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March 22, 2011

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 License Compliance Filing – Article 401(a)(12) – Pacific Lamprey Management Plan Comprehensive Annual Report

Dear Secretary Bose,

Please find enclosed the 2010 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(5)(b) (Appendix C) for the Priest Rapids Project.

The 2010 PLMP Comprehensive Annual Report summarizes the on-going activities undertaken at the Priest Rapids Project (Project) in 2010, 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 Water Quality Certification Condition requirement, 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 January 19, 2011, the Public Utility District No. 2 of Grant County, Washington (Grant PUD) prepared and disseminated the draft 2010 PLMP Comprehensive Annual Report to members of the Priest Rapids Fish Forum including the Washington Department of Ecology U.S. Fish & Wildlife Service, Washington Department of Fish & Wildlife (WDFW), Colville Confederated Tribes, Yakama Nation, the Columbia River Inter-Tribal Fish Commission, 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. Consultation comments were received from WDFW on

February 17, 2011, and Wanapum Indians on February 18, 2011. Copies of those comments, along with a summary table of Grant PUD's responses were incorporated as Appendix A to the final report. Based on comments received, Grant PUD modified the report to reflect appropriate revisions and edits.

The 2010 PLMP Comprehensive Annual Report is hereby filed with the Federal Energy Regulatory Commission for approval. This same report has also been provided to WDOE on March 22, 2011..

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

Sincerely,

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CC: Tom Dresser, Grant PUD
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Priest Rapids Fish Forum

2010
Pacific Lamprey Management Plan
Comprehensive Annual Report

Priest Rapids Hydroelectric Project (FERC No. 2114)

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March 2011

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, 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 2010, 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 second year of implementation of Grant PUD's PLMP, several activities were conducted in preparation and support of fish ladder modifications to improve lamprey passage and the monitoring infrastructure to perform the adult evaluation. The first significant effort was the installation of structural modifications made in the Project fishway facilities to improve passage for adult lamprey. These improvements included the installation of aluminum plating at the edges of diffusion grating, plating through orifices adjacent to diffusion grating, and installation of ramps at perched orifices, in both fish ladders at Priest Rapids Dam. In addition, fish count station crowders designed specifically for both salmonids and adult lamprey were installed in each of the fish ladders at Priest Rapids and Wanapum dams. These structural improvements were completed during the 2009-2010 winter fish ladder maintenance outage and were specifically designed to provide accurate counts and volitional passage at both Priest Rapids and Wanapum dams. To evaluate these modifications, a complex array of HDX-PIT telemetry antennas were installed at strategic locations in the Priest Rapids and Wanapum fishways to measure the passage efficiency of adult lamprey and identify any areas of impediment, and underwater video arrays were installed at two locations in the Priest Rapids right bank fish ladder to assess the effectiveness and use of the aluminum plating and new fish count station crowders. Underwater video of adult lamprey approaching and passing weir orifices and the fish count station, and HDX-PIT telemetry detections from adult lamprey tagged in the lower river have been collected and are currently under evaluation. Data analysis is expected to be completed and included in the 2011 PLMP Comprehensive Annual Report. Pacific lampreys were not HDX-PIT or acoustically tagged in 2010 by Grant PUD due to the insufficient number of returning adults. The PRFF agreed to continue to passively monitor HDX-PIT tagged fish that were previously tagged downstream and to conduct the evaluation when a sufficient sample size exists. In addition to implementation activities identified in the PLMP, Grant PUD also conducted a gatewell exclusion screen and gatewell escapement evaluation at the Project. Although the study was originally developed to evaluate juvenile salmonid outmigrants, small numbers of lamprey were also observed at monitored turbine intake

emergency wheelgate slots at both Wanapum and Priest Rapids dams. During the study period no impacts or screen impingement events were observed at these locations. A final report will be available in spring 2011. 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 (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. Grant PUD is currently evaluating juvenile salmonid passage and behavior through the Priest Rapids Top-spill bypass which includes modifications to spill bays 19 through 21 to allow near surface route-specific passage. 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, Hanson) drain into the Priest Rapids Reservoir.

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

Over the past 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 measures required in the Project's License Order, 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 Uncertainties" document and provided information to support the Tribal Recovery Plan (Nez Perce Umatilla, Yakama, and Warm Springs Tribes 2009). 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 and the Yakama Nation Lamprey Recovery Planning efforts.

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; written fishway fish collection dewatering procedures conducted 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 control program that has been proven to be effective at minimizing the impact on 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. Now, similar entrances are being installed by the Army Corps of Engineers (ACOE) 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 ¾ - inch gap spacing to accurately enumerate all adult lamprey counts. Significant improvements for downstream passage have been achieved by development of the Wanapum Future Unit Bypass and the Priest Rapids top-spill bulkhead for juvenile salmon which presumably provides a high survival alternative passage route for 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 and; providing upstream and downstream fish passage facilities and support for full-duplex (salmon) and half-duplex (lamprey) PIT detection systems for the ACOE 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, the installation of passage-enhancing structures in the fishways at Priest Rapids Dam including diffusion grate aluminum plating, ramps ascending perched orifices, and 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 and the PRFF conducted a study of the effectiveness of these modifications during the summer of 2010. Although a comprehensive Pacific lamprey passage study was planned, the number of lamprey returning to the Columbia River were not suitable to complete the evaluation. More specifically, HDX-PIT and acoustic tagging operations were cancelled. However, 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. Further, the installation and monitoring of underwater video at strategic locations was used to evaluate the use of newly installed lamprey passage structures and new fish count station crowders.

Grant PUD has been 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 demonstrates the continued allocation of effort and capital resources to achieve the goals and objectives of the PLMP.

1.3 Purpose of the 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, issued by the Washington Department of Ecology (WDOE) on April 3, 2007 and amended March 6, 2008 (WDOE 2007; FERC 2008), which states:

> License Order: *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, 2009) 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, 2009 through October 31, 2010) 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 5.0: 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 to the PRFF on January 18, 2011 for review. Written comments were received from the Washington Department of Fish and Wildlife and the Wanapum on February 17 and 18, 2011. A summary of comments by the PRFF as received by Grant PUD on the draft PLMP Comprehensive Annual Report have been compiled along with responses from Grant PUD (Appendix B). The summary is based on written (Appendix A) comments.

2.0 Pacific Lamprey Activities in the Columbia River Basin

2.1 Background and Existing Information

Pacific lamprey (*Lampetra tridentata*) are indigenous to many of the tributaries of the Columbia (Jackson et al. 1997a, Jackson et al. 1997b) and the Snake Rivers (Close et al. 1995). Wydoski and Whitney (1979) reported that the Pacific lamprey is one of three species of lamprey in the Columbia River Basin where river lamprey (*Lampetra ayresii*) 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, lamprey 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 all Columbia and Snake River 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 U.S. Fish and Wildlife Service (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 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

engaging researchers and managers throughout the Columbia River basin to facilitate communication and coordination for the conservation of Pacific lampreys throughout their range.

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[2]									▒	▒	▒	
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 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 *Lampetra* 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.

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. Activities associated with documenting key habitat related to spawning, rearing, and overwintering habitat as well as nest and escapement surveys are being conducted annually in the Deschutes watershed. Multi-year juvenile distribution and abundance sampling and larval trend monitoring is occurring in the Klickitat, Wenatchee and Methow watersheds. Researchers are studying the physiological ecology and life history of adult lamprey during their freshwater residency in the Willamette River, and conducting swimming performance and oxygen consumption experiments in laboratory settings (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.

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. Recently, juvenile lamprey were 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). Researchers are also beginning to evaluate the efficacy of different irrigation diversion screen panels to prevent juvenile lamprey impingement and entrainment at these locations (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 Willamette River. 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, Grande 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. In the upper Columbia River basin, distribution information is being collected in the Wenatchee and Methow rivers while adult translocation activities by the Nez Perce Tribe indicate 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 like Powerdale on the Hood River, and 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. 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).

Table 2 Annual counts of adult Pacific lamprey at select Columbia and Snake River basin dams.[1]

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[3]	833	1,114	2	114	15

Notes:

1 Ice Harbor day counts only. Wells and Priest Rapids 24-hour counts. Lower Granite and McNary 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 5, 2010.

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. The most recent 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).

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. A review of these translocation programs was conducted in 2009 and monitoring is ongoing (see Section 2.2: Updated Information for additional details about the review and monitoring 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).

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, half-duplex Passive Integrated Transponder 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. 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).

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 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 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 (see Section 2.2: Updated Information for additional details regarding Keefer et al. 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 was 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, Douglas PUD utilized Dual-frequency Identification Sonar (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. 2010).

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).

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).

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 (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 to assess juvenile lamprey macrophthalmia outmigration until recently. In 2009, two tagging studies were conducted (and continued in 2010); one on the biological criteria for active tags and the second regarding the development of standard protocols for PIT-tagging juvenile lamprey (see Section 2.2: Updated Information for additional details).

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. 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 3. 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, 2009 through October 31, 2010. 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. Except for the few instances where the Project was one of several dams included in an evaluation, activities regarding the Project are not described herein but rather are detailed in Section 3.0: Status of Pacific Lamprey Activities at the Project.

Table 3 Pacific lamprey activities in the Columbia River basin in 2010.

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
	General Biology, Ecology and Population Status					
1.	Spawning habitat and timing, rearing habitat, and over-wintering habitat	No associated hydro project	Deschutes	From 2005 to 2009, a radio-telemetry study of adult Pacific lamprey over-wintering and spawning habitats, spatial and temporal patterns of use, and spawn timing downstream of Pelton Round Butte Hydrologic Complex (PRB) was completed. The draft report was completed in 2010. A final report is not yet available.	CTWSR	Personal communication with Cyndi Baker, CTWSR (11/29/10)
2.	Redd surveys	No associated hydro project	Warm Springs and Shitike Creek	During spring 2010, from late-April through early-July, annual lamprey redd surveys were completed. Habitat characteristics of lamprey redds were recorded. Redd surveys continued from August - October to document potential fall spawning. Preliminary results not yet available.	CTWSR	Personal communication with Cyndi Baker, CTWSR (11/29/10)
3.	Estimate escapement of adult lamprey	No associated hydro project	Deschutes	In 2010, abundance, harvest, and escapement of adult lamprey at Sherars Falls were estimated. Preliminary results not yet available.	CTWSR	Personal communication with Cyndi Baker, CTWSR (11/29/10)
4.	Determine extent of juvenile rearing habitat and estimate relative abundance of lamprey	No associated hydro project	Deschutes, Crooked and Metolius	In 2009, a predictive model to relate ammocoete density and habitat characteristics was developed in Shitike Creek using data collected by electrofishing. In 2010, this model was used for a theoretical abundance estimate in habitats that may be re-colonized upstream of PRB. Water temperature was the main predictor of ammocoete density, given a narrow range of habitat characteristics associated with ammocoetes (*e.g.* substrate, water temperature). Preliminary results not yet available.	CTWSR	Personal communication with Cyndi Baker, CTWSR (11/29/10)

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
5.	Conduct juvenile distribution and abundance sampling	No associated hydro project	Yakima	In 2010, surveys were completed for the main stem Yakima River up to the City of Yakima and in the lower portions of the Naches River, Tieton River, Ahtanum, Wenas, Toppenish and Satus creeks. Although Western Brook lamprey were found throughout much of the basin, Pacific lamprey were also observed. Pacific lamprey were noted in Ahtanum Creek and in the Yakima River near Yakima. Surveys will continue in the Yakima Basin in 2011. Surveys were also conducted in several dewatered diversion ditches in autumn months. Many juveniles were found behind fish screens, consisting of various size classes, but only Western Brook lamprey were noted. Also in 2011, a pilot radio telemetry study in coordination with the USFWS and USBOR will be initiated. The primary objectives will be to evaluate passage over USBOR diversion dams in the lower Yakima River and to obtain information about migration and spawning behavior from tagged adults.	Yakama Nation	Personal communication with Bob Rose, Yakama Nation (2/5/11)
6.	Conduct juvenile lamprey distribution surveys	No associated hydro project	Entiat and Wenatchee	In 2010, juvenile lamprey distribution surveys were conducted in the Entiat and Wenatchee rivers. A draft report will be available by spring 2011.	USFWS	Personal communication with R. D. Nelle, USFWS (12/21/10)
7.	Conduct status and trend larval monitoring program	No associated hydro project	Methow	In 2008, a baseline distribution study and habitat assessment in the Methow watershed was conducted. Despite conclusions that juvenile lamprey appear to be absent from a significant portion of the Methow watershed (not detected in the upper Methow River or Twisp River) juvenile lamprey presence was confirmed in various areas including Thirtymile in the Chewuch River	Wild Fish Conservancy and USFS	Methow Lamprey Inventory and Restoration Assessment. Draft Report (Crandall 2010) Personal

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
				downstream to the mouth of the Methow River near Pateros, WA (Crandall 2010). Following 2008 baseline distribution and abundance sampling, each of four study sites was randomly sampled by electrofishing to examine efficiency. In 2010, as a component of ongoing larval status and trend monitoring in the Methow watershed (began in 2008), three sites, each in the Chewuch and lower Methow subbasins, were sampled by electrofishing. Sites in the Twisp River and upper Methow have not resulted in larval capture in previous years (2008-2009) and were not sampled in 2010 due to lack of funding. Additionally, tissue samples were collected during field activities for range wide analysis. Genetic analysis is being conducted by Margaret Dockers' lab at the University of Toronto. A status report is pending finalization.		communication with John Crandall, Wild Fish Conservancy (11/22/10)
8.	Lamprey physiology, behavior, and performance laboratory studies	N/A	N/A	A manuscript is currently being prepared describing oxygen consumption measurements of adult Pacific lampreys at rest and during swimming. The paper should be completed by the end of 2010.	USGS	Personal communication with Matt Mesa, USGS (11/23/10)
9.	Swimming performance of larval lamprey	N/A	N/A	In 2009, the prolonged-sustained and burst swimming speeds of wild larval Pacific lamprey were measured in the laboratory using annular variable speed swimming chambers and swimming raceway/digital video analysis, respectively. Mean length of time for prolonged-sustained swimming speed of juvenile lamprey (72-143 mm TL) ranged from 43.0 minutes at velocities of 10 cm/s, to 0.4 minutes at 50 cm/s. Burst swimming speeds tended to increase as length increased from 107 to 150	Fisheries and Wildlife Resources Group, USBOR	Swimming performance of larval Pacific lamprey (Sutphin and Hueth 2010)

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
				mm TL, and ranged from 33.3 to 75.0 cm/s.		
10.	The physiological ecology and life history of adult lamprey during freshwater residency	Willamette Falls	Willamette	Adult Pacific lamprey were collected at Willamette Falls and in the Klamath River estuary (baseline comparison) in 2007 and 2008 to ascertain morphology, fat content, stage of maturation, and fecundity. It appears as though relatively recent, sexually immature migrants enter Willamette Falls when river temperatures peak and when river flows are low, whereas the sexually mature fish (fish that had likely already entered freshwater the previous summer) were found during the spring. The warm water itself may prevent imminent sexual maturation during the summer while at the same time helping to expedite the maturation process for both sexes the following spring (Clemens et al. 2009.). Although sexual maturation appears to be unimodal, occurring only during the spring, the substantial variety in all of the measures displayed above suggests that the hypothetical scenario of two cohorts (last year's entrants, this year's spawners and this year's entrants, next year's spawners) may be overly simplistic. In fact, there may be several cohorts whose maturation timing is plastic, dependent upon ambient water temperatures. It is not known whether the ambient temperatures are negatively impacting the spawning population (as might be inferred by the atretic testes), as we do not know what a baseline level for population normalcy is (Schreck and Clemens 2010). Final results expected during early 2011.	Oregon Cooperative Fish and Wildlife Research Unit at OSU	Life histories of adult Pacific lamprey, National Fish and Wildlife Foundation final programmatic report (Schreck and Clemens 2010)
11.	Evaluate effectiveness of the Nez Perce trial translocation program	Lower Granite	Snake	In 2009, adult lamprey salvaged from John Day Dam fishways during the annual winter dewatering period were held through the winter at the Nez Perce Tribal Hatchery. In May they were released into four Snake River tributaries: Asotin Creek in	USFWS	Personal communication with Chris Peery, USFWS (11/20/10)

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
				Washington, and Lolo, Newsome, and Orofino creeks in Idaho. During 2007-2010, a total of 480 lamprey have been released for this program of which a sub-sample of 115 fish were outfitted with radio transmitters and released into 3 of the 4 streams. For the most part, radio-tagged lamprey remained in the release streams. Lamprey redds were observed in all release streams where surveys were conducted except for Asotin Creek in 2009. While not conclusive, the indication is that larval lamprey observed in Asotin, Lolo and Newsome creeks were primarily the progeny of the translocated adults. A GIS-based model to characterize usable habitat for adult and juvenile Pacific lamprey in Asotin Creek has been developed. A final report is currently being developed.		
12.	Evaluate effectiveness of the Umatilla Tribe translocation program	No associated hydro project	Umatilla	In 1999 and 2000, the CTUIR began implementing a restoration plan for Pacific lamprey in the Umatilla River. The restoration plan called for 1) locating an appropriate donor stock for translocation, 2) identifying suitable and sustainable habitat within the subbasin for spawning and rearing, 3) translocation of up to 500 adult lampreys annually, and 4) long-term monitoring of spawning success, changes in larval density and distribution, juvenile growth and outmigration, and adult returns. Translocated lamprey were successful in depositing fertilized eggs in redds and producing viable eggs in the Umatilla River and Meacham Creek. Larval abundance in index plots sharply	Translocation Subgroup (of the Lamprey Technical Work Group)	Translocating adult Pacific lamprey within the Columbia River Basin: State of the science (CRBLTWG 2010)

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
				increased one year after translocating adult lamprey to the Umatilla River. Larval distribution increased through time in the upper mainstem Umatilla River. Recently metamorphosed lamprey abundance sharply increased during the 2000-2001 outmigration and again 2005-2006. The number of adults increased over time, but the total number of individuals entering the Umatilla River was still low.		
13.	Assess herbicides effects on lamprey	No associated hydro project	Willamette and Siletz rivers	The Confederated Tribes of Siletz Indians are interested in determining potential causes for lamprey population declines. The Oregon Cooperative Fish and Wildlife Research Unit is addressing this interest by determining whether or not herbicides are having a deleterious effect on this threatened species. In 2011, behavioral trials, protein binding assays and heart rate experiments to determine if olfactory response, the primary sense used for migration and spawning, is altered in herbicide affected fish will be conducted.	the Oregon Cooperative Fish and Wildlife Research Unit at OSU Confederated Tribes of the Siletz Indians	Personal communication with April Lindeman, OSU (11/22/10) Advisor: Dr. Carl Schreck
14.	Assess possible effects contaminated sediment has upon survival, growth and behavior of lamprey ammocoetes	No associated hydro project	Lower Willamette	In summer and fall 2010, Pacific lamprey ammocoetes were exposed to sediments collected from Portland Harbor Superfund site and several reference sites upstream. Individual rearing methods were developed in order to collect survival and growth data on single ammocoetes. Behavioral trials were also conducted to examine ammocoete sediment preference between contaminated and uncontaminated sediments. Preliminary results not yet available.	the Oregon Cooperative Fish and Wildlife Research Unit at OSU Portland Harbor Trustee Council Stratus Consulting	Personal communication with Julia R. Unrein, OSU (11/22/10) Supervisor: Dr. Carl Schreck
15.	Develop methods to survey juvenile lamprey in deep water habitats	No associated hydro project	Snake	Researchers are developing a means to survey for the presence of juvenile lamprey ammocoetes in deep water habitats. A lowered sled outfitted with	ACOE (prepared by PNNL)	Evan Arntzen, PNNL, AFEP Presentation, 2010,

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
				electroshocker (modified ABP-2 backpack unit) and video cameras will be lowered to the sediment surface, electric charge will be applied and video images will be viewed and recorded to document the presence of lamprey. Sediment type (grabs) and size (video images), depth, temperature, and water velocity will be recorded to document habitat characteristics. A prototype sled has been constructed and testing will begin in 2011.		Portland, OR, 12/2/10
	<u>Lamprey Migration in Rivers</u>					
16.	Evaluate adult lamprey migration through the lower Columbia River	Bonneville, The Dalles, John Day, McNary, Ice Harbor, Priest Rapids, Wanapum	Columbia and Snake	The objectives of the 2007 and 2008 studies were to calculate lamprey passage times, to estimate escapement, and to evaluate potential correlates with lamprey escapement and behaviors through the study reaches. In 2009, 596 and 368 lamprey were radio-tagged and HDX-PIT tagged, respectively. Of these, 300 were double-tagged with both a radio transmitter and a PIT tag. Escapement estimates within reaches ranged 31 to 34% for radio-tagged fish and 47 to 56% for PIT tagged fish. 4% of RT lamprey passed McNary Dam and four PIT-tagged lamprey reached Priest Rapids Dam. Larger lampreys were more likely to migrate further upstream in the hydrosystem. Lamprey migration times were highly variable, but tended to be slow at dams and relatively rapid through reservoirs. Migration rates were slower early in the run during higher and colder flows. Large lampreys in both the radio-telemetry and HDX-PIT studies were significantly more likely than small lampreys to pass through most of the	ACOE (prepared by the University of Idaho Cooperative Fish and Wildlife Research Unit)	Adult Pacific lamprey migration in the lower Columbia River: 2009 radio-telemetry and half-duplex studies (Keefer et al. 2010)

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
				monitored dam-to-dam reaches. Escapement estimates were higher by HDX-PIT tagged fish, compared to radio-tagged fish. At top-of-ladder sites where both systems were deployed, the radio-telemetry arrays were generally more efficient at detecting double-tagged fish, although some fish were detected only on the HDX-PIT system. This suggests a tradeoff between tagging effects and the collection of high resolution, fine-scale data provided by the active radio tag telemetry system.		
17.	Evaluate adult lamprey migration through the Willamette Falls Dam	Willamette Falls	Willamette	In 2009, 300 fish were radio-tagged. Half were released below the falls (PGE passage evaluation) and half were released upstream of the falls (CRITFC study). In 2010, 219 adult lamprey were radio-tagged and released upstream of the falls. Fish are being monitored using series of fixed-receiver sites in the mainstem Willamette and most tributary streams from Clackamas up to Coast Fork (fixed sites and data from fixed sites monitored and maintained by the Confederated Tribes of the Grand Ronde and Cramer Fish Sciences). Boat and aerial mobile tracking are also being conducted by OSU. Monitoring will occur through winter until spawning in spring 2010. Of the 205 fish that entered the study area in 2009, upstream of Willamette Falls, 125 have been relocated at least once. Lamprey either move quickly upstream to the upper Willamette River or tributaries, move relatively little and holdover in the mainstem or are not detected again. Holding fish are typically associated with deep water areas, rock revetments, boulders, logs or other large substrate. Movements typically halt during summer warm water periods and are minimal during fall and winter. The Pudding, Yamhill and Santiam rivers appear to be tributaries of choice	PGE and CRITFC (conducted by the Oregon Cooperative Fish and Wildlife Research Unit at OSU in collaboration with the Confederated Tribes of the Grand Ronde and Cramer Fish Sciences)	Migration characteristics and habitat use of the imperiled adult Pacific lamprey in the Willamette Basin: Prelude to estimating requirements for persistence (Clemens et al. 2010) Personal communication with Chris Peery, Cramer Fish Sciences (11/21/10)

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
				for spawning fish. Lamprey tagged in 2010 are primarily holding in the lower and mid- Willamette and Santiam rivers. Monitoring will continue through the winter and through the spawning in the spring.		
18.	(1) Evaluate adult lamprey migration through the Winchester Dam (2) Assess adult lamprey habitat use (holding, overwintering and spawning) (3) Analyze upstream migration behavior (effects of river environment and morphology)	Winchester Dam	North Umpqua	In 2009, 25 lamprey were radio-tagged with Lotek NTC-6-2. In 2010, 45 lamprey were radio-tagged: Lotek NTC-6-2 (6 tags), NTC-3-2 (10 tags), and MST-820T (29 tags). Among the tagged lamprey that approached the dam after downstream release, approximately 10% in 2009 and 30% in 2010 successfully navigated past the dam to upstream habitat. Some of the tagged lamprey (8% in 2009 and 30% in 2010) were released upstream of the dam to compare the migration pattern and distance travelled among the two groups. Fixed stations were set up at Winchester Dam as well as near major tributary junctions (Little River, Rock Creek, and Steamboat Creek). Manual tracking was conducted semiweekly (summer) and biweekly (winter) both along riverside roads and on and along the river. Surprisingly, smaller lamprey had a higher rate of passage through Winchester Dam and they also traveled further upstream. In addition, early run lamprey had a higher rate of passage and travel distance compared to mid and late run lamprey. Preliminary results also suggest that temperature and flow play an important role in their adult migratory behavior. Glide and run type habitat units were used significantly more in comparison to what is naturally available (and also in comparison to pools and riffles) for overwintering habitat. Results from dam passage, migration behavior, and habitat selection all point to the fact that hyporheic exchange and subsurface flow is potentially an	Oregon Cooperative Fish and Wildlife Research Unit at OSU Partnership for Umpqua Rivers ODFW	Personal communication with Ralph Lampman, OSU (11/22/10) Advisor: Dr. Carl Schreck

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
				overarching driver for all three of these activities. Monitoring will continue till the 2010 tags spawn and/or expire in the summer of 2011.		
19.	Evaluate irrigation diversion screen panels and juvenile entrainment	N/A	N/A	In 2010, studies were done evaluating the efficacy of different irrigation diversion screen panels to prevent ammocoetes from becoming entrained. Overall, perforated plate screens prevented the entrainment of 85% the fish, protected all fish larger than 46 mm in length, and offered the best overall protection of the screen types tested. Interlock bar screen and vertical bar screens protected 74% and 67% of the fish and prevented all fish larger than 58 mm and 55 mm from becoming entrained, respectively. Wire cloth screens of 12 and 14 gauge prevented the entrainment of 34% and 38% of fish, prevented all fish larger than 90 mm and 78 mm from becoming entrained, and offered the lowest overall protection of the screen types tested.	USGS	Personal communication with Matt Mesa, USGS (11/23/10)
	Adult Passage at Hydroelectric Facilities					
	Structural and Operational Fishway Modifications					
20.	Inspect fishway at Priest Rapids and Wanapum dams and identify cases that could represent passage problems for adult Pacific lamprey	Priest Rapids, Wanapum	Columbia	In 2010, Grant PUD conducted multiple 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 (12/7/10)
21.	Fishway modifications	Rocky Reach	Columbia	Based upon a literature review and site visit conducted in spring of 2010, Chelan PUD currently plans to make modifications to the Rocky	Chelan PUD	Pacific lamprey upstream passage modifications

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
				Reach fishway during the 2010-2011 fishway maintenance period to improve adult lamprey passage at the Project. These improvements include installation of plating at diffuser gratings throughout the ladder, ramps at perched orifices in the upper ladder, and an HDX PIT tag detection system at key locations within the fishway.		literature review and analysis and recommendations for passage improvements in the Rocky Reach Fishway (Andersen et al. 2010) Personal communication with Jeff Osborn, Chelan PUD (12/13/10)
22.	Evaluate the performance of lamprey passage structure (LPS) and collector	Bonneville	Columbia	In 2007 and 2008, a new LPS was installed in the Washington-shore AWS (top of ladder). This and LPS structures at the Washington-shore entrance and Bradford Island auxiliary water supply (AWS) were evaluated using mechanical counters and HDX PIT detectors. 757 and 610 adult lamprey were tagged with HDX PIT tags and released downstream from the dam. During both years, 3% of lamprey used the Washington-shore AWS LPS and 4% and 8% of lamprey used the Bradford Island AWS LPS during the two years. Use of the entrance collector in 2007-2008 improved over that observed in 2006 when the ramp was enclosed. Lamprey numbers collected was higher during periods of high river discharge and tailwater levels.	ACOE (prepared by NOAA Fisheries)	Development of passage structures for adult Pacific lamprey at Bonneville Dam, 2007-2008 (Moser et al. 2010a) Development of Pacific lamprey fishways at hydropower dams (Moser et al. 2010b)
23.	Evaluate the performance of LPS and collector	Bonneville	Columbia	In 2009, structures were operating in the AWS's at the tops of the Bradford and Washington-shore fishways and at the Washington-shore and Cascades Island entrances at Bonneville Dam.	ACOE (prepared by NOAA Fisheries)	Moser et al. (2010c) presentation at 2010 USACE

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
				Mechanical counters were used to determine use of LPSs and HDX PIT lamprey were used to determine relative use. The number and proportion of lamprey using the top-of-ladder LPSs has increased. Raising picketed leads one inch at the Washington-shore AWS appeared to improve access to this LPS in 2010. Use of the entrance LPSs appear to be relatively low (48 lamprey counted) and may be related to ability of lamprey to locate and climb the initial ramp portion of the structure.		AFEP Review, Portland, OR, 12/2/10
24.	Evaluate the performance of LPS at Three Mile Dam	Three Mile	Umatilla	In 2010, effectiveness testing of an LPS installed at Three Mile Dam in 2009, was conducted. A total of 9 non-tagged, up migrant lamprey used the LPS. Data of radio-tagged lamprey have not yet been analyzed for 2010 and may be available in 2011.	CTUIR	Personal communication with Aaron Jackson, CTUIR (12/15/10)
25.	Evaluating effectiveness of modified Cascades Island fishway entrance to improve adult lamprey passage at Bonneville Dam	Bonneville	Columbia and Snake	During the 2008-2009 winter work period, the Cascades Island fishway entrance (south entrance in spillway channel) was modified to reduce maintenance and to improve adult lamprey passage. Modifications included changing to keyhole entrance bulkhead and adding bollards on the floor to create velocity refuge that lamprey could use to improve entrance success. A LPS was also added as a means to move lamprey over the dam. Radio-telemetry and HDX PIT tags were used to evaluate the modified entrance. Lamprey entrance efficiency at the Cascades Island fishway (58.8%) was higher in 2009 than 2008 (33.3%; P =0.002), Entrance efficiency at Bradford Island did not differ significantly among years, supporting the hypothesis that the increase at Cascades Island in 2009 was related to the modification. Exit ratios were higher (62%) in	ACOE (prepared by University of Idaho Cooperative Fish and Wildlife Research Unit and NOAA Fisheries)	Evaluation of adult Pacific lamprey passage at the Cascades Island fishway after entrance modifications, 2009 (Clabough et al. 2010a) Adult Pacific lamprey migration in the lower Columbia River: 2009 radio-telemetry and half-duplex studies (Keefer et al. 2010)

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
				2009. 79% of tagged lamprey returned to face of the dam following release to tailrace and 30% passed the dam and another 4% were recaptured and released upstream. 32 lamprey fell back at the dam. Where fish approached and entered were described. Entrance efficiencies ranged from 38 to 65%.Median time to pass the dam from first approach was 3.3 d.		
26.	Install 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 (12/7/10)
27.	Modify dewatering procedures	All ACOE projects	Columbia and Snake	Modifications to dewatering procedures to reduce strandings 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. Procedures are in place and ongoing.	ACOE	Personal communication with Sean Tackley, ACOE (12/14/10)
28.	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 Beau Patterson, Douglas PUD (12/7/10)
29.	Modify dewatering procedures	Rocky Reach, Rock Island	Columbia	Pursuant to the Rocky Reach and Rock Island HCPs (Chelan PUD 2002a and 2002b), dewatering protocols are in place.	Chelan PUD	Personal communication with Jeff Osborn, Chelan PUD (12/7/10)
30.	Modify dewatering procedures	Priest Rapids,	Columbia	Pursuant to the Project Fishway Operation Plan,	Grant PUD	Personal

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
		Wanapum		dewatering protocols are in place.		communication with Mike Clement, Grant PUD (12/20/10)
31.	Rehabilitate 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 are currently being proposed. Current information indicated that lamprey congregate in an area of this fishway early in the migration season. Operations of this fishway will allow lamprey, including salmon and steelhead that are currently salvaged as necessary from this area, volitional passage to the forebay of the project. The proposal is currently being evaluated by the implementation work group.).	PGE	Personal communication with Tim Shibahara, PGE (12/20/10)
32.	Install plating around perimeter of diffuser grating	McNary, Ice Harbor	Columbia and Snake	At McNary Dam during the 2009-2010 winter work period, steel plating was installed over a portion of the fish ladder diffuser grating. The plating was installed around the perimeter of three main sections (at the bottom of the fish ladder grating and up one side) at the Oregon shore fish ladder. Future evaluations of this modification are not currently planned. At Ice Harbor, a total of 8 diffuser grating sections in the fish ladder were plated. Diffuser sections 8-11 were no longer operational and were fully plated (entire section covered) and diffuser sections 4-7 received partial plating (perimeter). Future evaluations of this modification are not currently planned.	ACOE	Personal communication with Derek Fryer, ACOE (5/6/10)
33.	Install plating along the edges and through the orifices in the pools	Priest Rapids	Columbia	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	Grant PUD	Personal communication with Mike Clement, Grant PUD (12/22/10)

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
				assessment of Pacific lamprey behavior and passage efficiency at Priest Rapids and Wanapum dams.		
34.	Install lamprey orifices	McNary	Columbia	During the 2009-2010 winter work period, 3-inch high by 18-inch wide lamprey orifice openings were constructed flush with the fishway floor at 10 tilting weirs (with perched orifices) in the Oregon shore fish ladder. Evaluation of any potential impacts to migrating adult salmon is currently being conducted. Preliminary observations using underwater video have observed no interactions by migrating adult salmon/steelhead with the one open lamprey orifice. To date, approximately 19,000 salmon/steelhead have passed McNary Dam.	ACOE	Personal communication with Derek Fryer, ACOE (5/6/10)
35.	Install ramps at perched orifices	Priest Rapids	Columbia	During the 2009-2010 winter work period, aluminum ramps at elevated sills and lips were installed.	Grant PUD	Personal communication with Mike Clement, Grant PUD (12/7/10)
36.	Round corners in fishway	McNary	Columbia	During the 2009-2010 winter work period, the edges of the 26 inch by 26 inch salmon orifices located at the Oregon shore fish ladder exit were smoothed/rounded through the installation of additional metal plating to increase attachment area for Pacific lamprey. Future evaluations of this modification are not currently planned.	ACOE	Personal communication with Derek Fryer, ACOE (5/6/10)
37.	Round corners at perched orifices	The Dalles	Columbia	During the 2009-2010 winter work period, at the 3 locations in the east and north ladders, corners were rounded from 90 degrees to 2-in radius.	ACOE	Personal communication with Sean Tackley, ACOE (12/14/10-)
38.	Experimentally evaluate the effects of lowered water velocities at fishway entrances at Bonneville Dam on lamprey behavior and passage efficiency	Bonneville	Columbia	From 2007-2009, ladder flows of 1.2 m/s at night and near zero (standby mode) were compared to standard operations near 2 m/s at Powerhouse 2. Entrance efficiencies were significantly higher during reduced flow 26-29%, compared to	ACOE and USFWS (prepared by the University of Idaho	Effects of lowered fishway water velocity on fishway entrance success by Pacific lamprey at

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
				standard operations 13-20% and standby 5-9% at PH2 north entrances but not at PH2 south entrances. Results suggest that some reduction in entrance velocity is beneficial for lamprey passage, but that zero attraction flow is probably a deterrent.	Cooperative Fish and Wildlife Research Unit)	Bonneville Dam,2007-2009 (E.L. Johnson et al. 2010)
39.	Evaluate reduction of water velocities	McNary	Columbia	During 2009, water velocities were manipulated at the Oregon entrance by lowering the telescoping entrance weirs in a randomized block design between the hours of 2100 and 0400 daily. Monitoring of head differences using depth loggers revealed that the nighttime treatment manipulation was not as effective as anticipated, particularly after mid-August when the lowering of the weirs became less effective during conditions with high tailrace elevation. Radio-telemetry and HDX-PIT were used to evaluate the entrance modification but, consistent with a priori statistical power analyses, preliminary results of the first year of the two-year experiment suggest that the reduction of velocity during night did not have an extreme positive or negative effect on lamprey passage behavior.	ACOE	Evaluation of adult Pacific lamprey migration and behavior at McNary Dam with effects of night-time fishway flow reduction, 2009 and detection and behavior of translocated adult Pacific lamprey (Boggs et al. 2010)
40.	Assess the effects of temporary velocity reductions at fishway entrances on the (a) attraction and (b) relative entrance success of adult lampreys at Wells Dam	Wells	Columbia	During fall 2009, three alternative entrance flow velocities (i.e., existing high, moderate and low) were assessed using Dual-frequency Identification Sonar (DIDSON) in a randomized block design. The goal was to identify optimal hydraulic conditions conducive to entry of adult lampreys into the fishways at Wells Dam. Although only 5 complete behavioral sequences were observed in 2009, results suggest that reduced velocities show promise in providing an environment conducive to upstream passage of lampreys.	Douglas PUD	Assessment of adult Pacific lamprey response to velocity reductions at Wells Dam fishway entrances (P.N. Johnson et al. 2010) Personal communication with Bao Le, Long

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
				Based upon the low sample size but favorable preliminary results in 2009, Douglas PUD conducted a second year of study in 2010 with minor study design changes including increasing the daily sampling period and the overall study period, and the elimination of the low velocity treatment. The 2010 Columbia River basin lamprey run was one of the lowest on record. Although DIDSON data is still being processed, very few lamprey were observed at Wells Dam. A final report will be available in early 2011.		View Associates (12/13/10)
41.	Lift picket leads at count station at Washington-shore fish ladder	Bonneville	Columbia	To improve passage at the Washington-shore fish ladder, the picketed lead was raised to allow lamprey to access the AWS channel which led to an LPS.	ACOE	Personal communication with Sean Tackley, ACOE (12/14/10)
42.	Maintain fishway operations criteria	Rock Island	Columbia	Pursuant to the Rocky Reach and Rock Island Fish Passage Plan (Chelan PUD 2010), fishway operations criteria are in place.	Chelan PUD	Personal communication with Jeff Osborn, Chelan PUD (12/20/10)
43.	Maintain fishway operations criteria	Priest Rapids, Wanapum	Columbia	Pursuant to the Project Fishway Operation Plan (Grant PUD 2009), fishway operations criteria are maintained.	Grant PUD	Personal communication with Mike Clement, Grant PUD (12/22/10)
	Project Passage Effectiveness					
44.	Evaluate adult lamprey migration through the lower Columbia River	Bonneville, The Dalles, John Day, McNary, Ice Harbor, Priest Rapids, Wanapum	Columbia and Snake	In 2009, 596 radio-tagged adult lamprey were released downstream from Bonneville Dam. Of these 79% approached Bonneville, 64% entered and 30% eventually passed the dam, 19% reached The Dalles Dam, 7% reached John Day Dam and 2% reached McNary Dam. Dam passage efficiencies ranged from 39 to 80% per dam.	ACOE (prepared by the University of Idaho Cooperative Fish and Wildlife	General passage and fishway use summaries for adult Pacific lamprey at Bonneville, The Dalles and John Day dams, 2009

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
				Fishway passage efficiencies ranged from 49 to 80% per dam. Fishway entrance efficiencies ranged 35 to 64% at Bonneville Dam, 54% at John Day Dam (south shore only), and 81 to 100 % at The Dalles and McNary dams. Median passage times were 7.4 d at Bonneville, 4.8 d at The Dalles, and 3.8 d at John Day dams. Areas of passage difficulty were at transition pools, count windows, serpentine weirs and some entrances. Fallback was 18%, 13%, and 24% at the three dams.	Research Unit and NOAA Fisheries)	(Clabough et al. 2010b)
45.	Monitor adult lamprey at Bonneville Dam	Bonneville	Columbia	In 2007 and 2008, HDX PIT detectors were added to the top of the Cascades Island defunct ladder exit. In both years, approximately 8% of PIT-tagged lampreys were detected on these detectors indicating lamprey may be delayed within this dead-end channel. This location may be a candidate for future LPS.	ACOE (prepared by NOAA Fisheries)	Development of passage structures for adult Pacific lamprey at Bonneville Dam, 2007-2008 (Moser et al. 2010a)
46.	Evaluate fishway use at Bonneville and the Dalles dams and behavior at the Bonneville Dam count windows	Bonneville, The Dalles	Columbia	1,589 adult lampreys were radio-tagged and released at Bonneville Dam over three years, 2007-2009. Over the three years, the percentages of tagged lamprey that returned to the dam following released ranged from 68 to 79%. The greatest portion made their first approach at fishways for PH2, which had the priority for flow during this period. The proportion that entered the entrance that they first approached ranged from 33% (PH2 north entrance 2007) to 75% (PH2 south entrances 2007). Overall entrance efficiencies ranged from 6 to 53%. Of the fish that reached the dam, 31 to 38% were known to have passed.	ACOE and USFWS (prepared by the University of Idaho Cooperative Fish and Wildlife Research Unit)	Effects of lowered fishway water velocity on fishway entrance success by Pacific lamprey at Bonneville Dam, 2007-2009 (E.L. Johnson et al. 2010)

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
47.	Evaluate adult lamprey migration and behavior at McNary and Ice Harbor Dams	McNary, Ice Harbor	Columbia and Snake	During the 2009 Pacific lamprey migration, radio-telemetry and half-duplex PIT tag (HDX) monitoring were used to calculate passage efficiency and identify areas of difficult passage at McNary Dam. Dam passage efficiency was 56% (47 of 84). Values for previous four years ranged 12 to 41%. Entrance and fishway passage efficiencies were 93 and 89%, respectively. Later lamprey were more likely to successfully pass the dam. Most lamprey used the Oregon-shore fishway. Median passage times was 7.8 d. Passage times for passage segments were provided. Of 47 lamprey that passed McNary Dam, 72% reached upstream projects. Median reservoir passage times were 1.5 d from McNary to Ice Harbor Dam (n=3; one later reached Priest Rapids) and 12.4 d to Priest Rapids Dam (n=32). 79 lamprey were collected and PIT tagged at John Day Dam and released either near John Day Dam or at standard sites at McNary Dam. There was not a significant difference in detection rates or passage times between groups.	ACOE (prepared by the University of Idaho Cooperative Fish and Wildlife Research Unit)	Evaluation of adult Pacific lamprey migration and behavior at McNary Dam with effects of night-time fishway flow reduction,2009 and detection and behavior of translocated adult Pacific lamprey (Boggs et al. 2010)
48.	Evaluate adult lamprey passage at Willamette Falls	Willamette Falls	Willamette	The purpose of the 2009 study was to evaluate lamprey passage following improvements in the ODFW fishway (primarily improved hydraulic conditions in entrance 1, and cleaning of diffuser system). To date, 143 lamprey have been tagged. Preliminary results indicate that passage at the project has improved (42% so far) which historically has seen only 35% (two other studies saw 23 and 24%) of the fish returning to the project, passing upstream (based on return to vicinity of tailrace, not just fish entering the ladder). No test fish have been seen passing the experimental lamprey ramps and passage features	PGE	Personal communication with Tim Shibahara, PGE (12/9/10)

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
				(4 total; installed in 2009); however, an unquantified number of lamprey have been seen passing. The 2009 evaluation was finalized spring of 2010. The numbers previously stated held true to the end of the study. We are currently receiving comments from the agencies on the draft report and expect to finalize in December of 2010. In 2010, the Willamette Falls project continued to place lamprey ramps on the falls. There were no evaluations to enumerate but many were seen passing over the ramps.		
49.	Evaluate fishway modifications	Priest Rapids, Wanapum	Columbia	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 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. Underwater video and an HDX PIT system were used to collect data from fish tagged downstream of Priest Rapids Dam. Pacific lamprey were not HDX PIT tagged in 2010 by Grant PUD (as agreed to by the PRFF) as returning numbers were insufficient to conduct the evaluation. Data analysis will be completed as part of 2011 activities.	Grant PUD	Personal communication with Mike Clement, Grant PUD (12/17/10)
	Lamprey Counts at Dams					
50.	Conduct 24-hour lamprey counts	McNary, Lower Granite	Columbia and Snake	Counts include nighttime video window counts.	ACOE	Personal communication with Sean Tackley,

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
						ACOE (12/14/10)
51.	Conduct 24-hour lamprey counts	Wells	Columbia	On-going 24-hour fishway monitoring since the 1990's.	Douglas PUD	Personal communication with Beau Patterson, Douglas PUD (12/7/10)
52.	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 Jeff Osborn, Chelan PUD (12/7/10)
53.	Conduct 24-hour lamprey counts	Priest Rapids, Wanapum	Columbia	On going 24-hour fishway monitoring since the mid 1990's.	Grant PUD	Personal communication with Mike Clement, Grant PUD (12/7/10)
54.	Estimate Pacific lamprey at Willamette Falls	Willamette Falls	Willamette	Underwater video will be used in combination with HDX PIT monitoring to estimate the number of adult Pacific lamprey passing Willamette Falls. During 2010, around 2,000 adult lamprey were collected and released downstream of the falls. HDX PIT sites were installed late in the migration season so data will be limited.	BPA/ACOE (prepared by CTWSR)	Personal communication Cyndi Baker, CTWSR (11/29/10)
55.	Assess adult lamprey upstream movements at count stations	John Day	Columbia	Underwater video cameras and recording equipment were used to evaluate numbers of adult Pacific lamprey passing upstream through picketed leads at the north-shore count station at John Day Dam. During 50 d we observed 211 (net) adult lamprey pass upstream through picketed leads. At this same time 29 adult lamprey were counted during daytime counts. 35% of lamprey were observed during nighttime hours. We estimate daytime counts underestimated upstream passage by factor of 8.6.	ACOE (prepared by USFWS and CRITFC)	Feasibility of using video to estimate night time passage of lamprey at the north ladder of John Day Dam (Fryer et al. 2010)
56.	Structural modifications to count station	John Day	Columbia	In 2010, the following modifications were made at the north ladder:	ACOE	John Day Lock and Dam north fish

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
				- Raise count station floor one foot to match invert at new weir 1 (holey wall site) - Remove 23-inch ramp through count slot and lower viewing window by 11.5 inches - Upgrade count station lighting and add automated brush cleaner for viewing window - Replace antiquated crowder, adding new transition farings and horizontal vanes		ladder exit section and count station improvements, Design Documentation Report No. 1 (ACOE 2009a)
57.	Structural modifications to fish count stations	Priest Rapids, Wanapum	Columbia	During the 2009-2010 winter maintenance period, fish count station crowder structures were installed at the count stations to improve lamprey passage.	Grant PUD	Personal communication with Mike Clement, Grant PUD (12/20/10)
	Predation					
58.	Establish predation control measures (sea lions)	Bonneville	Columbia	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 2009b)
	Juvenile Passage at Hydroelectric Facilities					
	Structural and Operational Fishway Modifications					
59.	Lift/remove extended length screen during outmigration	McNary	Columbia	Installation of extended screens were delayed in the spring to reduce impacts to juvenile lamprey migrating out early.	ACOE	Personal communication with Sean Tackley, ACOE (12/14/10)
60.	Continue salvage activities during ladder maintenance de-watering	All ACOE projects	Columbia / Snake	Modifications to dewatering procedures to reduce strandings 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	ACOE	Personal communication with Sean Tackley, ACOE (12/14/10)

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
				lamprey to move through gratings when stranded; and adequate personnel and equipment to ensure timely salvage.		
61.	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 Lamprey Management Plan.	Douglas PUD	Personal communication with Beau Patterson, Douglas PUD (12/7/10)
62.	Continue salvage activities during ladder maintenance de-watering	Rocky Reach, Rock Island	Columbia	Pursuant to the Rocky Reach and Rock Island HCPs (Chelan PUD 2002a and 2002b), dewatering protocols are in place.	Chelan PUD	Personal communication with Jeff Osborn, Chelan PUD (12/7/10)
63.	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 species during ladder maintenance activities.	Grant PUD	Personal communication with Mike Clement (12/7/10)
64.	Maintain bypass operations criteria	Rock Island	Columbia	Pursuant to the Rocky Reach and Rock Island Fish Passage Plan (Chelan PUD 2010), bypass operations criteria are in place.	Chelan PUD	Personal communication with Jeff Osborn, Chelan PUD (12/20/10)
65.	Maintain bypass operations criteria	Priest Rapids, Wanapum	Columbia	Grant PUD has existing bypass systems, which includes gatewells, spillways, the Wanapum Future Unit Fish Bypass (WFUFB), and Priest Rapids Top-Spill Bypass.	Grant PUD	Personal communication with Mike Clement, Grant PUD (12/22/10)
	Project Passage Effectiveness					
66.	Develop biological criteria for an active juvenile tag	N/A	N/A	In 2009 and 2010, juvenile lamprey were collected at McNary Dam juvenile bypass system and transported to Dworshak National fish Hatchery. Dummy transmitters of various sizes and weights were fashioned from lead and plastic resin (2009)	ACOE (prepared by USFWS)	Personal communication with Chris Peery, USFWS (12/5/10)

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
				or metal stock in plastic coating (2010) and surgically inserted into the fish. Some lamprey were also tagged with PIT-tags and sham-tags others to provide a point of reference. On average, tagged fish survived two weeks post-tagging as compared to three weeks for sham-tagged lamprey. For dummy-tagged fish, width of dummy tag had the higher correlation ($r^2 = 0.65$) as compared to tag length, weight and volume. For juvenile lamprey that averaged 159 mm length and 5.2 g weight, tags of 15 mm length, 2.0 to 2.25 mm width and up to 0.33 g appear feasible.		
67.	Develop PIT-tagging protocols for juvenile lamprey	N/A	N/A	In 2009-2010, fish ranging from about 100 – 190 mm in length were collected in June from the John Day Dam, transferred to the USGS laboratory, and groups of fish were subjected to one of three treatments: (1) surgical PIT tag insertion via an incision along the mid-ventral line; (2) PIT tag insertion via an incision lateral to the mid-ventral line; and (3) handling and anesthesia only (control fish). After applying the treatments, fish were held for 32 days and mortality and tag loss were monitored. Mortality was related to fish size and temperature in all groups. Most of the fish that died had fungal, parasitic, or bacterial infections. During the tests no tags were lost and incisions healed well. Survival was best (97%) at 9°C, lowest at 12°C (28%) and intermediate (64%) at 15°C over 40 d. Fish over 150 mm and longer could be easily tagged. Fish transitioned slowly to saltwater experienced high survival up to day 94, after which, survival gradually declined.	USGS	Development of standard protocols for tagging juvenile lampreys with Passive Integrated Transponder (PIT) tags.[DRAFT] (Mesa et al. 2010)
68.	Monitor passage timing, number, and mortalities of juvenile lamprey collected at	Bonneville, McNary, Lower	Columbia and Snake	Monitoring is occurring at all of the identified projects.	ACOE	Personal communication with Sean Tackley,

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
	projects with juvenile fish bypass facilities	Monumental, Little Goose, Lower Granite				ACOE (12/14/10)
69.	Evaluation of prototype turbine intake emergency gatewell exclusion screens	Priest Rapids, Wanapum	Columbia	During the 2010 juvenile salmon outmigration period, turbine intake emergency wheelgate exclusion screens were monitored at the Project using DIDSON. Although the study was primarily focused on juvenile salmonid outmigrants, small numbers of lamprey were observed in the monitored locations of both dams. In total, 31 and 161 lamprey were observed at Wanapum and Priest Rapids dams, respectively. Over the entire study period, no negative impacts or screen impingement events were observed. A final report will be available in 2011.	Grant PUD	Personal communication with Mike Clement, Grant PUD (1/14/11)
	Predation					
70.	Establish predation control measures (pike minnows and birds)	All ACOE projects	Columbia	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 2009b)
71.	Predation control measures	Wells	Columbia	As part of their HCP obligations, Douglas PUD implements predation control activities. The northern pikeminnow control program to protect outmigrating juvenile anadromous salmonids removes approximately 20,000 northern pikeminnow annually. Nonlethal avian control actions include maintenance of a wire array over the tailrace to hinder avian predators, and hazing with foot patrols, motorized vehicles (boats and	Douglas PUD	Personal communication with Beau Patterson, Douglas PUD (12/13/10)

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
				pickups) and pyrotechnics. These activities are also expected to indirectly benefit outmigrating juvenile lamprey at the project.		
72.	Predation control measures	Rocky Reach, Rock Island	Columbia	Controlling predators of juvenile salmonids, both fish and birds, is another tool Chelan PUD is using to contribute to achieving HCP survival standards for juvenile fish. 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, 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 61,215 Northern pikeminnow annually from Rocky Reach and Rock Island Project areas combined, and a total of 428,505 Northern pikeminnow from 2003 to 2009.	Chelan PUD	Personal communication with Jeff Osborn, Chelan PUD (12/14/10)
73.	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 BiOp. These measures include use of lethal and non-lethal control and monitoring presence and absence of juvenile lamprey through dietary sub sampling. These predation control activities are expected to indirectly benefit outmigrating juvenile lamprey at the project.	Grant PUD	Personal communication with Mike Clement, Grant PUD (12/10/10)
	Policy/Recovery Activities					
74.	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") finalized a lamprey restoration plan for the Columbia River basin.	Nez Perce, Umatilla, Yakama and Warm Springs tribes	Tribal Pacific lamprey restoration plan for the Columbia River basin (Nez Perce,

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
				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 2010 (see other categories in Table 3).		Umatilla, Yakama, and Warm Springs Tribes 2009)
75.	Develop/implement implementation plan for Pacific lamprey restoration	All ACOE projects	Columbia and Snake	In July 2009, ACOE finalized its 10-year (2008-2018) passage improvements implementation plan. Pursuant to a May 2008 MOA between the Action Agencies (ACOE and USFWS), the Accord Treaty Tribes (Umatilla, Warm Springs, and Yakama) and the Columbia River Inter-Tribal Fish Commission, the ACOE collaborated with the tribes and the USFWS to develop a 10-year lamprey plan that provides a proposed funding stream and total cost of implementing improvements, and identifies specific actions to be considered to improve lamprey passage and survival.	ACOE	ACOE Pacific lamprey passage improvements implementation plan, 2008-2018 (ACOE 2009b)
76.	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 and protocol development, and participation in regional conservation and recovery activities. Early implementation of some management plan activities is underway.	Douglas PUD	Personal communication with Bao Le, Long View Associates (12/7/10)
77.	Develop/implement management plan for Pacific lamprey restoration	Rocky Reach	Columbia	On-going implementation of the PLMP that was developed and finalized in 2005. In addition to fishway evaluations and activities to	Chelan PUD	Rocky Reach Pacific Lamprey Management Plan (Chelan PUD 2005)

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
				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.		
78.	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 and protocol development, and participation in regional conservation and recovery activities.	Grant PUD	Priest Rapids PLMP (Grant PUD 2009)
79.	Best Management Practices	N/A	N/A	The purpose of this document is to provide information on Best Management Practices for Pacific lamprey that can be incorporated into any stream disturbing activity (e.g., aquatic habitat restoration, prescribed fire, recreational development, grazing, gravel extraction/mining, water diversions, etc.) on lands managed by the Forest Service and Bureau of Land Management throughout the range of Pacific lamprey. In addition, this information can help other federal, state, tribal and private land managers with implementing stream disturbing activities that also afford protection for individual lamprey and lamprey populations.	USFWS	Best Management Practices to Minimize Adverse Effects To Pacific Lamprey (USFWS 2010)
80.	Lamprey Technical Work Group • Passage Subgroup • Translocation	All ACOE projects, Wells, Rocky Reach, Rock	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	USFWS	Personal communication with Bao Le, Long View Associates

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
	Subgroup	Island, Priest Rapids		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 2010, the CRBLTWG met twice (3/11/10 and 10/19/10). Additional subgroup meetings were convened during the year to discuss lamprey passage standards and translocation. In 2010, the Passage Standards Subgroup completed a draft of the second phase of the Pacific Lamprey Passage Metrics exercise. A phase 3 subgroup will be convened in 2011to determine which of the metrics are measurable with scientific rigor and then to quantify the effects of biological relevance. In 2010, the Translocation Subgroup completed a literature review paper outlining the potential benefits and risks of translocation. The paper will be provided to the Anadromous Fish Committee to determine next steps for dissemination.		(12/7/10)
81.	Pacific Lamprey Conservation Initiative	All ACOE projects, Wells, Rocky Reach, Rock Island, Priest Rapids	Columbia and Snake	The Pacific Lamprey Conservation Initiative, developed in 2007, is an effort led by the USFWS to facilitate communication and coordination for the conservation of Pacific lampreys throughout their range. The primary goal of the initiative is to develop a Pacific Lamprey Conservation Plan (Plan) which will initiate the implementation of conservation actions and research to restore and sustain habitat and Pacific lamprey populations throughout their range. In 2010, the Conservation Initiative Team	USFWS	Personal communication with Christina Luzier, USFWS (12/9/10)

	Activity	Hydroelectric Project	River	Results / Description of Activity	Lead Entity(ies)	Source
				completed the first draft of the Pacific Lamprey Draft Assessment and Template for Conservation Measures (formerly the Pacific Lamprey Conservation Plan). The USFWS is currently reviewing comments received during the comment period (October 29, 2010 to December 3, 2010).		

Notes:
ACOE = Army Corps of Engineers
AWS = auxiliary water supply
BPA = Bonneville Power Administration
CBFWA = Columbia Basin Fish and Wildlife Authority
CRBLTWG = Columbia River Basin Lamprey Technical Work Group
CRITFC = Columbia River Inter-Tribal Fish Commission
CTUIR = Confederated Tribes of the Umatilla Indian Reservation
CTWSR = Confederated Tribes of the Warm Springs Reservation
DIDSON = Dual-frequency Identification Sonar
HCP = Habitat Conservation Plan
HDX = half duplex
LPS = lamprey passage system
mm = millimeters
N/A = not applicable
NMFS = National Marine Fisheries Service
ODFW = Oregon Department of Fish and Wildlife
OSU = Oregon State University
PGE = Portland General Electric
PIT = Passive Integrated Transponder
PLMP = Pacific Lamprey Management Plan
PNNL = Pacific Northwest National Laboratory, Battelle
PRB = Pelton Round Butte
PRFF = Priest Rapids Fish Forum
PUD = Public Utility District
RM = river mile
USBOR = U.S. Bureau of Reclamation
USFWS = U.S. Fish and Wildlife Service
USGS = U.S. Geological Survey

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 4. 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 2010 and any variations in schedule. In general, measures are currently on schedule except for one task which has been delayed with implementation under consideration as appropriate.

Table 4 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 2010	Variation from Schedule (if applicable)
Objective 1: Identify, address, and fully mitigate Project effects to the extent reasonable and feasible to achieve NNI					
1.	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, 2011.	No
Objective 2: Provide safe, effective, and timely volitional passage for adult upstream and downstream migration					
2.	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
3.	Develop adult Pacific lamprey passage criteria.	To be determined by the PRFF. Annual passage detection monitoring initiated in July 2010.	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.	No

	Implementation Measure	Evaluation Timeframe	Relevant to Current Reporting Period	Action Taken in 2010	Variation from Schedule (if applicable)
4.	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 fish video count stations at the Project 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 2010	Variation from Schedule (if applicable)
5.	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 left and right bank fishways and the Wanapum left bank fishway facilities during the 2009-2010 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 is to collect data in support of determining whether the modifications improved adult passage. Data analysis is expected to be completed as part of 2011 activities.	No
6.	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)	Yes	Grant PUD completed improvements proposed in the FLA and included in the FERC License. Modifications at Priest Rapids Dam include plating at edges of diffusion grating, plating through orifices adjacent to diffusion grating, ramps at perched orifices, and new crowders at fish counting stations designed for both lamprey and salmonids. These structural improvements were completed during the 2009-2010 winter fish ladder maintenance outage.[1]	No

[1] Typically scheduled between December 1 and February 28.

	Implementation Measure	Evaluation Timeframe	Relevant to Current Reporting Period	Action Taken in 2010	Variation from Schedule (if applicable)
7.	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. Underwater video and HDX PIT data from fish tagged in the lower river have been collected to assess lamprey movement and behavior are currently being evaluated. Pacific lamprey were not HDX PIT tagged in 2010 by Grant PUD (as agreed to by the PRFF) as returning numbers were insufficient to conduct the evaluation.	Yes, ahead of schedule
8.	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
9.	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
10.	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

	Implementation Measure	Evaluation Timeframe	Relevant to Current Reporting Period	Action Taken in 2010	Variation from Schedule (if applicable)
11.	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 Columbia River Basin Lamprey Technical Workgroup.	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
12.	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
Objective 3: Provide safe, effective and timely volitional passage for juvenile migration					
13.	Identify and mitigate for Project effects on juvenile Pacific lamprey	No later than 10 years following license issuance (2018)	Yes	In 2010, Grant PUD evaluated turbine intake emergency wheelgate exclusion screens at the Project using DIDSON. Although the study was focused on juvenile salmonids, small numbers of lamprey were also observed. Results indicate that negative impacts or impingement in these areas of the Project did not occur.	Yes
14.	Develop juvenile Pacific lamprey passage criteria	Unspecified	No	None. At this time, technology does not exist to measure juvenile Pacific lamprey passage.	No
15.	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 Columbia River Basin Lamprey Technical Workgroup.	Annually for the life of the license	Yes	Grant PUD is an active participant in all regional forums including workgroups, subgroups, initiatives and associated meetings that are described in Table 3 of Section 2.2.	No

	Implementation Measure	Evaluation Timeframe	Relevant to Current Reporting Period	Action Taken in 2010	Variation from Schedule (if applicable)
Objective 4: Avoid and mitigate Project impacts on rearing habitat					
16.	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)	No	None. 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.	No

Notes:
CRITFC = Columbia River Inter-Tribal Fish Commission
FERC = Federal Energy Regulatory Commission
FLA = Final License Application
NNI = No Net Impact
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 5 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:

1). "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.

2). "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.

3). "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 3 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 3. For planned or proposed efforts (which are not identified as current activities in Table 3) the source of the information is noted at the end of Table 5.

Table 5 Pacific lamprey activities in the Columbia River basin and applicability to the Priest Rapids Project.

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P[1] or Proposed = PR[2]	River(s)	Table 3 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.	Determine the extent of adult spawning	No associated hydro project (I) Winchester Dam (I)	Deschutes Warm Springs, Shitike Creek North Umpqua	#1 #2 #18	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) Rocky Reach (P)	Columbia Columbia	N/A[3] N/A[4]	No.	No. This activity is not required by Grant PUD's PLMP.	N/A
3.	Monitor adult population status and trends (unrelated to counting at hydroelectric projects)	No associated hydro project (I)	Deschutes	#3	No.	No. This activity is not required by Grant PUD's PLMP.	N/A
4.	Determine the extent of juvenile rearing habitat	No associated hydro project (I) Wells (P) Rocky Reach (P) Priest Rapids and Wanapum (P)	Deschutes, Crooked, Metolius Columbia Columbia Columbia	#4 N/A[3] N/A[4] N/A[5]	No.	Yes. PLMP Objective 4 requires quantification of lamprey habitat in the Project area.	Yes. Habitat surveys will be conducted to detect presence/absence and Project effects within the PRPA within 10 years of license issuance.
5.	Develop measures to protect juvenile rearing habitat	Wells (P) Rocky Reach (P)	Columbia Columbia	N/A[3] N/A[4]	No.	No. This activity is not required by Grant PUD's PLMP.	N/A

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P[1] or Proposed = PR[2]	River(s)	Table 3 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)	No associated hydro project (I) Wells (P) Rocky Reach (P) Priest Rapids and Wanapum (P)	Klickitat Entiat and Wenatchee Methow Columbia Columbia Columbia	#5 #6 #7 N/A[3] N/A[4] N/A[5]	No.	Yes. PLMP Objective 4 requires the assessment of juvenile presence / absence and relative abundance.	Yes. Population surveys will be conducted to detect presence / absence and Project effects within the PRPA within 10 years of license issuance.
7.	Evaluate lamprey physiology, energy use, swimming performance	N/A (I) N/A (I) Willamette Falls (I)	N/A N/A Willamette	#8 #9 #10	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.	Implement and monitor translocation or supplementation programs from mainstem dams to upstream watersheds	Lower Granite (I) Three-Mile Dam (I)	Snake Umatilla	#11 #12	Yes.	No. This activity is not required by Grant PUD's PLMP.	N/A
9.	Evaluate the impact of contaminants on lamprey	No associated hydro project (I) No associated hydro project (I)	Willamette and Siletz Lower Willamette	#13 #14	No.	No. This activity is not required by the PLMP. Evaluating the impact of contaminants on lamprey 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[1] or Proposed = PR[2]	River(s)	Table 3 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost Effective for Priest Rapids Project
10.	Develop technologies for sampling juveniles in deep water habitat	No associated hydro projects (I)	Snake	#15	No.	No. This activity is not required by the PLMP. Developing technologies for 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.	N/A
11.	Determine genetic structure and maintain genetic integrity	PR (as identified in the Tribal Pacific Lamprey Restoration Plan for the Columbia River)	N/A	N/A	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
12.	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	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

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P[1] or Proposed = PR[2]	River(s)	Table 3 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost Effective for Priest Rapids Project
13.	Evaluate the need for a lamprey aquaculture facility based upon a limiting factor analysis	PR (as identified in the Tribal Pacific Lamprey Restoration Plan for the Columbia River)	N/A	N/A	No.	No. This activity is not required by the PLMP.	N/A
14.	Restore tributary habitat and passage	PR (as identified in the Tribal Pacific Lamprey Restoration Plan for the Columbia River)	N/A	N/A	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
	Lamprey Migration in Rivers						
15.	Evaluate adult migration in rivers	Bonneville (I) Dalles (I) John Day (I) McNary (I) Ice Harbor (I) Priest Rapids (I) Wanapum (I) Willamette Falls (I) Winchester Dam (I)	Columbia Columbia Columbia Columbia Snake Columbia Columbia Willamette North Umpqua	#16 #16 #16 #16 #16 #16 #16 #17 #18	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 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.

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P[1] or Proposed = PR[2]	River(s)	Table 3 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost Effective for Priest Rapids Project
16.	Assess impacts of irrigation water withdrawal structures on juvenile passage/habitat	N/A (I)	N/A	#19	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
	Adult Passage at Hydroelectric Facilities						
	Structural and Operational Fishway Modifications						
17.	Inspect / inventory / document / assess structural improvements for fishway	Priest Rapids and Wanapum (I) Wells (P)	Columbia Columbia	#20 N/A[3]	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. Underwater video and HDX PIT data from fish tagged in the lower river have been collected to assess lamprey movement and behavior are currently being evaluated. Pacific lamprey were not HDX PIT tagged in 2010 by Grant PUD (as agreed to by the PRFF) as returning numbers were insufficient.

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P[1] or Proposed = PR[2]	River(s)	Table 3 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) Priest Rapids and Wanapum (I) Wells (P)	Columbia Columbia Columbia	#21 #78 N/A[3]	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).
19.	Install/evaluate lamprey passage system (LPS)	Bonneville (I) Three-Mile Dam (I) John Day (P) McNary (P)	Columbia Umatilla Columbia Columbia	#22, 23, 25 #24 N/A[6] N/A[6]	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 project, this method would not be appropriate to implement.	N/A
20.	Install/evaluate slotted "keyhole" fishway entrances	Bonneville (I) Priest Rapids and Wanapum (I) John Day (P) McNary (P)	Columbia Columbia Columbia Columbia	#25 #26 N/A[6] N/A[7]	Yes.	Yes. Keyhole entrances are currently utilized at both Wanapum and Priest Rapids dams.	Yes. See adjacent response.
21.	Develop / implement / evaluate ladder dewatering procedures	All ACOE projects[8] (I) Wells (I) Rocky Reach (I) Rock Island (I) Priest Rapids and Wanapum (I)	Columbia / Snake Columbia Columbia Columbia Columbia	#27 #28 #29 #29 #30	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.

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P[1] or Proposed = PR[2]	River(s)	Table 3 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost Effective for Priest Rapids Project
22.	Rehabilitate old or existing fishway for lamprey passage	Willamette Falls (P)	Willamette	#31	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, 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)	ACOE projects (exact ones unspecified) (P) Wells (P)	Columbia / Snake Columbia	N/A[6] N/A[3]	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 has replaced the fish count stations at both dams with picket-lead grating that is 11/16-inch gap to ensure accurate adult counts.	N/A

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P[1] or Proposed = PR[2]	River(s)	Table 3 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	McNary (I) Ice Harbor (I) Priest Rapids (I) John Day (P) Rocky Reach (P)	Columbia Snake Columbia Columbia Columbia	#32 #32 #33 N/A[7] N/A[9]	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).
25.	Install lamprey orifices	McNary (I)	Columbia	#34	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
26.	Install/evaluate ramps at sills and lips	Priest Rapids (I) The Dalles (P) John Day (P) McNary (P) Ice Harbor (P) Rocky Reach (P)	Columbia Columbia Columbia Columbia Snake Columbia	#35 N/A[7] N/A[7] N/A[7] N/A[7] N/A[9]	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.

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P[1] or Proposed = PR[2]	River(s)	Table 3 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	McNary (I) The Dalles (I) John Day (P) Ice Harbor (P)	Columbia Columbia Columbia Snake	#36 #37 N/A[7] N/A[7]	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
28.	Reduce/evaluate ladder entrance flow velocities at night	Bonneville (I) McNary (I) Wells (I) Priest Rapids (P) Ice Harbor (P)	Columbia Columbia Columbia Columbia Snake	#38 #39 #40 N/A[10] N/A[6]	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).

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P[1] or Proposed = PR[2]	River(s)	Table 3 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost Effective for Priest Rapids Project
29.	Modify/evaluate weir head differentials	PR (as identified in the Tribal Pacific Lamprey Restoration Plan for the Columbia River)	N/A	N/A	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.
30.	Manage flows to a peaking hydrograph	PR (as identified in the Tribal Pacific Lamprey Restoration Plan for the Columbia River)	N/A	N/A	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
31.	Establish protocol for formal inspection of passage facilities	Priest Rapids and Wanapum (I)	Columbia	#78	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.
32.	Establish protocol for annual lamprey passage reporting	Priest Rapids and Wanapum (I)	Columbia	#78	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.
33.	Develop and/or maintain fishway operations criteria	Bonneville (I) Wells (I) Rocky Reach (I) Rock Island (I) Priest Rapids and Wanapum (I)	Columbia Columbia Columbia Columbia Columbia	#41 #76 #77 #42 #43	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).	Yes. Specific operations criteria are presented in Grant PUD's Project Adult Fishways Operational Plan (Grant PUD 2008).

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P[1] or Proposed = PR[2]	River(s)	Table 3 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						
34.	Develop adult lamprey passage criteria	Rocky Reach (P) Priest Rapids and Wanapum (P)	Columbia Columbia	N/A[4] N/A[5]	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.
35.	Evaluate effectiveness of dam passage	Bonneville (I) The Dalles (I) John Day (I) McNary (I) Ice Harbor (I) Priest Rapids and Wanapum (I) Willamette Falls (I) Winchester Dam (I) Rocky Reach (P)	Columbia Columbia Columbia Columbia Snake Columbia Willamette North Umpqua Columbia	#44, 45, 46 #44, 46 #44 #44, 47 #44, 47 #44, 49 #48 #18 N/A[4]	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 dam passage efficiency. Pacific lamprey were not HDX-PIT tagged in 2010 by Grant PUD (as agreed to by the PRFF) as returning numbers were insufficient. On-going and subsequent studies will evaluate this metric.

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P[1] or Proposed = PR[2]	River(s)	Table 3 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost Effective for Priest Rapids Project
36.	Evaluate upstream passage modifications	Priest Rapids and Wanapum (I) Rocky Reach (P) [Note: evaluations performed on existing structural / operational improvements at ACOE dams are identified earlier in the table, under the heading, *Structural and Operational Fishway Modifications*.]	Columbia Columbia	#49 N/A[4]	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 modification 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. Data analysis will be completed as part of 2011 activities.
	Lamprey Counts at Dams						
37.	Develop feasibility, techniques, and protocols to improve 24-hour counting / conduct counts	McNary (I) Lower Granite (I) Wells (I) Rocky Reach (I) Rock Island (I) Priest Rapids and Wanapum (I) Willamette Falls (I)	Columbia Snake Columbia Columbia Columbia Columbia Willamette	#50 #50 #51 #52 #52 #53 #54	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.

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P[1] or Proposed = PR[2]	River(s)	Table 3 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost Effective for Priest Rapids Project
38.	Develop/evaluate passage alternatives related to count facilities	John Day (I) Priest Rapids and Wanapum (I) Wells (P)	Columbia Columbia Columbia	#55, 56 #57 N/A[3]	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"). Grant PUD expects fish count accuracy to be at or near 100% for adult lamprey and other fishes.
	Predation						
39.	Establish predation control measures (sea lions)	Bonneville (I)	Columbia	#58	Yes.	No. Sea lions are not present in the PRPA.	N/A
	Juvenile Passage at Hydroelectric Facilities						
	Structural and Operational Fishway Modifications						
40.	Conduct a literature review of juvenile Pacific lamprey passage and survival	Priest Rapids and Wanapum (I) Wells (P)	Columbia Columbia	#78 N/A[3]	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.

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P[1] or Proposed = PR[2]	River(s)	Table 3 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost Effective for Priest Rapids Project
41.	Replace turbine intake screens with smaller spacing	All ACOE projects (P)	Columbia / Snake	N/A[7]	No.	No. Grant PUD dams are not equipped with turbine intake or diversion screens.	N/A
42.	Lift/remove extended length screens during outmigration	McNary (I)	Columbia	#59	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
43.	Manage flows to a peaking hydrograph	PR (as identified in the Tribal Pacific Lamprey Restoration Plan for the Columbia River)	N/A	N/A	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
44.	Establish/continue salvage activities during ladder maintenance de-watering	All ACOE projects (I) Wells (I) Rocky Reach (I) Rock Island (I) Priest Rapids and Wanapum (I)	Columbia / Snake Columbia Columbia Columbia Columbia	#60 #61 #62 #62 #63	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.

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P[1] or Proposed = PR[2]	River(s)	Table 3 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost Effective for Priest Rapids Project
45.	Develop and/or maintain bypass operations criteria	Wells (I) Rocky Reach (I) Rock Island (I) Priest Rapids and Wanapum (I)	Columbia Columbia Columbia Columbia	#76 #77 #64 #65	Yes.	Yes. Grant PUD has existing bypass systems, which includes gatewells, spillways, the Wanapum Future Unit Fish Bypass (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.
	Project Passage Effectiveness						
46.	Evaluate tagging and development of miniature tags	N/A N/A	N/A N/A	#66 #67	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
47.	Develop juvenile lamprey passage criteria	Priest Rapids and Wanapum (P)	Columbia	N/A[5]	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.

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P[1] or Proposed = PR[2]	River(s)	Table 3 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost Effective for Priest Rapids Project
48.	Evaluate downstream passage and survival when technology available	Wells (P) Rocky Reach (P) Priest Rapids and Wanapum (P)	Columbia Columbia Columbia	N/A[3] N/A[4] N/A[5]	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.
49.	Monitor passage timing, number, and mortalities of juvenile lamprey collected at projects with juvenile fish bypass facilities	Bonneville (I) McNary (I) Lower Monumental (I) Little Goose (I) Lower Granite (I)	Columbia Columbia Snake Snake Snake	#68 #68 #68 #68 #68	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
50.	Monitor and report on juvenile impingement	Rocky Reach (I) Priest Rapids and Wanapum (I)	Columbia Columbia	#77 #69	Yes.	Yes. The PLMP does not include a specific PM&E related to this activity; however, Grant PUD through its evaluation of juvenile salmonid outmigration escapement at turbine intake emergency wheelgate exclusion screens at Priest Rapids and Wanapum dams did observe small numbers of lamprey in these areas. Results indicate that negative impacts or impingement are not a concern.	Yes

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P[1] or Proposed = PR[2]	River(s)	Table 3 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost Effective for Priest Rapids Project
	Predation						
51.	Continue predation control measures (pike minnows and birds)	<u>Pike minnow only</u> All ACOE projects (I) <u>Pike minnow and birds</u> Wells (I) Rocky Reach (I) Rock Island (I) Priest Rapids and Wanapum (I)	Columbia / Snake Columbia Columbia Columbia Columbia	#70 #71 #72 #72 #73	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 be expected to provide a benefit to lamprey.
	<u>Policy and Recovery Activities</u>						
52.	Develop/implement Pacific Lamprey Management Plans	All ACOE projects (I) Wells (I) Rocky Reach (I) Priest Rapids and Wanapum (I)	Columbia / Snake Columbia Columbia Columbia	#74, 75 #76 #77 #78	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 this plan is in progress.
53.	Establish regional data protocols for collection, storage and analysis; develop means to widely access and share information	All ACOE projects (I) Wells (I) Rocky Reach (I) Priest Rapids and Wanapum (I) N/A (I)	Columbia / Snake Columbia Columbia Columbia N/A	#74, 75 #76 #77 #78 #79	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 Columbia River Basin Lamprey Technical Workgroup the USFWS Lamprey Conservation Initiative and the CRITFC Pacific Lamprey Recovery Plan planning processes.

	Activity in Basin (Proposed, Planned or Implemented)	Project where Implemented = I Planned = P[1] or Proposed = PR[2]	River(s)	Table 3 Cross-Reference	Consistent with Measures Taken at Other Projects	Appropriate to Implement at Priest Rapids Project	Cost Effective for Priest Rapids Project
54.	Establish coordinated public education and other outreach programs	Priest Rapids and Wanapum (I)	Columbia	#78	No.	Yes. The PLMP does not include a specific PM&E related to this activity; however, Grant PUD participates in education 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.
55.	Participate in regional lamprey activities	All ACOE projects (I) Wells (I) Rocky Reach (I) Priest Rapids and Wanapum (I)	Columbia / Snake Columbia Columbia Columbia	#74, 75, 80, 81 #76 #77 #78	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 Columbia River Basin Lamprey Technical Workgroup the USFWS Lamprey Conservation Initiative and the CRITFC Pacific Lamprey Recovery Plan planning processes.

Notes:

1. Defined as a measure identified for implementation in the ACOE Pacific Lamprey Passage Improvement Implementation Plan (ACOE 2009b) or the mid-Columbia PUDs' Pacific lamprey management plans (Chelan PUD 2005, Grant PUD 2009, and Douglas PUD 2009, respectively), that has not yet been implemented.
2. Defined as a measure identified in the Tribal Pacific Lamprey Restoration Plan for the Columbia River (Nez Perce, Umatilla, Yakama, and Warm Springs Tribes 2009), that has not already been implemented or planned by the ACOE or mid-Columbia PUDs.
3. Per requirement in Wells Project PLMP (Douglas PUD 2009).
4. Per requirement in Rocky Reach PLMP (Chelan PUD 2005).
5. Per requirement in Priest Rapids PLMP (Grant PUD 2009); see Table 4 for status.
6. Per commitment in ACOE's 10-year implementation plan (ACOE 2009b).
7. Per personal communications with David Clugston, ACOE (11/9/09, 11/10/09, and 12/11/09).
8. "All ACOE projects" includes Bonneville, The Dalles, John Day, McNary, Ice Harbor, Lower Monumental, Little Goose, and Lower Granite.
9. Planned for 2010-2011 fishway maintenance period, per personal communication with Jeff Osborn, Chelan PUD (12/13/10).
10. An evaluation of reducing fishway flows at night was planned for the 2009-2010 winter work period; however, the evaluation was done (as agreed to by the PRFF) as returning numbers were insufficient.

ACOE = Army Corps of Engineers
CRITFC = Columbia River Inter-Tribal Fish Commission
FERC = Federal Energy Regulatory Commission
FLA = Final License Application
HCP = Habitat Conservation Plan
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
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 second year of PLMP implementation, several planned activities were conducted on schedule. During the scheduled 2009-2010 winter fish ladder maintenance outage, structural improvements and monitoring equipment installations were made to the fishway facilities including:

1). Installation of aluminum plating over the diffuser grates, ramps at perched orifices, and through orifices in fishways at Priest Rapids Dam;
2). Installation of new fish count station crowder structures at the count stations of Priest Rapids and Wanapum dams specifically designed for accurate counts and volitional passage for both lamprey and salmonids;
3). Installation of HDX-PIT tag detection equipment and infrastructure at Priest Rapids and Wanapum dams;
4). Installation of underwater video equipment in select locations of the Priest Rapids right bank fishway;
5). Installation of an acoustic telemetry array in the junction pool fish entrances of Priest Rapids left bank fishway;
6). Installation of infrastructure used to trap/collect adult lamprey such as catwalks, davit systems, an automated pneumatic orifice closure device, and associated rail system; and
7). Modification of fish husbandry facilities used to hold and tag adult lamprey at Priest Rapids Dam.

In addition, Grant PUD conducted 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;
2). Evaluate the passage of adult lamprey through sections of the Priest Rapids fishways where new structures have been installed to facilitate upstream movement;
3). Determine if a reduction of flow (i.e., velocity) in the lower fishways at Priest Rapids Dam affects the use and passage of lamprey in lower sections of the fishway.

In 2010, the Columbia River return of adult Pacific lamprey was one of the lowest on record. As a result, tagging activities and parts of the study were postponed by Grant PUD in consultation with the PRFF. Specifically, HDX-PIT and acoustic tagging was postponed so that there would be no handling-effects on the low numbers of lamprey passing Priest Rapids Dam. Further, the PRFF determined that objective 3 (reduction in flows) was not appropriate to implement given its potential impacts on the passage of migrating salmon.

In summary, three of the 2010 study plan objectives were modified to some extent. Despite these limitations, Grant PUD was able to study aspects of objectives 1 (dam passage efficiency) and 2

(fishway structures use) through the use of passive monitoring techniques. First, using the newly installed HDX-PIT detection array at Priest Rapids and Wanapum dams, Grant PUD monitored the passage of lamprey that had been tagged at ACOE projects in the lower Columbia River, and collected valuable data for a small number of fish. Secondly, using the newly installed underwater camera array in the Priest Rapids right bank fishway, Grant PUD collected video of lamprey using newly installed plating on diffusion grates and through orifices, and passage events at the new fish crowders immediately downstream and approaching the count station. The analysis of these data are scheduled to be completed in 2011.

In addition to the planned activities for lamprey in 2010, Grant PUD evaluated turbine intake emergency wheelgate prototype exclusion screens at the Project using DIDSON. Although the study was originally developed to evaluate juvenile salmonid outmigrants, small numbers of juvenile and potential adult lamprey were observed at monitored locations at both Wanapum (n=31) and Priest Rapids (n=161) dams, although specific size and age class were indiscernible. 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).

In 2011, Grant PUD plans to complete PLMP-required activities and study planning / implementation efforts including:

1). PRFF on-site inspection of Priest Rapids and Wanapum fish facilities during the 2010-2011 winter fish ladder maintenance outage.
2). Pre-season testing and calibration of HDX-PIT arrays.
3). Preparation of lamprey trapping, tagging, and data protocols as to implement a passage study.
4). Tracking lamprey enumeration statistics for lower Columbia River dams.

If suitable numbers of adult Pacific lamprey migrate in 2011, the passage evaluation will begin with trapping activities on approximately July 15 and continue until the target number of lamprey (n=300) for tagging has been achieved. A combination of technologies will be used to monitor the behavior of Pacific lamprey, and quantify the overall passage effectiveness through standard metrics (Nass et al. 2003). Adult lamprey will be collected at Priest Rapids Dam, outfitted with HDX PIT tags, released downstream of the dam, and monitored using an array of detectors at Priest Rapids and Wanapum dams to measure passage efficiency. Acoustic telemetry will be used to evaluate the movement of lamprey through the bifurcation pool in the Priest Rapids Dam left bank fishway. Monitoring data will be assessed over the study period, and data analysis and reporting will be conducted during the period November 15, 2011 and March 31, 2012.

Also in 2011 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
PRFF Comments on Draft PLMP Comprehensive Annual Report

From: Verhey, Patrick M (DFW) [mailto:Patrick.Verhey@dfw.wa.gov]
Sent: Thursday, February 17, 2011 5:28 PM
To: Mike Clement; Tom Dresser
Cc: Mangold, Marcie (ECY); Hallock, Molly (DFW); Stephen_Lewis@fws.gov; Ross Hendrick; brose@yakama.com; Verhey, Patrick M (DFW)
Subject: revised - WDFW comments on the Priest Rapids 2010 Pacific Lamprey Management Plan Comprehensive Annual Report

Mike, thanks for the opportunity to comment on the 2010 Pacific Lamprey Management Plan Comprehensive Annual Report for the Priest Rapids Project. The document contains a wealth of information consolidated into one easily accessed location. We appreciate the effort and time Longview Associates and Grant PUD staff have invested in the development and writing of this comprehensive document. Based on our recent telephone conversation in regards to the small sample size of videotaped lamprey using the aluminum plating, I am retracting the comment. I believe we will have some time in the near future to discuss the lamprey video after your presentation to the Priest Rapids Fish Forum in order to determine whether or not it is important for Grant PUD to conduct additional studies to identify if there is or isn't a size class distinction of lamprey that use the plating.

Specific Comments:

- Page 11, section 2.1.3.3 WDFW recommends including Margaret Docker's latest information that was provided to the lamprey technical work group, regarding Pacific Lamprey Meta Populations.
- Page 12, section 2.1.4 second paragraph, please clarify which dam is being referenced in the sentence "Recent radio-telemetry studies 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."
- Page 13, section 2.1.4 fourth paragraph, please note which dams installed design enhancements during the 2009-2010 winter fish ladder maintenance outage.
- Page 77, section 5.0 second paragraph, Please identify the life stage, IE. juvenile or adult lamprey, in the sentence "Although the study was originally developed to evaluate juvenile salmonid out migrants, small numbers of lamprey were also observed at monitored locations at both Wanapum (n=31) and Priest Rapids (n=161) dams."

Let me know if you have any questions or concerns.

Patrick Verhey
WDFW Hydroelectric Mitigation Biologist
Conservation Planning Section
1550 Alder St N.W.
Ephrata, WA 98823
(509) 754-4624 ex. 213

WANAPUM

February 18, 2011

Public Utility District No. 2 of Grant County
Attn: Mike Clement
P.O. Box 878
Ephrata, WA

Re: Pacific Lamprey Management Plan Annual Report

Mr. Clement,

Wanapum acknowledge efforts being made toward license implementation on behalf of Grant PUD concerning the Pacific Lamprey Management Plan Comprehensive Annual Report. Wanapum participate in the PRFF to ensure Wanapum interests in pacific lamprey are considered. Pacific lamprey, among most species of Columbia River anadromous fish and especially those found in the Priest Rapids Project are very sacred to Wanapum and those affected by Grant PUD and the license should consider Wanapum input for a coordinated and parallel approach to maintain positive natural and cultural resource stewardship. Access to the Priest Rapids Project lands and waters for harvest, gather and religious purposes is a necessity for Wanapum and we request timely discussion on any activities that may cause unavoidable access restrictions.

If you have any questions regarding these comments, please call me at (509) 754-5088 ext. 3113.

Sincerely,

Rex Buck, Jr.
Wanapum

Appendix B
Summary of PRFF Comments on Draft PLMP Comprehensive Annual Report and Grant PUD Responses

Summary Table of Agency/Tribal Comment and Grant PUD Responses for 2010 PLMP Annual Comprehensive Report

Submitting Entity	Date Received	Paragraph #	Agency Comment	Grant PUD Response
WDFW	17-Feb-11 Email from Patrick Verhey to Mike Clement	1	Thanks for the opportunity to comment on the 2010 Pacific Lamprey Management Plan Comprehensive Annual Report for the Priest Rapids Project. The document contains a wealth of information consolidated into one easily accessed location. We appreciate the effort and time Longview Associates and Grant PUD staff have invested in the development and writing of this comprehensive document.	Comment noted.
		1	Based on our recent telephone conversation in regards to the small sample size of videotaped lamprey using the aluminum plating, I am retracting the comment. I believe we will have some time in the near future to discuss the lamprey video after your presentation to the Priest Rapids Fish Forum in order to determine whether or not it is important for Grant PUD to conduct additional studies to identify if there is or isn't a size class distinction of lamprey that use the plating.	Grant PUD believes that "conducting additional studies to identify if there is or isn't a size class distinction of lamprey that using the plating" is not a specific requirement of the PLMP. However, detection of a sufficient sample size of HDX PIT tagged adult lamprey over the next few years should result in evaluation of incidental information related to adult passage.
		2	Page 11, section 2.1.3.3 WDFW recommends including Margaret Docker's latest information that was provided to the lamprey technical work group, regarding Pacific Lamprey Meta Populations.	Grant PUD has modified page 11, section 2.1.3.3 to include this information.
		3	Page 12, section 2.1.4 second paragraph, please clarify which dam is being referenced in the sentence "Recent radio-telemetry studies 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."	Grant PUD has modified page 12, section 2.1.4 to provide clarification related to previous radio-telemetry evaluations on the lower Columbia River.
		4	Page 13, section 2.1.4 fourth paragraph, please note which dams installed design enhancements during the 2009-2010 winter fish ladder maintenance outage.	Grant PUD has modified page 13, section 2.1.4 to provide clarification on which dams were installed with enhancements during the 2009-2010 winter outages.
		5	Page 77, section 5.0 second paragraph, Please identify the life stage, IE. juvenile or adult lamprey, in the sentence "Although the study was originally developed to evaluate juvenile salmonid out migrants, small numbers of lamprey were also observed at monitored locations at both Wanapum (n=31) and Priest Rapids (n=161) dams."	Grant PUD has included additional information related to observations of varying life history stages of Pacific lamprey on page 77, section 5.0 related to Grant PUD's Gatewell Exclusion Screen Didson Evaluation in 2010.

Wanapum	18-Feb-11 Letter from Rex Buck Jr. to Mike Clement	1	Wanapum acknowledge efforts being made toward license implementation on behalf of Grant PUD concerning the PLMP Comprehensive Annual Report. Wanapum participate in the PRFF to ensure Wanapum interests in Pacific lamprey are considered. Pacific lamprey, among most species of the Columbia River anadromous fish and especially those found in the Priest Rapids Project are very sacred to Wanapum and those affected by Grant PUD and the license should consider Wanapum input for a coordinated and parallel approach to maintain positive natural and cultural resource stewardship. Access to the Priest Rapids Project lands and waters for harvest, gather and religious purposes is a necessity for Wanapum and we request timely discussion on any activities that may cause unavoidable access restrictions.	Grant PUD acknowledges this comment and appreciates the efforts of the Wanapum related to continued implementation of the PLMP and participation in the PRFF.