ADULT LAMPREY PASSAGE AND ENUMERATION STUDY PLAN, WELLS DAM - 2015

WELLS HYDROELECTRIC PROJECT

FERC NO. 2149

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Public Utility District No. 1 of Douglas County
East Wenatchee, Washington

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Table of Contents

List of Figures

List of Tables

ABSTRACT

In an effort to better understand Pacific lamprey (*Entosphenus tridentatus*) behavior at Wells Dam, Public Utility District No. 1 of Douglas County (Douglas PUD), in consultation with the Aquatic Settlement Work Group, is proposing to conduct a multi-faceted adult lamprey passage study at Wells Dam in 2015. This study is intended to collect information necessary to continue implementation of Objective 1 of the Pacific Lamprey Management Plan (PLMP) found in the Aquatic Settlement Agreement (ASA).

The goal of the study is to evaluate the effect of the Wells Hydroelectric Project (Wells Project) and its operations on adult Pacific lamprey upstream passage behavior and enumeration in the Wells Project fishways.

Specific objectives of the study include:

1. *Adult Pacific Lamprey Upstream Passage Evaluation (PLMP section 4.1.6).*
    - Evaluate passage behavior and success of radio-tagged adult Pacific lamprey through Wells Dam fishways; with an emphasis in the lower fishway section (entrance to adult fish trap).
    - Evaluate adult Pacific lamprey use and entrance efficiency in the re-opened low level fishway entrances
2. *Upstream Fishway Counts and Alternative Passage Routes (PLMP section 4.1.3)*
    - Evaluate the enumeration efficiency, behavior and fish passage efficiency of the fish count station at Wells Dam following sealing of gaps and alternative routes through the fish count stations.
    - Evaluate the use of a lamprey enumeration structure (LES) in the fish count windows.

Implementation of the study is consistent with requirements contained within the Wells Project PLMP. The study results are intended to support the goal of the PLMP, which is to implement measures to monitor and address impacts, if any, on Pacific lamprey resulting from the Wells Project during the term of the new license.

1.0 INTRODUCTION

1.1 Aquatic Settlement Agreement and Pacific Lamprey Management Plan

During the relicensing process for the Wells Hydroelectric Project (Wells Project or Project), Public Utility District No. 1 of Douglas County (Douglas PUD), in collaboration with federal, state and tribal relicensing participants, developed six Aquatic Resource Management Plans in support of a comprehensive Aquatic Settlement Agreement (ASA). The Pacific Lamprey Management Plan (PLMP) is one of the six Aquatic Resource Management Plans contained within the ASA that directs the implementation of Protection, Mitigation, and Enhancement measures (PMEs) for Pacific lamprey (*Entosphenus tridentatus*) during the term of the new Wells Project operating license.

The goal of the PLMP is to implement measures to monitor and address impacts, if any, on Pacific lamprey resulting from the Wells Project during the term of the new license. Objective 1 of the PLMP is to identify and address any adverse Project-related impacts on passage of adult Pacific lamprey. Pursuant to this objective, Douglas PUD is proposing to conduct an adult active tag study to 1) collect additional information on the passage characteristics and behavior of adult lamprey migrating through the Wells Project fishways (section 4.1.6 of the PLMP); and 2) to evaluate enumeration efficiency in the vicinity of the Wells Project fishway count windows (section 4.1.3 of the PLMP) toward identifying alternatives to improve adult lamprey count accuracy.

2.0 BACKGROUND

2.1 Wells Project Pacific Lamprey Passage Studies

As part of the Wells Project relicensing, Douglas PUD conducted several adult lamprey passage studies (2001-2003, 2007, and 2008) to evaluate the effect of the Wells Project and its operations on adult Pacific lamprey upstream migration and behavior as it relates to fishway passage, timing, and downstream passage events through the dam.

2.1.1 2001-2003 Pacific Lamprey Radio-telemetry Study

In 2004, Douglas PUD contracted with LGL Limited to conduct a lamprey radio-telemetry study at Wells Dam in coordination with Chelan PUD, which was conducting a similar study at Rocky Reach Dam. A total of 150 lamprey were radio-tagged and released at or below Rocky Reach Dam. The radio tags used in this study had an expected operational life of 45 days (Nass et al. 2005). Only 18 of these tagged fish were detected upstream at Wells Dam and many of the radio tags detected were within days of exceeding their expected battery life.

The 2004 study at Wells Dam was implemented through a combination of fixed-station monitoring at the dam and fixed-stations at tributary mouths. Collectively, these monitoring sites were used to determine migration and passage characteristics of lamprey entering the Project Area. Of the 150 adult lamprey released at or below Rocky Reach in 2004, 18 (12% of

150) were detected in the Wells Dam tailrace, and ten (56% of 18) of these were observed at an entrance to the fishways at Wells Dam. A total of 3 radio-tagged lamprey passed Wells Dam prior to expiration of the tags, resulting in a Fishway Efficiency estimate of 30% (3 of 10) for the study period. A single lamprey was detected upstream of Wells Dam at the mouth of the Methow River (Nass et al. 2005).

For lamprey that passed the dam, the majority (92%) of Project Passage time was spent in the tailrace. Median time required to pass through the fishway was 0.3 d and accounted for 8% of the Project Passage time (Nass et al. 2005).

Although the 2004 study at Wells Dam provided preliminary passage and behavioral information for migrating adult lamprey, the limited observations due to the small sample size (n=18) were insufficient in addressing the objectives of the 2004 study.

2.1.2 2007-2008 Pacific Lamprey Radio-telemetry Study

In 2007, Douglas PUD contracted with LGL Limited to conduct another active tagging study. Twenty-one lamprey were captured, radio-tagged, and released from August to October. Tags used in this study had an expected tag life of 87 days. Of the twenty-one fish, 10 were released into the tailrace and 11 were released directly into the middle fishway section of the Wells fishways. One tailrace-released fish was recaptured and re-released into the fishway, bringing total in-ladder releases to twelve. Ten of the 12 (83%) lamprey released into the middle fishway section successfully ascended, with a median upper fishway passage time of 7.9 hours. Seven of the 10 (70%) lamprey released into the tailrace were detected at the outside of a fishway entrance. Only one of these seven (14%) lamprey entered into the collection gallery and ascended the fishway with a lower fishway passage time of 6.1 hours and upper fishway passage time of 5.9 hours.

During the 2007 study, a total of 11 radio-tagged adult Pacific lamprey passed the fish counting facilities in both fishways. Nine of these fish were detected by an antenna monitoring the count window bypass area (i.e., an area in the fishway accessed through a picketed lead just downstream of the count window which allows lamprey to migrate through the fish counting facilities undetected; Figure 1), although 3 fish were detected for less than 20 seconds and probably did not completely enter the bypass area. Eight of these lamprey were not observed at the count window, and 2 fish had zero detections on the above count window antenna (LGL and Douglas PUD 2008). The results suggested that visual detections at the count windows could be significantly lower (e.g., under estimating by 73% according to these data) than the actual total number of lamprey passing the fish counting facilities.

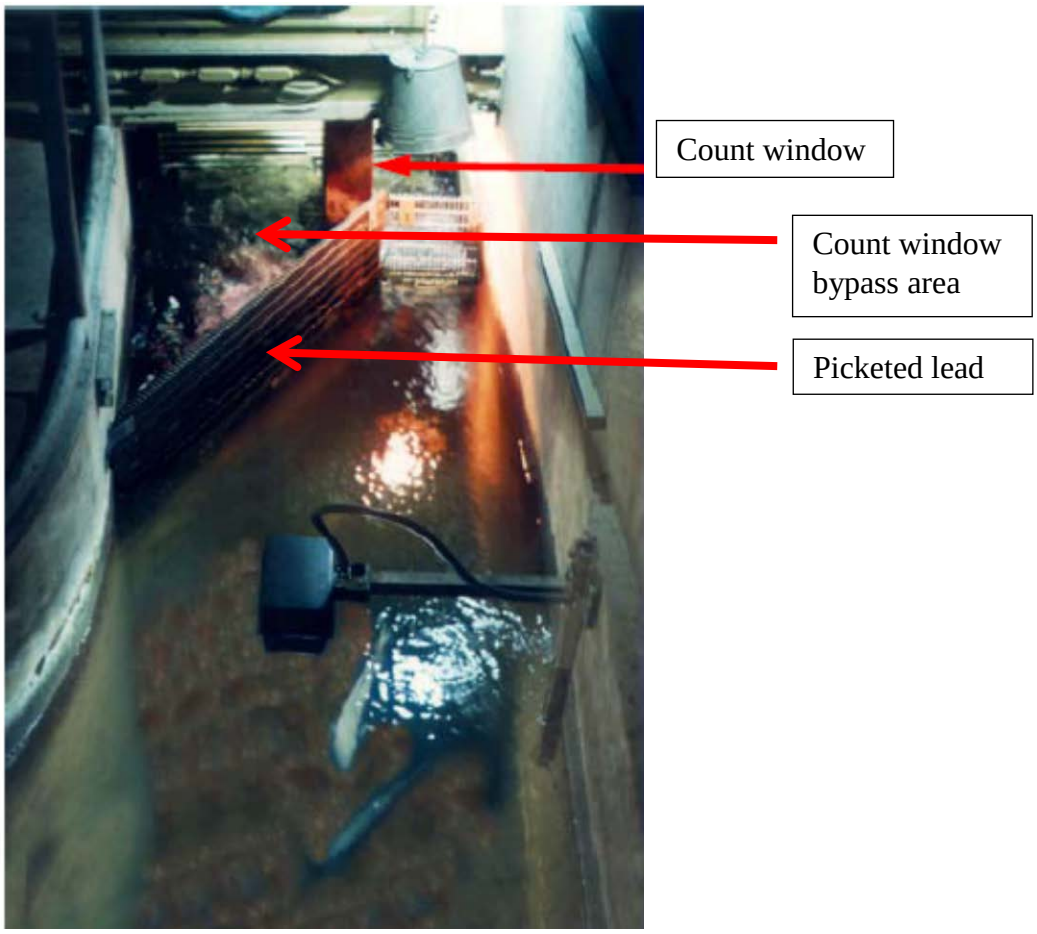

Figure 1. **Picketed lead immediately downstream of the fishway count window. Behind the picketed lead is the count window bypass area.**

In 2008, Douglas PUD conducted another adult lamprey passage study where 38 radio-tagged adult Pacific lamprey were released in the tailrace (n= 18) and fishways (n=20) of Wells Dam to continue an evaluation of behavior and passage performance, and to identify potential areas of passage impediment. In 2008, 15 lamprey approached the fishway from the tailrace, five (33%) of which entered the fishway. Movements within the collection gallery indicated that lamprey were able to move relatively unrestricted by flows. At least 11 of 19 (58%) lamprey which volitionally entered or were released in the collection gallery ascended to the lamprey trapping area in the middle fishway section. However, modifications to increase lamprey trapping efficiency effectively obstructed migration and 12 of 14 fish (86%) that encountered the lamprey traps were ultimately blocked. This artifact likely biased lower fishway passage times significantly. Upper fishway passage times of four radio-tagged lamprey that ascended past the trapping area were relatively fast (< 4 hours), except for one fish that ceased upstream movement during daylight hours. No fallbacks of fish that successfully ascended the fishway were observed for the second consecutive year. Overall, results indicate that any potential areas of impediment are restricted entirely to the entrance and lamprey trapping facility, as upper fishway passage efficiency was 100% for the second consecutive year.

During the 2008 study, of the four tagged lamprey that ascended into the upper fishway section, three bypassed the count window via the count window bypass area supporting the 2007 findings that a majority of lamprey that ascend Wells Dam may be uncounted (Robichaud et al. 2009). As concluded in the 2007 study, use of the count window bypass area appears to be an enumeration issue, rather than a passage concern (i.e., tagged fish generally move through this portion of the fishway efficiently and at above average speeds). The study recommended that further consideration should be given regarding effective monitoring of lamprey passage through the count window bypass area depending upon the importance of accurate counts at the Wells Project (LGL and Douglas PUD 2008).

The results of the 2007-2008 studies indicated that: 1) adult lamprey are having difficulty negotiating the fishway entrance; 2) lamprey passage in the fishway can be inhibited by the installation of lamprey traps on the bottom orifices within the middle section of the fishway (traps were removed in 2009); 3) lamprey are passing the middle and upper fishway sections at high rates, in a reasonable amount of time, and with negligible drop back within the ladder; and 4) a large proportion of the adult lamprey are bypassing the adult salmon counting windows (LGL and Douglas PUD 2008).

A comprehensive report was produced in February of 2009 (Robichaud et al. 2009). One of the recommendations by the researchers was to implement a reduction in fishway head differential to reduce entrance velocities to levels within the swimming capabilities of Pacific lamprey (0.8 to 2.1 m/s) during the hours of peak lamprey activity (i.e., nighttime) and within the primary migratory period at Wells Dam (August-September).

2.1.3 2009-2010 Wells Project DIDSON Studies

In response to Robichaud et al. (2009), Douglas PUD, in consultation with the Aquatic Settlement Work Group (Aquatic SWG), prepared a plan to implement and evaluate measures to enhance entrance efficiency of adult Pacific lamprey at Wells Dam (Johnson et al. 2011). These measures, originally scheduled for year two after license issuance (2013), were designed to determine whether temporary velocity reductions at the fishway entrances would enhance the attraction and relative entrance success of adult lamprey at Wells Dam.

DIDSON units were deployed at Wells Dam fishway entrances during the peak of historic Pacific lamprey migration in 2009 (20 August to 24 September) and 2010 (7 August to 30 September). DIDSON was used to sample lamprey behavior and upstream passage events along the entire width of the fishway entrances and 1.3 m of vertical coverage above the sills (about 26% of the wetted vertical opening). Lamprey passage was examined relative to variable head differential treatments and entrance velocities. In 2009, three head differential treatments were tested: existing high (0.48 m; or 3.0 m/sec), moderate (0.31 m; or 2.4 m/sec) and low condition (0.15 m; or 1.8 m/sec) (Johnson et al. 2010). In 2010, only two of the 2009 treatments were used: existing high, and the moderate head differential conditions (Johnson et al. 2011). Treatments were grouped in 3-day blocks and lasted four hours each evening in 2009 (21:00 through 00:59). In 2010, the treatments were paired and lasted eight hours each evening (17:00 through 00:59). Data collected during the treatment periods were reviewed and all lamprey observations were described.

Combining both years, a total of seven lamprey observations were recorded where lamprey were observed to encounter the entrance sill heading upstream (N = 5 in 2009; and N = 2 in 2010). Five of these seven observations were in the east fishway and two were in the west fishway. Overall, five of the seven observations showed successful entry into the fishways (71%). During reduced head differential treatments, five observations were recorded with four of the five resulting in successful entry (80% efficiency). Three of three observations with the moderate head differential condition resulted in successful entry (100% entrance efficiency). During high head differential conditions, one of the two lamprey observed entered a fishway (50% entrance efficiency).

Four lamprey exhibited attach and burst behaviors (one during low (25%), two during moderate (50%) and one during high head differential conditions (25%)), all of which resulted in successful entry into the fishways. One of three lampreys that did not exhibit the former behavior successfully entered the fishway, under the moderate treatment condition. The other two lamprey that did not exhibit attach and burst behavior did not successfully enter the fishway.

Extremely low Columbia River basin lamprey runs in 2009 and 2010 resulted in few fish observed at Wells Dam (the ninth and last hydroelectric project on the Columbia River [river mile 516] with fish passage). Low sample sizes precluded statistical evaluation of these results. Nonetheless, operational modifications implemented in these two years of study suggest that lamprey entrance efficiency may be increased with lower head conditions. Pooling observations that occurred during reduced head differential treatments shows 80% (4 of 5) entrance efficiency compared to 50% (1 of 2) under the current operating condition (high condition). Study results suggest that reduced head differentials show promise in providing an environment conducive to upstream passage of lamprey.

2.1.4 2011-2012 Lamprey Operations

As a best management practice in 2011 and 2012 Douglas PUD operated the fishways with a 1.0 ft head differential during the hours 17:00 and 00:59, once five lamprey had been counted at Rocky Reach Dam and continuing through September 30. Beyond those hours, fishway collection-gallery operations should be maintained at the “normal” head differential of 1.5 feet.

2.1.5 2013 Adult Lamprey Passage and Enumeration Study

In 2013, Douglas PUD conducted a study to evaluate physical and operational modifications to the Wells Dam fishwyas that were designed to improve adult lamprey passage and enumeration efficiency. Physical modifications included the installation of $11/16^{th}$ inch gap diffuser to exclude lamprey from the count window bypass chamber and the installation of solid aluminum plate ramps leading into and out of the count window area. Operation modifications involved reduction in fishway head differential from 1.5 feet to 1.0 foot.

Adult Pacific lamprey were captured at Bonneville and Priest Rapids dams, and transported to the Wells Fish Hatchery for tagging. Radio and PIT tags were surgically implanted, and the tagged fish were released into the Wells Dam tailrace (n=92) or into the Wells Dam fishways above the adult fish trap (pool 38; n=18). To monitor movements, underwater antenna arrays

were deployed throughout both Wells Dam fishways, and aerial antennas were deployed at the mouths of upstream tributaries (Okanogan and Methow Rivers).

Two head differential treatments were compared: a high condition (0.48 m or 1.5 ft) and a moderate condition (0.31 m or 1.0 ft). Treatment conditions occurred in 7-hour blocks (19:00 through 02:00) and alternated daily. Between treatments, the head differential was set at 0.48 m (1.5 ft). From 7 July to 7 October, 80 treatment conditions were tested, including 40 replicate tests of each treatment. The lamprey that were released into the tailrace approached the fishways on 89 occasions (35 during the high differential treatment, 12 moderate). Entrance Efficiency (the proportion of approach events that were followed by an entrance event) was 67% during the moderate treatment and 51% during the high treatment. Differences were not statistically significant, but statistical power was low.

Previous studies had identified an area ('bypass' behind the picketed lead) that allowed lamprey to move upstream through picketed leads without passing through the fishway video count window. Concerns about accurate passage count data prompted the installation of modified picketed leads with narrower spacing to help exclude lamprey from the bypass area. Count Station Passage (the proportion of tagged fish detected below the count window that were directed through the Count Station, rather than the bypass) was 88%, which was a significant improvement from before the new leads were installed (53.3%). Count Station Enumeration Efficiency (the proportion of fish known to have passed the count window that were tallied by the count video technicians) was significantly higher in the west fishway (68%) than in the east (33%), and was 51% overall. Count Station Enumeration Efficiency in 2013 was 11% higher than that estimated prior to installation of the modified picketed leads, but the statistical power of the comparison limited.

The results of the study showed that radio-tagged lamprey exhibited low passage efficiency in the lower fishways between the collection gallery and adult fish trap. This was evidenced by the large proportion of lamprey that entered the fishways but failed to ascend any higher than weir 7. The results also suggested that lamprey are still capable of bypassing the fish count window and avoid enumeration. Inspection of the fishways in June 2014 revealed gaps and alternative passage routes that lamprey could potentially use to bypass the fish count window.

3.0 GOALS, ASSUMPTIONS AND HYPOTHESES

3.1 Goals and Objectives

The goal of the 2015 Pacific lamprey study is to evaluate the effect of the Wells Project and its operations on adult Pacific lamprey upstream passage behavior and enumeration in the Wells Project fishways.

Specific objectives of the study include:

1. *Adult Pacific Lamprey Upstream Passage Evaluation (PLMP section 4.1.6).*

A. Evaluate passage efficiency of radio-tagged adult Pacific lamprey through Wells Dam fishways; with an emphasis in the lower fishway section (i.e., fishway entrance to adult fish trap).
B. Evaluate travel time of radio-tagged adult Pacific lamprey through Wells Dam fishways; with an emphasis in the lower fishway section (i.e., fishway entrance to adult fish trap).
C. Evaluate radio-tagged adult lamprey behavior through Wells Dam fishways; with an emphasis in the lower fishway section (i.e., fishway entrance to adult fish trap).
D. Determine if radio-tagged lamprey use the newly installed lamprey side entrances and the entrance efficiency for that route.
E. Determine the proportion of radio-tagged lamprey that enter the auxiliary water supply system (AWS) and compare passage success of those that enter the AWS and those that do not.
F. If a sufficient sample size of study fish is available, determine the proportion of acoustic-tagged lamprey released in Rocky Reach Reservoir that approach and interact with the Wells Project.

2. *Upstream Fishway Counts and Alternative Passage Routes (PLMP section 4.1.3)*
   A. Evaluate the enumeration efficiency of adult lamprey at the fish count station at Wells Dam following modifications made to seal gaps and alternative passage routes that bypass the count window.
   B. Evaluate the efficacy of lamprey enumeration structures (LES) as an alternative to the existing fish count window alone.
   C. Evaluate the effect of LESs on lamprey passage behavior in the fish count station area.

3.2 Hypotheses

The following null and alternative hypotheses per each objective are as follows:

Objectives 1A, B and C:

H_o: There is no difference in passage metrics (i.e., passage efficiency, travel time and behavior) compared to other mainstem Columbia River projects.
H_{alt}: Passage metrics for lamprey differ compared to other mainstem Columbia River projects.

Objective 1D

H_o: There is no difference in the proportion of tagged lamprey that successfully enter the Wells Dam fishways via the side lamprey entrances and the main entrance.
H_{alt}: A greater proportion of tagged lamprey successfully enter the Wells Dam fishways via the lamprey side entrances than the main entrances.

Objective 1E

H_o: Radio tagged lamprey that enter the AWS and those that do not have equal fishway passage success.
H_{alt}: Radio tagged lamprey that enter the AWS and those that do not have different fishway passage success.

Objective 1F

H_o: The proportions of acoustic-tagged and radio-tagged lamprey that are detected approaching and interacting with the Wells Project are equal.
H_{alt}: The proportions of acoustic-tagged and radio-tagged lamprey that are detected approaching and interacting with the Wells Project not equal.

Objective 2A:

H_o: The proportion of tagged lamprey passing the count window is similar to previous studies.
H_{alt}: The proportion of tagged lamprey passing the count window is dissimilar to previous studies.

H_o: The number of lamprey heard on antenna(s) upstream of the count window is the same as the number of tagged lamprey seen at the count window.
H_{alt}: The number of lamprey heard on antenna(s) upstream of the count window is different from the number of tagged lamprey seen at the count window.

Objective 2B:

H_o: The number of lamprey observed using the LES is the same as the number passing through the existing count window.
H_{alt}: The number of lamprey observed using the LES differs from the number passing through the existing count window.

Objective 2C:

H_o: The length of time and number of attempts (based on radio telemetrny detections) for tagged lamprey to pass the count station is the same for the LES and existing count window routes.
H_{alt}: The length of time and number of attempts for tagged lamprey to pass the count station differs between the LES and existing count window routes.

4.0 METHODOLOGY

4.1 Fish Source

A total of 150 lamprey, to support radio telemetry objectives, and 50 lamprey, to support acoustic telemetry objectives, will be collected at Priest Rapids Dam. Lamprey from other locations may also be utilized if sufficient numbers cannot be obtained at Priest Rapids Dam.

It is assumed that fish captured at and transported from trapping locations will be exhibiting upstream migratory behavior and will attempt to pass Wells Dam. Since most fish losses from hauling stress are caused by poor water quality and improper handling (Wynne and Wurts 2011), appropriate handling and transport protocols will be developed to ensure study fish in good health are delivered to the Wells Fish Hatchery.

Only adult lamprey in healthy condition (e.g., no signs of injury, disease, etc.) should be collected for transport. All captured fish should be immediately placed in covered hauling tanks via nets. No anesthetics will be used during trapping operations as this can produce a biological response similar to that caused by stress (Wynne and Wurts 2011).

Covered tank(s) of an appropriate volume will be used to avoid stressors and disease transmission related to overcrowding. Each tank will be filled with river water and water temperature and dissolved oxygen will be measured prior to transport. During transport, both temperature and dissolved oxygen will be checked hourly, levels recorded, and adjustments to equipment will be made to maintain pre-transport water quality conditions. A final evaluation of fish and water quality conditions and total transport time will be noted upon delivery to the Wells Fish Hatchery.

4.2 Tagging and Release Procedures

Tagging procedures will follow methods described in previous lamprey radio-telemetry studies conducted at Wells Dam (LGL and Douglas PUD 2008) and will consider recent advances in knowledge and understanding of fish health and condition (e.g., Cooke et al. 2011a; b). An effort will be made to minimize impacts to the biological and physiological condition of the study fish. Specific attention will be made to minimize incision length, possibility of infection, handling time, water temperature stressors, and air exposure.

Study fish will be tagged with model NTC-4-2L Nano Tags (Lotek® Newmarket, Ontario) or an equivalent providing less than 0.5% tag burden (tag mass/fish mass) and sufficient tag life. Tags have an expected life of 162 days at a pulse rate interval (PRI) of 5.0 seconds. Tag dimensions are 16mm (length) by 4mm (height) by 6mm (width) and weight 1.10 grams in air. If enough study fish are available, a subset of 50 lamprey will be tagged with acoustic tags. Acoustic tags with similar dimension to the radio tags will be used to avoid introducing bias in fish behavior due to differences in tag burden. In addition, each fish will be given a full-duplex passive

integrated transponder (PIT) tag with tag dimensions of 12mm by 2.12mm and weighing 0.1 grams. Total combined weight of both tags is 2.2 grams and a tag burden of less than 1% of body mass is proposed. Brown et al. (2006) noted that 4% is considered an acceptable burden for tagging studies, however tag burden should be minimized whenever possible.

After surgery, fish will be transferred to a covered tank with flow through river water for recovery (approximately one hour). For the purposes of the study, it is assumed that tagged fish are representative of untagged fish.

All tagged fish that have recovered from the tagging process will be transported by truck in a 113 L cooler filled with river water. An air tank and air stones will be used to maintain oxygen levels. Release locations of both radio tagged and acoustic tagged lamprey will be chosen based on the number of fish available with priority given to locations closer to Wells Dam to ensure that the primary study objectives related to at Project passage are addressed. If a sufficient sample size is available, release locations that serve secondary study objectives may be selected in consultation with the Aquatic SWG.

4.3 Radio-telemetry

The movement and passage of radio-tagged lamprey (Objectives 1 and 2) will be documented by a combination of underwater and aerial antenna arrays (dipole and yagi antennas) at Wells Dam. Tag testing conducted by the contractor during installation will drive antenna location and placement.

4.3.1 Fixed-Station Telemetry Array

Fixed-station telemetry receivers and associated arrays similar to those used in past lamprey studies at Wells Dam (LGL and Douglas PUD 2008) will be deployed to monitor movements of radio-tagged lamprey at the Wells Dam fishway entrances, at select locations throughout the fishway, and at the fishway exits. Underwater dipole antennas will be used in the fishways. Antenna arrays for tagged fish monitoring will be deployed at the following locations within each fishway (east and west):

1. Outside the main fishway entrance
2. Inside the main fishway entrance
3. Outside the side lamprey entrance
4. Inside the side lamprey entrance
5. Inside the collection gallery at the exit of the side entrance chamber
6. Two locations within the AWS (upper and lower)
7. Pool 1 (collection gallery exit)
8. Pool 3 (serves as detection efficiency location for Pool 1)
9. Pool below the adult fish trap (Pool 39 in the west fishway and Pool 38 in the east fishway)
10. Below the video count window (lower portion of Pool 64 below count window)
11. Above the video count window (upper portion of Pool 64 above count window)

12. Within the count window bypass area behind the picketed lead
13. Fishway exit (Pool 72 or 73)

Fixed station telemetry arrays will also be deployed at the mouths of Methow and Okanogan rivers. In addition, Douglas PUD will analyze data provided from a station operated by any stakeholder at the mouth of the Entiat or Wenatchee rivers. PTAGIS will also be queried to determine if any of the tagged lamprey were detected on in-stream PIT arrays in the Entiat and Methow, or Okanogan Rivers at the request of the Aquatic SWG.

4.3.2 Within-fishway Mobile Tracking

Following the final installation of fixed telemetry arrays within the fishway, antenna range and coverage will be tested to identify potential "dead zones", areas without radio telemetry detection capability that may provide long-term holding opportunities or passage impedance for lamprey. If such areas are identified mobile tracking will be employed to gather information about any lamprey that may be holding in those areas. The timing and frequency of mobile tracking operations will be determined in consultation with the Aquatic SWG. Douglas PUD will ensure that appropriate funding and staff are available to carry out within-fishway tracking, as frequently as once per week over the course of the study, should it be necessary.

4.4 Acoustic-telemetry

Acoustic telemetry listening stations will be deployed at locations in both the Wells tailrace and reservoir. These stations will be deployed and maintained in support of the Douglas PUD sturgeon program monitoring and evaluation, however they may be able to provide useful information about lamprey movements and behavior as they approach and after they pass Wells Dam. One objective of the acoustic telemetry facet of the study will be to determine the proportion of lamprey that approach Wells Dam but do not interact with the fishways in a way that they can be detected by radio-telemetry or PIT tag arrays. This information can be used to infer what proportion of radio-tagged lamprey approach the dam but are not detected. Acoustic telemetry listening stations placed immediately downstream of Wells Dam will be used to detect any acoustic tagged lamprey that are released further downstream if they actively migrate upstream and approach the dam. Listening stations in the Wells Reservoir will be used to examine movements of lamprey prior to entering tributaries. Exact locations of acoustic telemetry listening stations will be determined in coordination with the sturgeon monitoring and evaluation program to ensure the most effective use of the equipment to collect information about both sturgeon and lamprey.

4.5 Count Station Efficiency

During the 2014-2015 Wells Dam ladder maintenance period (typically from December through January), gaps greater than ½ inch identified during fishway inspections in 2014 will be sealed. This study will evaluate the behavior and performance of adult lamprey through the existing fish count stations after the sealing of gaps which provided potential routes for lamprey to bypass the count window. The data collected during this study will be compared to prior years of study at

Wells Dam to determine whether lamprey enumeration has been improved without negatively impacting lamprey passage rates and times within the upper fishways.

4.6 Lamprey Side Entrances

The low-level side fishway entrances on both Wells Dam fishways will be re-opened and be equipped with prototype lamprey entrances (See attached 3D rendering.) The lamprey entrances will consist of a fiberglass box with an opening to the tailrace one inch tall by eight feet wide. The interior of the box will house six rows of pipe bollards that serve to reduce water velocity and head differential. The designed water discharge and velocity of the lamprey entrances are approximately 1 cfs and 2 ft/s. Each lamprey entrance will be equipped with a PIT antenna capable of reading half and full duplex PIT tags.

4.7 Lamprey Enumeration Structures (LES)

Lamprey enumeration structures (LES) will be installed at the fish count stations of both fishways. The LES will provide lamprey a low velocity passage route through the fish count window. In addition, the LES will provide lamprey a route through the count window that is shielded from the bright lights focused on the count window. The portion of the LES that passes through the count window will be illuminated by infrared light in order for lamprey to be visible to the count window video camera and be enumerated as they pass.

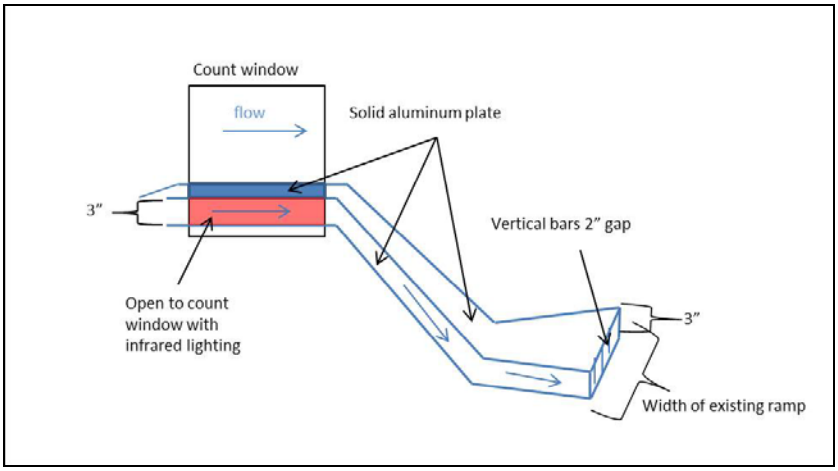

Figure 3. Conceptual drawing of Lamprey Enumeration Structure LES. Side view. Drawing not to scale.

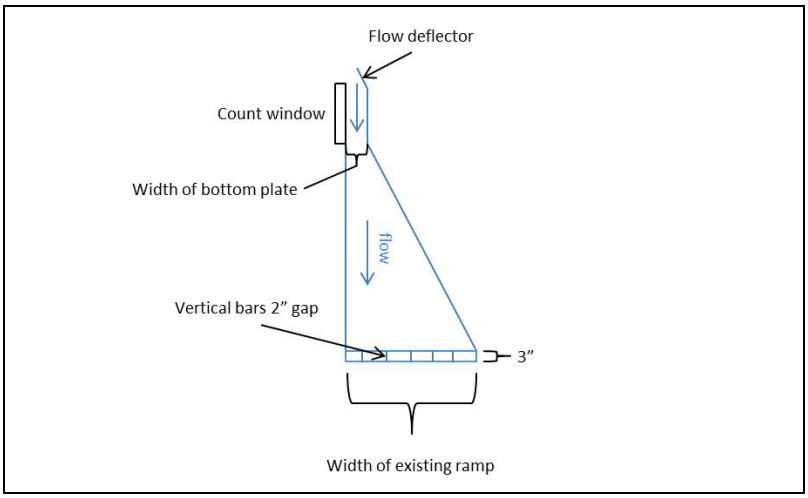

Figure 4. Conceptual drawing of Lamprey Enumeration Structure LES. Top view. Drawing not to scale.

4.8 Statistical Analyses and Reporting

4.8.1 Passage Efficiency and Travel Time

Telemetry data collected during the study will be managed in an appropriate database where individual antennas will be grouped into "zones" that define pivotal areas of interest, such as individual fishway entrances and exits.

Numbers of fish detected at each zone will be summarized. Each time a fish is detected in a zone, the duration of the detection event (the amount of time the fish spent in the zone) will be calculated. The operational database will also be used to map movements of fish among zones. For every combination of among-zone movements, the number of times a fish performed that movement and the amount of time it took to get from one zone to the next, will be calculated.

Passage times will be calculated from benchmark dates and times corresponding to the first and last detection of a given radio-tagged lamprey at specific locations. At Wells Dam, benchmark times for lamprey passing the Project will be as follows:

Time:

1. first detection at the fishway entrance (outside antenna). (Note that in order to be considered a treatment fish for the study, tagged fish must be detected at this location),
2. last detection at the fishway entrance (inside antenna)
3. first detection at the 'end of collection gallery' zone (Pool 1)
4. first detection at the 'adult fishway/middle fishway section' zone (Pool 39)
5. first detection at the 'below video count window' zone (lower portion of Pool 64)
6. first detection at the 'above video count window' zone (upper portion of Pool 64)
7. first detection at the 'count window bypass' zone
8. last detection at the 'count window pass' zone – note same as #6
9. first detection at the fishway exit (Pool 72 or 73)

10. last detection at the fishway exit.
11. first detection at tributary mouth (Methow or Okanogan)

From these benchmark times, passage times can be calculated for the following segments:

1. Entrance passage time – Time 1 to 2
2. Collection gallery passage time – Time 2 to 3
3. Lower fishway passage time – Time 2 to 4
4. Passage from count window to exit – Time 5 to 10
5. Upper fishway passage time – Time 4 to 10
6. Project passage time – Time 1 to 10
7. Exit to tributary passage time – Time 10 to 11

To evaluate use of the count window bypass area, times can be calculated for the following segments:

1. Below count window to count window bypass – Time 5 to 7
2. Residence time in count window bypass area – Time 7 to 6
3. Count window bypass to exit – Time 7 to 10

The residence and passage times and route of passage (in count window area) for each radio-tagged lamprey will be determined by working backwards through a sequence of detections. The fishway of ultimate passage and the respective passage time will be determined by identifying a sequence of detections in the ascent of a fishway, starting with detections in a fishway exit zone.

Information about passage efficiency and travel time will be compared to other hydropower projects on the Columbia River.

4.8.2 Entrance Efficiency

Radio-telemetry data from entrance locations (i.e., outside and inside fishway entrance arrays) will be used to evaluate differences in entrance efficiency between the two entrance routes (main entrances and low level entrances). The total number of tagged lamprey detected outside each type of fishway entrances over the course of the study will serve as the total sample size for statistical analyses. Entrance efficiency will be calculated as the total number of successful entries of fish detected outside the fishway entrances. During the course of the study, successful entry will be defined as either a detection by the arrays outside the fishway entrances followed by a subsequent detection by the arrays inside the fishway entrances or a detection on any array upstream of the fishway entrance. Difference in entrance efficiency between the entrance routes will be evaluated using statistical methods developed with assistance from the University of Washington school of Aquatic and Fisheries Sciences.

4.8.3 Approach and Passage Attempt

Acoustic-telemetry data will be used to estimate the proportion of translocated lamprey that are tagged and released downstream of Wells Dam that migrate upstream and approach the dam. It

will be assumed that an acoustic tagged lamprey detected approaching the dam is attempting to enter and pass the dam. The proportion of lamprey that approach the dam will be calculated as the total number of unique acoustic tagged lamprey that are detected by the acoustic telemetry listening station located immediately below the dam divided by the total number of acoustic tagged lamprey that are released. It is not possible to calculate fishway entrance efficiency for acoustic tagged lamprey due to the lack of detection capability of acoustic tags or PIT tags at the fishway entrances. However, passage information can still be collected based on PIT tag detections in the side lamprey entrances, fishway pools 19 and 67, and on in-stream arrays in the Methow or Okanogan basins.

4.8.4 Enumeration Efficiency

The efficiency of enumerating lamprey using the existing counting station will be evaluated by examining observations of tagged fish via radio-telemetry detections at the "above video count window" location (upper portion of Pool 64 above count window) and comparing them to observations below the count stations (upstream weir wall in Pool 62). Enumeration efficiency will be reported as a percentage (i.e., tagged fish observed above count station/tagged fish detected below count window X 100). Given the low numbers of lamprey that have passed Wells Dam in recent years, confounding observations due to high numbers of passage events at this location during the study is not expected. Each fish ladder can be treated separately prior to grouping entrance numbers. Release groups will also be pooled together if statistically justified (either by low sample size or by insignificance lack of significant differences).

4.8.5 Lamprey Side Entrance Evaluation

Radio telemetry antennas will placed outside of the lamprey side entrances in the tailrace and inside the fishway collection galleries where the side entrance chamber opens just below weir one. Entrance efficiency of lamprey that used the side entrance will be determined as the proportion of radio tagged lamprey that are detected on the tailrace antennas outside of the side entrance that are also detected on another antenna in the collection galleries or further upstream in the fishways. PIT detection capability in the side entrances can also be used to estimate entrance efficiency. However, without other detection methods, subsequent detections at pool 19 or pool 67 arrays will be required to say with certainty that a fish successfully entered and passed using the side entrances.

4.8.6 Lamprey Enumeration Structure Evaluation

Lamprey use of the LES at each count station will be evaluated using both video observation and radio telemetry detections. Video counts of all lamprey will be used to make comparisons between the number of lamprey that utilize the LES to pass the count stations and that do not. Detections of tagged lamprey by antennas above and below the count stations will be used to determine at what time an individual fish passes the count station and the route each fish takes will be confirmed by video footage. The length of time from the detection of a tagged lamprey below the count window to detection above the count window will be also calculated. The count station passage duration will be compared between tagged lamprey that use the LES and those that do not.

4.9 Regional Coordination

Douglas PUD will notify other agencies and groups conducting lamprey research in the region of plans to conduct the lamprey passage and enumeration study in 2015. Tag codes and other information on study lamprey that are used in 2015 will be made available upon request, and PIT tag data will be uploaded to PTAGIS. When possible, Douglas PUD will coordinate with other researchers studying lamprey in the area on efforts that are consistent with the objectives of the 2015 study.

4.10 Schedule and Reporting

Reporting will be a collaborative effort between the contractor and the Douglas PUD contract manager for this study. The schedule for study planning and development, implementation, draft reporting, review, and final reporting are presented in Table 1 below.

Table 1. Estimated timeline for study development, implementation and reporting.

		Parties Involved			
#	Item	PUD	ASWG	Contractor	Date
1	Study Plan Development	X			July-August 2014
2	Study Plan Review Aquatic SWG	X	X		August 2014
3	Study Plan Finalized	X	X		November 2014
4	Contracting	X		X	November 2014
5	Telemetry Installation	X		X	December 2014-January 2015
6	Study Implementation (capture, transport, tagging, monitoring)	X		X	June-October 2015
7	Preliminary data summary to Aquatic SWG	X		X	January 2016
8	Draft Interim Report to PUD			X	January 2016
9	Draft Report to Aquatic SWG	X	X		March Meeting 2016
10	Final Report Integrating Changes from Review to PUD			X	April 2016
11	Final Report to Aquatic SWG	X	X		May Meeting 2016

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