.

Figure 1. McCumber Beach, just south of Sand Hollow Creek (RM 418); the most downstream juvenile lamprey sampling site.

Figure 2. A live lamprey (ammocoete) sampled at Sunland Estates (RM 431).

Figure 3. Dead Lamprey observed at Crescent Bar (RM 441) and Sunland Estates (RM 431).

Appendix A. Daily sampling notes.

Tuesday, 3/4/14

The first site visited was a Type-1 habitat on the south end of Sunland Estates (RM 431). This location had extremely low water levels and the actual sample area was dry. Sampling at this location was not possible due to sinking mud that made conditions dangerous. No evidence of juvenile lamprey were recorded but the area contained stranded bivalves, and raccoon tracks were observed as well.

The second site visited was a Type-1 habitat site, on the north end of Sunland Estates (Figure 1; RM 431). The sample area was dry, however electrofishing along the shoreline was possible. Three juvenile lamprey ammocoetes were collected (lengths 110,110, and 120 mm). One other juvenile lamprey was observed when sampling but escaped. In addition, along a stretch of shoreline with thick milfoil just above the sampling area, a stranded juvenile lamprey was observed along with other species such as stickleback, bivalves, crayfish, sculpin and shiners. Three of the approximately 10 observed juvenile lamprey morts were randomly selected and lengths measured (114, 118, 120 mm).

Figure 1. Blue Leaf staff sampling at Sunland Estates (RM 431).

The third site location was near the Vantage Bridge (RM 420) on left bank near RM 418 (Figure 2; Sand Hollow area). The field crew walked along the shoreline and approached stranded pools to see if electrofishing would be feasible. Due to steep slopes and muddy conditions, sampling was determined to be too dangerous. Type-1 and Type-2 habitats (adjacent) were inspected and the designated sample zones

were dry. Shoreline below was too dangerous with steep slopes and sinking mud to be sampled. No juvenile lamprey, live or dead, were observed in the area. In designated habitat zones we observed stranded bivalves, but little other biota. Below habitat zones and shoreline we found steep slopes with variable rock sizes and sinking mud.

Figure 2. Sand Hollow area sampling location, near river mile 418.

Wednesday, 3/5/14

Three sites located along the right bank near Rock Island were sampled. Water levels were sufficiently low such that the waterline was below the designated sample areas. Grant PUD provided an escort for the sampling crew and proceeded to the furthest upstream randomly selected Type-1 habitat. This site was not suitable for electrofishing due to the steep drop off at the water's edge. A band of dead plant life was observed that was similar to other areas where stranded dead lamprey were noted in other locations (Figure 3). While no dead lamprey were observed, there were raccoon and heron tracks. No other stranded fish were present, suggesting that the area may potentially have been scavenged by wildlife.

Figure 3. Potential sampling site on right bank near Rock Island.

Other selected sites in the region were inaccessible due to private property.

The next randomly selected site was located at Yo Yo Rock boat launch (RM 449). There was an area with a wide band of dead aquatic plant life. The remains of approximately 30 dead lamprey were exposed on the shore. Sampling just below the selected site yielded no additional lamprey. The adjacent area below what would normally be a Type-2 habitat was also sampled without any results. This area should be considered for future additional sampling under normal project operations due to its relative accessibility and amount of likely habitat at higher elevations.

Thursday, 3/6/14

A large area around Crescent Bar on the left bank between approximately RM 440.5 and 441.5 (Figure 4) was explored. Upon arrival to the Crescent Bar region, it was observed that the water line was approximately 1000 feet below normal shoreline level (e.g. there was approximately 1000 feet of exposed shoreline that would normally be submerged). The sampling team walked the shoreline along designated sample sites and found two bands of vegetation approximately 7 feet wide with stranded mortalities including approximately 25 juvenile lamprey alongside bivalves and crayfish. An additional 12 stranded juvenile lamprey as well as other species of fish, including sculpin, shiners, and sticklebacks were observed further down the beach in the vicinity of Trinidad Creek (RM 441). In general, the region was comprised of soft muddy sand with a few rocky sections, and one stream that cut through the habitat. Many avian and mammalian tracks in the area were observed. After observing the general region it was concluded that electrofishing could potentially yield juvenile lamprey, however the water line region did not appear to be a suitable habitat.

Figure 4. Potential lamprey sampling sites in the Crescent Bar area (RM 440.5-441.5).

Friday, 3/7/14

Two sites in the Wanapum Reservoir were explored for sampling juvenile lamprey. The first site was the Getty's Cove area located just upstream of Wanapum Dam on the right bank (Figure 5; RM 416). The entire area was exposed due to extremely low water elevations of 541.6 feet. No juvenile lamprey carcasses or any other species of fish were observed, however stranded bivalves numerous tracks of a large birds were present.

The next site visited was a randomly selected Type-1 habitat located just upstream of Getty's Cove on the right bank (RM 417). Stranded bivalves were observed, but no fish. Sinking mud and extreme high winds prevented approach to the water's edge. Other sites were not sampled due to inclement conditions.

Figure 5. Potential lamprey sampling sites in the Wanapum Reservoir, just upstream of Getty's Cove on right bank (RM 416).

Thursday, 3/13/14

A boat was used to access five sites on Wanapum right bank, focusing on creek tributary mouths. The first site was Cayuse Creek (RM 425), however deep mud prevented sampling at the site. Observing the shoreline from the boat, there were no stranded fish observed, however stranded bivalves were present. The next site was Whiskey Dick Creek (RM 426), however, the shoreline was inaccessible due to steep muddy banks. Skookumchuck Creek (RM 427) was the next site visited but the mud was too deep to allow safe sampling. Only bivalves were observed from the boat.

The next site was Quilomene Bay (RM 433). Only a limited section was sampled due to deep mud along the shore. During sampling, no fish and only a few stranded bivalves were observed. The final site was Tekison Creek (RM 437.5) where sampling was completed at the creek mouth (Figure 6). This Type-2 habitat site yielded only bivalves.

Figure 6. Tekison Creek sampling site (RM 437.5).

Friday, 3/14/14

Forecasted extreme high winds precluded the use of a boat to travel to sites on the Wanapum Reservoir. Instead, the sampling crew traveled to the Crescent Bar (RM 441) area via truck (Figure 7). The accessible areas around Crescent Bar were explored on foot but no stranded lamprey were observed. Many stranded bivalves, crayfish, and one stickleback were observed. One Type-2 habitat area was sampled, however no fish were observed in the area. Wind created poor visibility for much of the sampling. Continued extreme high winds prevented further sampling.

Figure 7. The Crescent Bar sampling area (RM 440.5).

Appendix C:
Pacific Lamprey Volitional Passage Evaluation at WFEPS

Pacific Lamprey Volitional Passage Evaluation at Wanapum Fishway Exit Passage Systems

Background

In response to a horizontal fracture discovered in the spillway monolith No. 4 at Wanapum Dam, the Wanapum Reservoir was lowered to a safe operating elevation range between 545 feet and 541 feet on March 4, 2014. As a result of the drawdown, the fish ladder exit sections at Wanapum Dam were dewatered, preventing upstream migrating fish from passing and exiting Wanapum Dam. Fishway Exit Passage Systems were installed at Wanapum Dam on April 15 (on left-bank) and April 26 (right-bank) and were operated throughout the fish passage season. The Wanapum Fishway Exit Passage Systems (WFEPS) successfully passed adult salmonids (spring Chinook, coho, sockeye, etc.), steelhead and other resident species (mountain white fish, northern pikeminnow, etc.). To facilitate adult lamprey passage at both the left and right bank fishways at Wanapum Dam, lamprey ramps were designed and installed as part of the WFEPS. An in-season modification (June 6 - left-bank and June 18 - right-bank) included the installation of perforated plate to preclude adult lamprey from attaching to the backside, or downstream side of the false weir and WFEPS ramp. Similar modifications and additional plating were made to the sides of the false weir ramp on August 8 for both left and right bank ladders.

Based on previous years count data, Pacific lamprey typically begin arriving at Priest Rapids Dam in July, with the peak of the run around mid-August. Grant PUD, acting proactively in close coordination with and based upon guidance from the Priest Rapids Fish Forum (PRFF), planned to test the WFEPS effectiveness for passing lamprey prior to the peak of the lamprey run's arrival at Wanapum Dam. The test would involve the release of 20-30 half-duplex (HD) Passive Integrated Transponder (PIT) tagged lamprey directly into the Wanapum left bank fish ladder immediately downstream of the false weir, and subsequent video monitoring of the false weir and surrounding area. Results from the HD PIT tag detections and video monitoring would help determine whether additional lamprey passage techniques would need to be employed.

Tagged Lamprey Release

Originally, all test lamprey were to be translocated from John Day Dam to ensure an adequate number of study fish. It was later decided that half the lamprey would come from John Day Dam and half would come from Grant PUD's trapping efforts at Wanapum and Priest Rapids Dam to compensate for any abnormal behavior of the translocated lamprey. On July 24, 2014, 22 Pacific lamprey originally allocated as broodstock for the Yakama Nation Fisheries' Pacific Lamprey Project were transported from John Day Dam to the fish holding facility at Wanapum Dam. After several hours of recovery time on flow through river water, 15 (of the 22) lamprey from John Day Dam along with 15 lamprey from Grant PUD trapping efforts at Wanapum and Priest Rapids Dams were anesthetized and implanted with HD PIT tags. The remaining seven lamprey from John Day Dam were included in the trap and transport effort and released at Kirby Billingsley Hydro Park, approximately 2 miles south of East Wenatchee, Washington. Tagged fish were then held for over 24 hours to allow for recovery before being released on the evening of July 25 into the Wanapum left bank fish ladder upper turning pool immediately downstream of the WFEPS.

Twenty-eight of the 30 tagged lamprey were released into the Wanapum left bank fish ladder upper turning pool immediately downstream of the WFEPS just after 21:00 on July 25. After the discovery of an interruption of fresh water in-flow to one of the holding coolers, all lamprey were assessed and two

were removed from the evaluation, both of Grant PUD trapping origin. The HD PIT station at the Wanapum Dam left bank fish ladder exit was downloaded daily from July 26 to August 1 to determine which of the tagged fish ascended to the vicinity of the WFEPS, or traveled downstream in the fish ladder. The remaining nine HD PIT stations at the left and right bank fish ladders (five and four respectively) were downloaded biweekly as part of the regular monitoring efforts.

Overall, 27 of the 28 tagged lamprey released were detected within the seven-day monitoring period. Twenty-six of the 27 lamprey were last detected at the final weir of the fishway during the nights of July 25 and July 26 (Table 1). The exit itself was not monitored. One fish was never detected after release and may have shed its tag, stayed within unmonitored portions of the ladder, or exited the ladder undetected.

Table 1. PIT detections for 28 tagged lamprey released at the upper turning pool of Wanapum Dam left bank fishway on 7/25/14.

Unique tags detected at dam	100% (27 of 27)
Total last detected at final weir of fishway	96.3% (26 of 27)
Right fishway	0% (0 of 26)
Left fishway	100% (26 of 26)
Total last detected at entrance	0% (0 of 27)
Right fishway	0
Left fishway	0
Total last detected in fishway	3.7% (1 of 27)
Right fishway	0% (0 of 1)
Left fishway	100% (1 of 1)

Video Monitoring

Two Canon XA10 HD camcorders, with additional illumination provided by a CMVision IR110 infrared light, were used to assess lamprey passage and behavior over the false weir and approximately the first 10 feet downstream of the weir crest at night, when most lamprey passage occurs. This viewpoint allowed observation of lamprey ascending to the weir crest and passing over to the downstream "slide" structure, eventually descending to the Wanapum Dam forebay (the exit structure was out of view of the video camera). Night video monitoring was conducted for the lamprey evaluation in addition to continuing daytime effort to monitor the false weir for adult salmonid passage. Night time video monitoring occurred from approximately 20:00 to 8:00 for two nights (July 25, July 26) immediately following the release of 28 tagged lamprey into the upper left bank fish ladder and after the installation of perforated plating to preclude adult lamprey from attaching to the downstream side of the false weir and WFEPS ramp. Additional night video monitoring occurred for one night (August 12) immediately following the release of 47 untagged lamprey into the upper turning pool at the Wanapum Dam left bank fishway and the installation of perforated plating to the sides of the false weir slide. The plating was installed to prevent lamprey from attaching to and re-ascending the weir after passing the crest. The purpose of the video review was to describe behavior of all visible lamprey on the weir, rather than identification and tracking of individual fish. Net lamprey passage for each observational period was calculated by tallying the total number of lamprey that entered the weir from the pool and subtracting the number of lamprey that re-entered the pool. Overall, the net lamprey passage percentage was similar for all three observational periods, ranging from 26-30% (Table 2).

Table 2. Video monitoring results for the nights of July 25, July 26, and August 11, 2014 at the Wanapum Dam left bank fish ladder false weir.

	Total Entered Weir From Pool	Total Re-Entered Pool	Estimated Net Passage	% Net Passage
7/25/2014	75	55	20	26.70%
7/26/2014	74	55	19	25.70%
8/11/2014	87	61	26	29.90%

Lamprey behavioral observations were also noted from August 7 to 27, 2014 during regular daytime efforts to monitor the false weir for adult salmonid passage. From the top observation point at both right and left bank false weirs, the number of lamprey that entered the weir from the pool and either re-entered the pool or successfully passed into the forebay was tallied. From the lower observation point, number of lamprey that exited the slide into the forebay and how many attached to the slide was noted.

Fewer fish entered the weir on a daily basis during the day than what was observed during night video observations, with the highest daily total being 31 lamprey observed at the left bank false weir on August 19 (Table 3). The right bank false weir had far fewer lamprey observed than the left bank weir, with no lamprey observed for 13 out of the 21 observation days (Table 4). Overall, net passage of lamprey was observed to be higher during the day than what was observed from night video monitoring when all observation were combined (46.5% for day, 27.5% at night). In response to these results, Grant PUD and the PRFF determined it was necessary to continue and expand the trap and transport effort for the entire lamprey run at Priest Rapids and Wanapum Dams to improve lamprey passage. Through this effort, a total of 2,269 lamprey were trapped at Priest Rapids and Wanapum Dams and released at Kirby Billingsley Hydro Park, approximately 2 miles south of East Wenatchee, Washington (see Priest Rapids Hydroelectric Project Pacific lamprey adult trap and transport effort, summer 2014 memo for details).

Table 3. Lamprey behavior observations at the Wanapum Dam **left bank fish ladder** false weir from August 7 to 27, 2014.

	Top Observation Point			Lower Observation Point	
Date	**Successful Pool to Weir**	**Re-Enter Pool**	**Successful to Forebay**	**Exit to Forebay**	**Attachment in Tube**
8/7/2014	5	2	3	0	1
8/8/2014	13	6	7	0	3
8/9/2014	0	0	0	0	0
8/10/2014	13	5	7	0	1
8/11/2014	9	3	4	0	0
8/12/2014	12	3	9	0	2
8/13/2014	19	12	4	0	2
8/14/2014	0	0	0	0	0
8/15/2014	13	2	11	9	0
8/16/2014	14	1	11	9	2
8/17/2014	0	0	0	0	0
8/18/2014	25	8	15	0	0
8/19/2014	31	1	0	21	11
8/20/2014	3	0	2	1	0
8/21/2014	5	0	2	8	1
8/22/2014	1	1	1	0	0
8/23/2014	15	3	12	0	0
8/24/2014	5	2	0	1	1
8/25/2014	3	1	2	0	1
8/26/2014	12	2	3	3	1
8/27/2014	8	2	5	1	3
Total	206	54	98	53	29

Table 4. Lamprey behavior observations at the Wanapum Dam **right bank fish ladder** false weir from August 7 to 27, 2014.

	Top Observation Point			Lower Observation Point	
Date	**Successful Pool to Weir**	**Re-Enter Pool**	**Successful to Forebay**	**Exit to Forebay**	**Attachment in Tube**
8/7/2014	0	0	0	0	0
8/8/2014	0	0	0	0	0
8/9/2014	0	0	0	0	0
8/10/2014	0	0	0	0	0
8/11/2014	0	0	0	0	0
8/12/2014	0	0	0	0	0
8/13/2014	0	0	0	0	0
8/14/2014	0	0	0	0	0
8/15/2014	0	0	0	0	0
8/16/2014	3	0	2	1	0
8/17/2014	5	5	0	0	0
8/18/2014	2	0	1	0	1
8/19/2014	0	0	0	0	0
8/20/2014	3	1	2	0	0
8/21/2014	4	4	0	0	0
8/22/2014	0	0	0	0	0
8/23/2014	1	0	0	1	1
8/24/2014	1	0	1	0	1
8/25/2014	0	0	0	0	0
8/26/2014	1	0	1	0	0
8/27/2014	0	0	0	0	0
Total	20	10	7	2	3

Appendix D:
Priest Rapids Project Pacific Lamprey Trap and Transport Effort, Summer 2014

PRIEST RAPIDS HYDROELECTRIC PROJECT PACIFIC LAMPREY ADULT TRAP AND TRANSPORT EFFORT, SUMMER 2014

Background

On February 27, 2014, a horizontal fracture was discovered in the spillway monolith No. 4 at Wanapum Dam. The fracture opened a crack on the upstream face of the structure approximately 2 inches high by 65 feet long on the spillway monolith. Grant PUD immediately initiated its Emergency Action Plan (EAP; level B) and began to draw the Wanapum Reservoir down in a steady controlled state.

Initial calls were made to National Oceanic Atmospheric Administration (NOAA) Fisheries and U.S. Fish and Wildlife Service (USFWS) on February, 28, 2014 informing them of potentially developing fish passage issues at Wanapum Dam and concerns related to the situation at Wanapum monolith spillway 4. In addition, other members and stakeholders of the Priest Rapids Coordinating Committee and Priest Rapids Fish Forum were contacted by Grant PUD.

On March 2, 2014, Grant PUD fisheries staff conducted fish removal and salvage activities within the Wanapum right bank ladder in anticipation of the ladder becoming inoperable. The Wanapum left bank ladder had been previously dewatered for routine annual maintenance.

As of March 4, 2014, the Wanapum Reservoir was lowered to a safe operating elevation range between 545 feet and 541 feet. As a result of the drawdown, the fish ladder exit sections at Wanapum Dam were dewatered, preventing upstream migrating fish from passing and exiting Wanapum Dam.

The fish ladder entrances at Wanapum remained operational, due to the tailwater elevation. At an elevation of 560-562 feet, the Wanapum Dam fish ladders exits would be able to be operated within criteria and without modifications. Fishways at Priest Rapids Dam remained fully operational.

Fishway Exit Passage Systems were installed at Wanapum Dam on April 15 (on left-bank) and April 26 (right-bank) and were operated throughout the fish passage season. The Wanapum Fishway Exit Passage Systems (WFEPS) successfully passed adult salmonids (spring Chinook, coho, sockeye, etc.), steelhead and other resident species (mountain white fish, northern pikeminnow, etc.). To facilitate adult lamprey passage at both the left and right bank fishways at Wanapum Dam, lamprey ramps were designed and installed as part of the WFEPS. An in-season modification (June 6 - left-bank and June 18 - right-bank) included the installation of perforated plate to preclude adult lamprey from attaching to the backside, or downstream side of the false weir and WFEPS ramp. Similar modifications and additional plating were made to the sides of the false weir ramp on August 8 for both left and right bank ladders.

In addition to the volitional passage via the Priest Rapids fishways and WFEPS, Grant PUD trapped and transported adult Pacific lamprey collected from Priest Rapids and Wanapum dam fishways and released them above Rock Island Dam at Kirby Billingsley Hydro Park approximately 2 miles south of East Wenatchee, Washington. While the preferred passage route for migrating adult lamprey was through the adult fish ladders under normal operation, trap and transport reduced the potential migration delay and was a temporary solution to increase passage success until the Wanapum Reservoir returned to normal operational elevations and Wanapum Dam adult fish ladders are fully operational. These measures were proactive and collaborative with stakeholders to ensure protection of resources, and as such, this extra effort was completed

Trapping Activities

Adult Pacific lamprey were trapped from the left and right bank fishways at Wanapum and Priest Rapids Dams from July 17 to September 30, 2014, through the peak of the upstream adult lamprey migration.

Traps included 36 tube style traps, distributed between Wanapum and Priest Rapids Dams, and four mechanical weir traps at Priest Rapids Dam. All trapped lamprey were scanned for a Half Duplex Passive Integrated Transponder (HD PIT) tag, and previously tagged lamprey were transported and released immediately upstream of the dam where they were trapped. Untagged lamprey were then held in a circular holding tank at Wanapum Dam right-bank fish facilities (Wanapum Fishtown) until there were sufficient numbers to transport them upstream to the Kirby Billingsley Hydro Park (RM 461), approximately eight miles upstream from Rock Island Dam. A portion of the untagged lamprey were transported by Blue Leaf Environmental staff to Rocky Reach Dam (RM 473.7) for tagging and release as part of an agreement with Grant PUD, Chelan PUD, and the Priest Rapids Fish Forum.

Approximately 2,269 lamprey were trapped and transported (Table 1). Due to the large quantities of lamprey involved and time separation between trapping and transport efforts, exact counts were not possible, however the best available data was reported here. As such, GPUD is aware that there were discrepancies in reported total quantities of lamprey trapped and total transported.

Forty-five previously PIT-tagged lamprey were released just upstream of the dam where they were trapped, 286 were transported to Rocky Reach dam for PIT-tagging and release, 28 were released into the turning pool of the Wanapum Dam left bank fish ladder to investigate lamprey passage through the modified WFEPS (see Background section above), and the remainder were released at Kirby Billingsley Hydro Park (n=1,910). Over 72% of the lamprey trapped were caught at Priest Rapids Dam (Table 2). The highest percentage of lamprey were trapped from the Priest Rapids Dam right-bank fish ladder (39%) while the lowest was from the Wanapum Dam right-bank fish ladder (4%). The mechanical weir style traps caught a majority of the total lamprey trapped at Priest Rapids Dam (72%; Figures 1 and 2), while at Wanapum Dam a majority of the lamprey were caught in the tube traps in the middle of the ladders, clustered around the fish count station crowders and video count station (52%; Figures 3 and 4).

The percentage of the total lamprey run trapped at Priest Rapids Dam was calculated using the number of lamprey that passed weekly by the count stations at both left and right bank ladders. An adjustment factor was needed to account for lamprey that were trapped below count stations in the Priest Rapids fish ladders. The majority of the lamprey trapped at Priest Rapids Dam were from below the count station window for both left and right bank ladders (64% and 91% respectively) and not included in the total run numbers reported for the Columbia River DART (www.cbr.washington.edu/dart). The percentage of the run reported in Table 2 includes the adjustment factor of the number of lamprey trapped below the count station added to the numbers reported on DART.

Table 1. Approximate number of lamprey transported upstream by release location, summer 2014.

Date	TotalTransported	PreviouslyTagged	Origin	ReleaseLocation
7/17/2014	16	0	Priest, Wanapum	Kirby Billingsley Hydro Park
7/24/2014	1	1	Priest	Desert Aire
7/25/2014	15	0	John Day	Wanapum fish ladder
7/25/2014	13	0	Priest, Wanapum	Wanapum fish ladder
7/25/2014	48	0	Priest, Wanapum	Kirby Billingsley Hydro Park
7/25/2014	2	2	Priest	Desert Aire
7/26/2014	1	1	Priest	Desert Aire
7/27/2014	1	1	Priest	Desert Aire
7/28/2014	1	1	Wanapum	Wanapum upstream boat launch
7/29/2014	83	0	Priest, Wanapum, John Day	Kirby Billingsley Hydro Park
7/30/2014	40	0	Priest, Wanapum	Rocky Reach juvenile sampling facility
8/4/2014	34	0	Priest, Wanapum	Rocky Reach juvenile sampling facility
8/5/2014	134	0	Priest, Wanapum	Kirby Billingsley Hydro Park
8/6/2014	1	1	Priest	Desert Aire
8/10/2014	2	2	Priest	Desert Aire
8/11/2014	1	1	Wanapum	Rocky Coulee
8/12/2014	47	0	Priest, Wanapum	Wanapum fish ladder
8/13/2014	1	1	Priest	Desert Aire
8/13/2014	40	0	Priest, Wanapum	Rocky Reach juvenile sampling facility
8/13/2014	235	0	Priest, Wanapum	Kirby Billingsley Hydro Park
8/14/2014	1	1	Priest	Desert Aire
8/15/2014	3	3	Priest	Desert Aire
8/15/2014	1	1	Wanapum	Rocky Coulee
8/18/2014	287	0	Priest, Wanapum	Kirby Billingsley Hydro Park
8/18/2014	3	3	Priest	Desert Aire
8/19/2014	2	2	Priest	Desert Aire
8/20/2014	1	1	Priest	Desert Aire

8/21/2014	44	0	Priest, Wanapum	Rocky Reach juvenile sampling facility
8/22/2014	2	2	Priest	Desert Aire
8/24/2014	1	1	Priest	Desert Aire
8/24/2014	456	0	Priest, Wanapum	Kirby Billingsley Hydro Park
8/25/2014	1	1	Priest	Desert Aire
8/26/2014	1	1	Priest	Desert Aire
8/26/2014	40	0	Priest, Wanapum	Rocky Reach juvenile sampling facility
8/27/2014	1	1	Priest	Desert Aire
8/28/2014	1	1	Priest	Desert Aire
8/29/2014	2	2	Priest	Desert Aire
8/29/2014	296	0	Priest, Wanapum	Kirby Billingsley Hydro Park
8/30/2014	1	1	Priest	Desert Aire
9/1/2014	2	2	Priest	Desert Aire
9/2/2014	2	2	Priest	Desert Aire
9/4/2014	1	1	Wanapum	Wanapum upstream boat launch
9/5/2014	1	1	Wanapum	Wanapum upstream boat launch
9/5/2014	1	1	Priest	Desert Aire
9/6/2014	2	2	Wanapum	Rocky Coulee
9/8/2014	1	1	Priest	Desert Aire
9/9/2014	1	1	Priest	Desert Aire
9/9/2014	44	0	Priest, Wanapum	Rocky Reach juvenile sampling facility
9/14/2014	170	0	Priest, Wanapum	Kirby Billingsley Hydro Park
9/15/2014	1	1	Priest	Desert Aire
9/18/2014	44	0	Priest, Wanapum	Rock Island tagging station
9/29/2014	1	1	Wanapum	Rocky Coulee
10/2/2014	138	0	Priest, Wanapum	Kirby Billingsley Hydro Park
Total	**2,269**	**45**		

Table 2. Approximate number of lamprey caught in traps set in left and right bank fish ladders at Priest Rapids and Wanapum Dams, and adjusted percent of the run for Priest Rapids Dam, factoring in lamprey caught downstream of count stations.

		WK 1 (7/17-7/20)	WK 2 (7/21-7/27)	WK 3 (7/28-8/03)	WK 4 (8/04-8/10)	WK 5 (8/11-8/17)	WK 6 (8/18-8/24)	WK 7 (8/25-8/31)
Priest	Left	21	78	91	84	81	68	144
	Right	4	13	33	112	199	295	202
	Total	25	91	124	196	280	363	346
	% Run	12.4	20.1	14.7	20.6	20.9	38.4	28.3
Wanapum	Left	0	14	49	38	72	153	92
	Right	0	1	0	0	1	21	2
	Total	0	15	49	38	73	174	94

		WK 8 (9/1-9/7)	WK 9 (9/8-9/14)	WK 10 (9/15-9/22)	WK 11 (9/23-9/30)	total
Priest	Left	97	93	51	21	829
	Right	48	31	19	2	958
	Total	145	124	70	23	1787
	% Run	21.9	22.7	15.9	9.3	22.8
Wanapum	Left	46	57	28	25	574
	Right	20	7	19	31	102
	Total	66	64	47	56	676

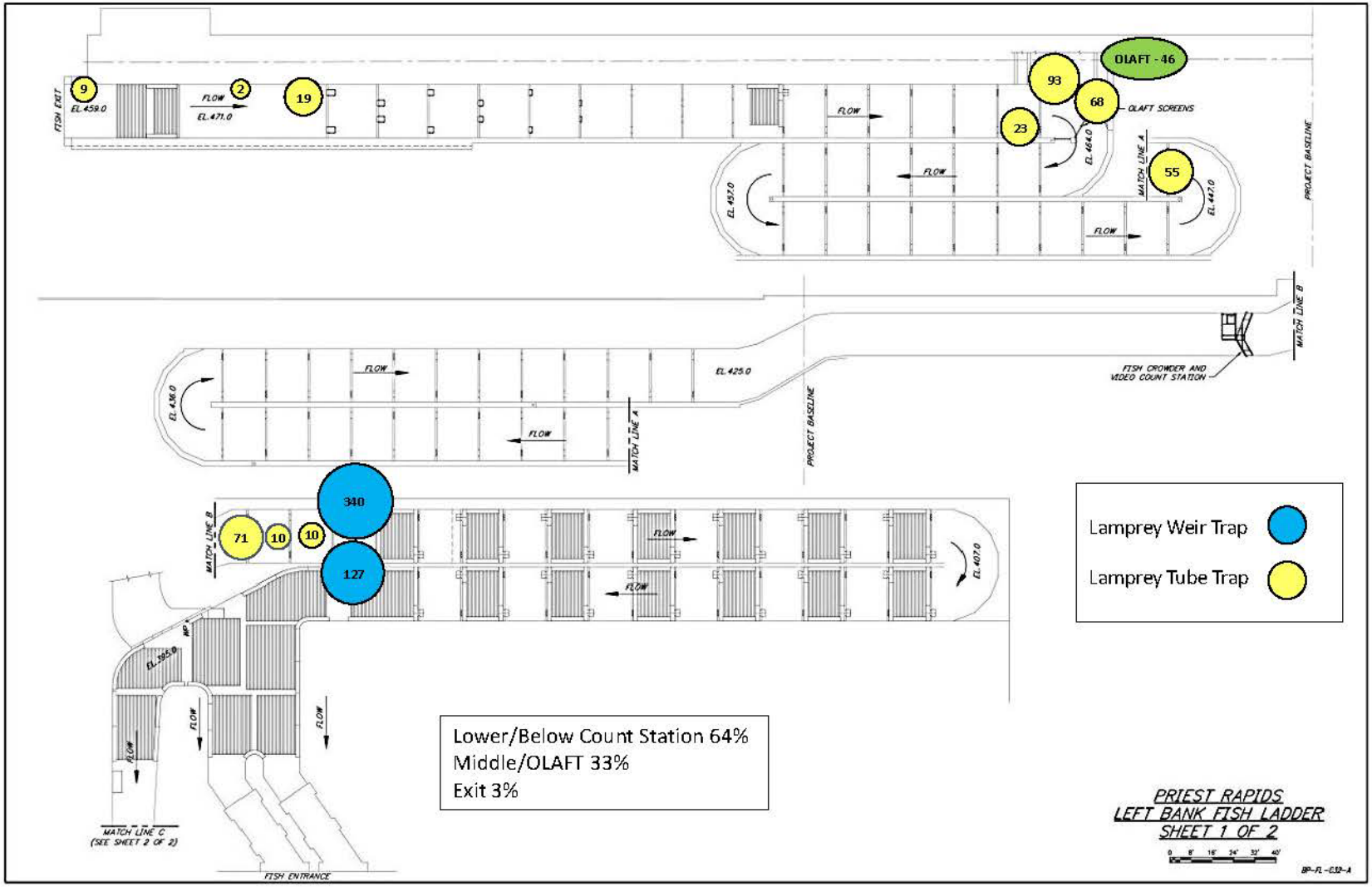

Figure 1. Type and location of all traps that caught lamprey in the Priest Rapids Dam left bank fish ladder. Size of circle and numbers within the circle represent the number of lamprey caught in the trap. Proportion of total lamprey caught in each section of the ladder is also reported. The Exit is the upper portion of the fish ladder, Middle/OLAFT is from the area around the OLAFT to above the count station, and Lower/Below Count Station is from the count station to the fish ladder entrance.

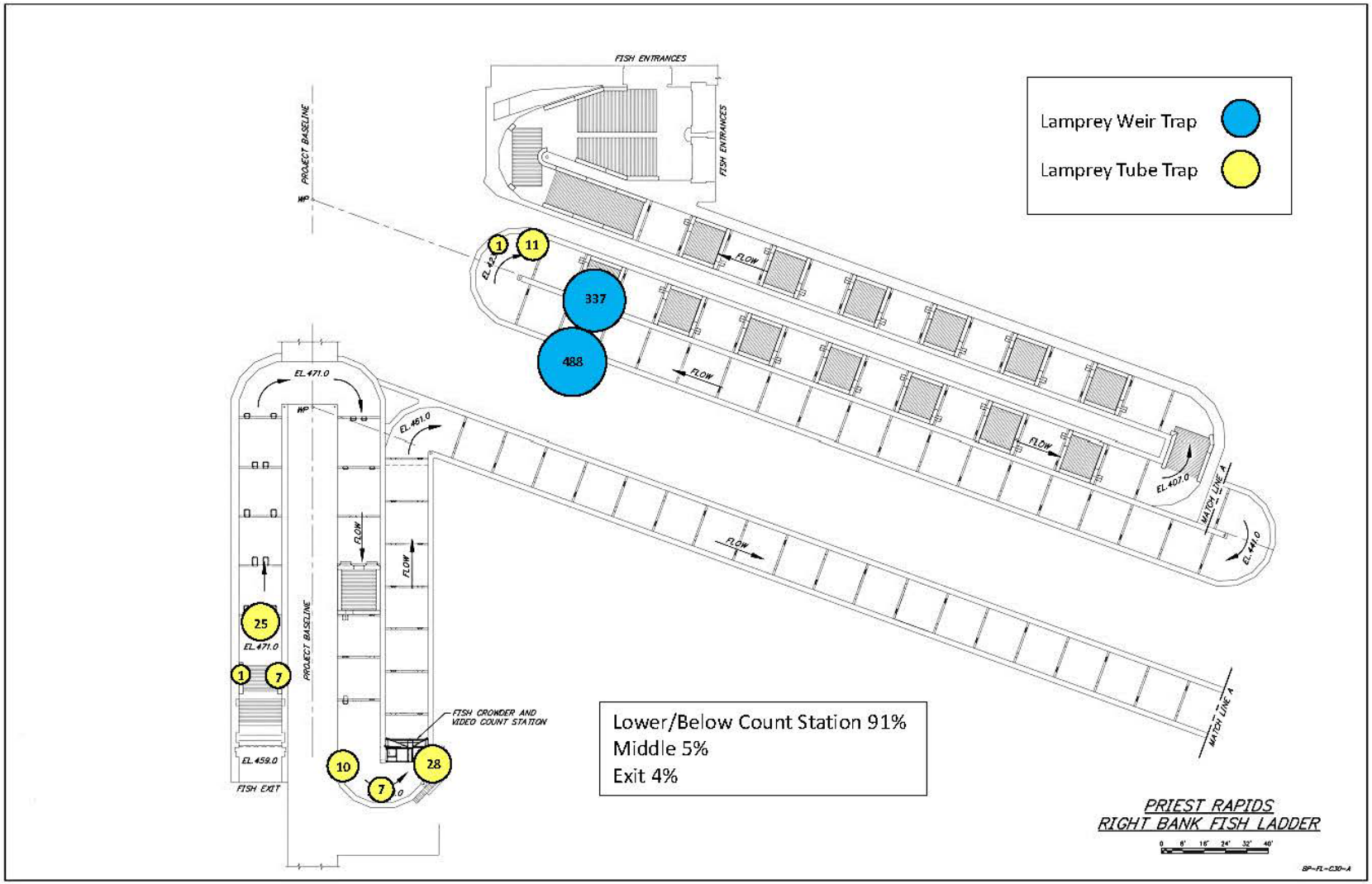

Figure 2. Type and location of all traps that caught lamprey in the Priest Rapids Dam right bank fish ladder. Size of circle and numbers within the circle represent the number of lamprey caught in the trap. Proportion of total lamprey caught in each section of the ladder is also reported. The Exit is the upper portion of the fish ladder, Middle is the area just above the count station, and Lower/Below Count station is from below the count station to the fish ladder entrance.

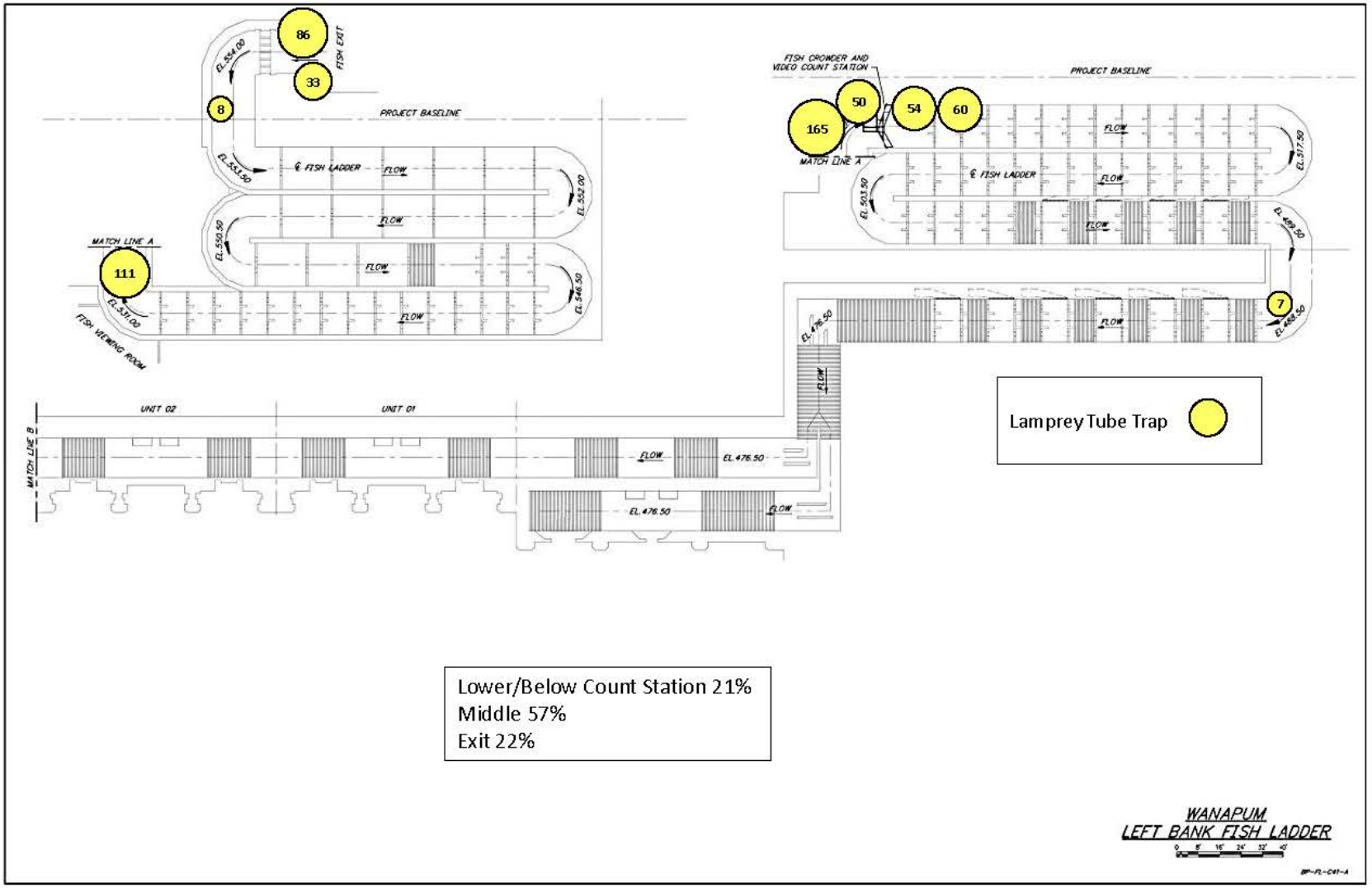

Figure 3. Type and location of all traps that caught lamprey in the Wanapum Dam left bank fish ladder. Size of circle and numbers within the circle represent the number of lamprey caught in the trap. Proportion of total lamprey caught in each section of the ladder is also reported. The Exit is the upper portion of the fish ladder, Middle is the area just above the count station, and Lower/Below Count station is from below the count station to the fish ladder entrance.

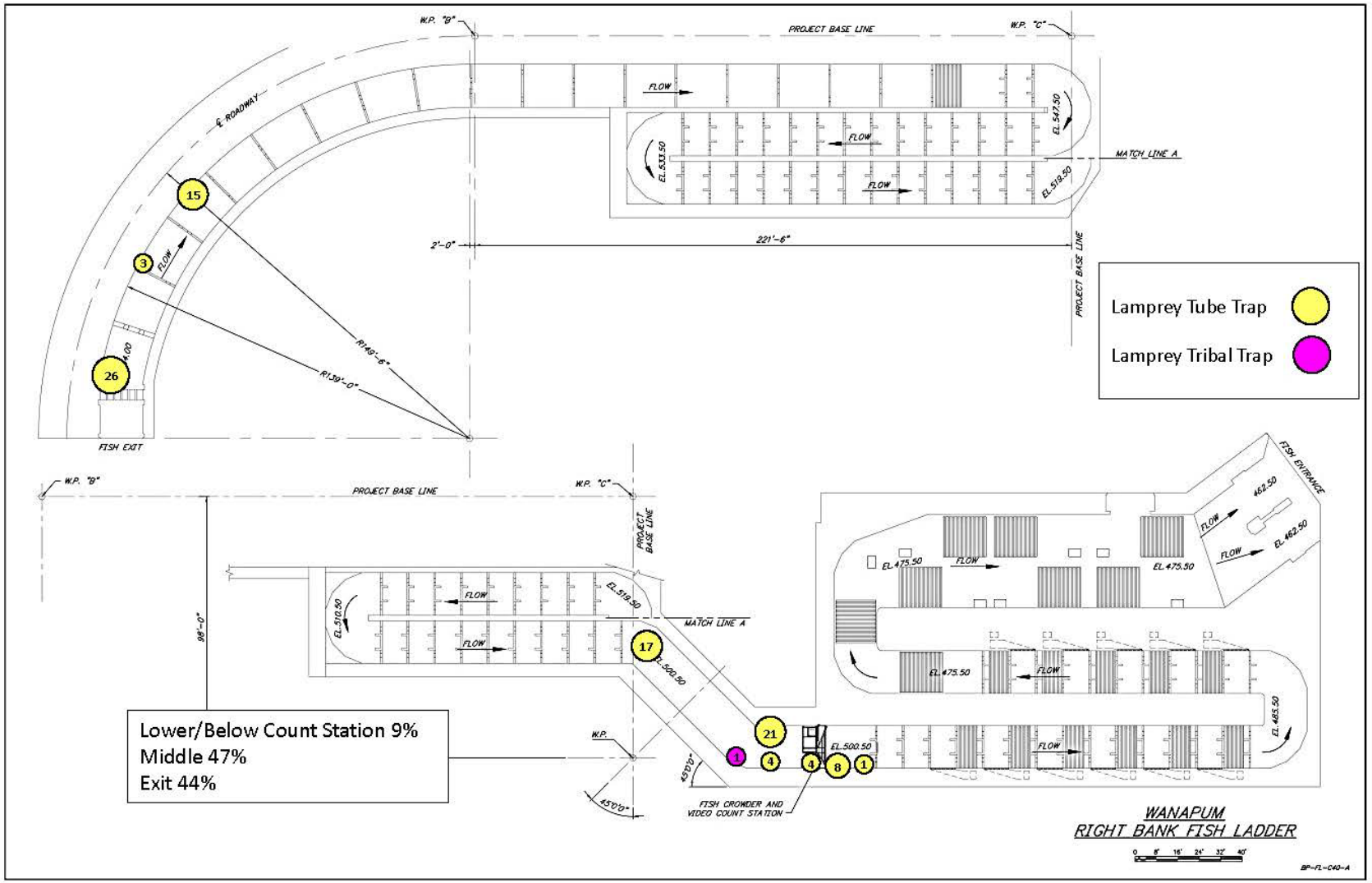

Figure 4. Type and location of all traps that caught lamprey in the Wanapum Dam right bank fish ladder. Size of circle and numbers within the circle represent the number of lamprey caught in the trap. Proportion of total lamprey caught in each section of the ladder is also reported. The Exit is the upper portion of the fish ladder, Middle is the area just above the count station, and Lower/Below Count station is from below the count station to the fish ladder entrance.