Evaluation of Pacific Lamprey Passage at Rocky Reach Hydroelectric Project

Study Plan

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TABLE OF CONTENTS

SECTION 1: PROPOSAL SUMMARY ................................................................................................................................. 1

SECTION 2: INTRODUCTION ............................................................................................................................................. 2

SECTION 3: STUDY OBJECTIVE........................................................................................................................................ 3

SECTION 4: METHODS...................................................................................................................................................... 4
  4.1 Sample Size ............................................................................................................................................................. 4
  4.2 Fish Capture ............................................................................................................................................................ 4
  4.3 Tag Description ....................................................................................................................................................... 7
  4.4 Tagging Techniques .................................................................................................................................................. 7
  4.5 Release of Tagged Fish .............................................................................................................................................. 8
  4.6 Monitoring ............................................................................................................................................................... 8
  4.7 Tributary Monitoring ............................................................................................................................................... 11
  4.8 Mobile surveys ......................................................................................................................................................... 11

SECTION 5: DATA ANALYSIS ......................................................................................................................................... 12

SECTION 6: REPORT WRITING ..................................................................................................................................... 14

SECTION 7: PROJECT SCHEDULE.................................................................................................................................. 15

SECTION 8: PROJECT PARTICIPANTS................................................................................................................................ 16

SECTION 9: REFERENCES ................................................................................................................................................ 19

LIST OF FIGURES

Figure 1: Daily ladder counts of Pacific lamprey migrating past Rocky Reach dam, 2003. The yellow area indicates the period (July 31 to Sept. 30) when 90 percent of the lamprey past the project ...................................................... 6

Figure 2: Proposed schedule for the number of lamprey to be tagged and released each week at Rocky Reach dam, 2004 ......................................................................................................................................................... 6
SECTION 1: PROPOSAL SUMMARY

Chelan Public Utility District No. 1 of Chelan County (Chelan PUD) is interested in evaluating passage of adult Pacific Lamprey (Lampetra tridentata) at Rocky Reach Hydroelectric Project. The study will provide important information to Chelan PUD to evaluate passage through the fish ladder system at their project and document occurrence of fallback. Moreover, the evaluation will assist in identifying locations that may impede the passage of Pacific lamprey.

Three components of adult migration through the Rocky Reach Hydroelectric Project may affect Pacific lamprey: delay at project fishways, passage success at project structures, and injuries and mortalities resulting from upstream and downstream passage through project facilities. To evaluate the passage performance of Pacific lamprey, we propose to use radio-telemetry techniques to monitor the upstream movement of radio-tagged lamprey past specific segments along their passage route from entry into the tailrace to exit of the fishway system. Evaluation of specific segments of the passage route will help identify areas of concern that may delay or prevent successful passage of Pacific lamprey. The monitoring system will also assess the number of lamprey that fallback or migrate back downstream after they have successfully passed the fishway. The plan is to capture and tag fish within the ladder and allow a portion to continue their migration through the project while others are transported and released downstream so that they may be monitored as they pass the project.

In the following sections, we provide details that outline the study objectives, methods, data analysis and personnel that will be involved in this study. A preliminary schedule has also been drafted that will be refined in consultation with Chelan PUD. A budget under a separate cover has been submitted for the time and materials needed to conduct this study.
SECTION 2: INTRODUCTION

Pacific lamprey occur in most tributaries to the Columbia River and the mainstem during their adult migration stage. Counts at Rocky Reach Dam have shown a steady decline from over 17,000 fish in 1969 to average counts of 330 between 1983 and 2001. However, there have been recent signs that the populations may be rebuilding with counts of 1,842 in 2002, and 2,521 in 2003. The upstream migration of adult Pacific lamprey in the Rocky Reach Project area typically occurs from July through November, with peak migration occurring in late August. Two recent reviews of Pacific lamprey (Hillman and Miller 2000; Golder Associates Ltd. 2003) in the Mid-Columbia River have indicated that little specific information is known on their status.

Chelan PUD is attempting to fill the information gap by understanding how Rocky Reach Dam and its operations affect the migration of Pacific lamprey. Clearly, a better understanding may reveal that it is possible to modify physical conditions or hydro-operations to increase successful passage and minimize fallback at the project. Recent research in the Columbia River indicates that successful passage of adult Pacific lamprey may be related to the configuration of a particular dam or fishway (Vella et al. 1999a, b; Moser et al. 2002b). That is, upstream migration may be delayed or deterred at various structures within a fishway including fish counting stations, fishway entrances, diffuser grating, fishway weirs, orifices gates and collection channels.

The problems facing successful passage of Pacific lamprey at dams may be related to their unique method of movement and specific areas within fishways. 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 0.86 m/s at 15°C (Mesa et al. 2003) and a burst swimming speed calculated at 2.1 m/s (Bell 1990). Average velocities in the Rocky Reach adult fishway are approximately 0.3 – 1.2 m/s in channels and up to 2.1 – 2.5 m/s at entrances, orifices and weirs (Golder Associates Ltd. 2003). The physiological response of adult Pacific lamprey to exhaustive exercise may be immediate, sometimes severe, but short-lived (Mesa et al. 2003). This may suggest that lamprey have difficulty negotiating fishways with high current velocities.
**SECTION 3: STUDY OBJECTIVE**

Chelan PUD has identified several objectives that need to be addressed in the study plan. These objectives will assist in their management goals for Pacific lamprey during the Rocky Reach relicensing process. The objectives of the study are as follows:

- Identify methods for capturing, tagging, and releasing lamprey at Rocky Reach Dam
- Compare passage rates to other Columbia River dams
- Report overall passage rates through the fishway as well as the tailrace, the fishway entrance, collection channel, counting station, etc.
- Evaluate frequency of fallback
- Evaluate overall passage efficiency
- Identify possible means to improve passage efficiency
SECTION 4: METHODS

To assess passage behavior at Rocky Reach Dam, and success through the Rocky Reach Dam fishway for lamprey, we will use radio-telemetry techniques. The telemetry systems to be employed in the study are currently installed and operational at the tailrace and adult fishway, as well as the turbine intakes and spillbays. These systems were designed and installed by BioAnalysts, Inc. in 1997, and have been used to assess passage of adult salmonids including bull trout. We envision that the current systems will be adequate to meet a number of the objectives of the study. However, it is likely that it will be necessary to revise some systems, and install others.

Research at other mainstem dams has identified areas within adult fishways that are problematic for lamprey passage. Therefore, it will be necessary to install antennas in strategic locations to compare migration rates through segments of the adult fishway to help identify potential passage problems. In many cases, this will simply require moving existing antennas. In other cases, it may require the installation of new ones. During the planning phase of the study, we will consult with the PUD to assess the need for any revisions. The following sections briefly describe the telemetry systems, as well as capture and tagging methods to be employed in the study.

4.1 Sample Size
For this study, we propose releasing a total of 150 radio-tagged lamprey, with 125 fish being released downstream of Rocky Reach Dam, and 25 fish within the Rocky Reach fishway. The downstream release will provide information on tailrace residence time and passage behavior within the fishway. The fishway release will supplement the downstream release in assessing fallback through the project. At Bonneville Dam, approximately 85% of the fish released downstream of the project were detected at the dam. Of those detected at the dam, 35 to 40% successfully migrated upstream and were detected at the ladder exits (Vella et al. 1999a; Vella et al. 2001; Ocker et al. 2001; and Moser et al. 2002a). Assuming similar results at Rocky Reach, approximately 105 of the 125 fish released downstream of Rocky Reach Dam would be detected at an entrance of the Rocky Reach fishway, and of those, 35 to 40 would exit the ladder system. While a forebay sample of 35 to 40 fish would be adequate to assess fallback through the project, it seems prudent to assume that the actual number of lamprey that will successfully migrating through the ladder system will be less. Therefore, a release of 25 fish near the fishway exit is proposed to ensure an adequate forebay sample to assess fallback.

4.2 Fish Capture
One of the most challenging aspects of this study will be the capture of test animals. Throughout the mainstem Columbia River system, a number of capture methods have been employed at different hydroelectric projects with varying degrees of success. At Bonneville Dam, NOAA Fisheries has been conducting lamprey passage studies dating back to 1996 (Vella et al. 1999a; Vella et al. 2001; Ocker et al. 2001; and Moser et al. 2002a). In those investigations, Pacific lamprey were captured with a passive trap located within the fishway, which straddled an overflow weir. For Bonneville Dam, this type of trap was effective in capturing an adequate number of test animals.
A similar trap was employed by Grant County PUD in 2001 at Priest Rapids Dam with minimal success (Tom Dresser, personal comm.). In that study, an overflow weir trap was constructed and deployed at Priest Rapids Dam. During the capture efforts, only four Pacific lamprey were collected. As an alternative, the PUD used dip-net techniques to acquire the necessary sample, and did not attempt the use of the overflow weir trap in 2002. In 2002, dip-netting was used exclusively and it collected 400 to 500 lamprey.

For this study, we propose the use of potentially three capture methods. The first, and likely the most successful method will be dip-netting within the fishway. The location of this activity will depend on access and ease of capture, and adequate facilities to hold the captured fish. While this method may be the most efficient means of capturing test animals, it will be labor intensive.

The second alternative is to use the existing trapping facility located near the ladder exit. This facility has been used to collect both adult bull trout and steelhead. For this facility to be effective, it will require some modification. It should be noted that while adult lamprey have entered the capture vessel during the trapping of other species, this facility has never been used to actively capture lamprey. Therefore, its viability as a capture method is unknown. As with dip-netting, this alternative is labor intensive as it requires an operator to monitor passage and to activate the trapping mechanism.

The third option is to construct a trap similar to the one used at Bonneville and Priest Rapids dams. While not effective at Priest Rapids, this system was effective at Bonneville Dam, and may warrant testing in this study. The advantage of this system is that it collects test animals passively, and does not require constant monitoring while fishing. Therefore, the trap can be deployed at night, and checked the following morning. If effective, this method would reduce the amount of personnel effort to capture test fish.

We suggest that rather than identify a specific method of capture at this time, options be further explored in consultation with the PUD. It may be beneficial to employ all three methods initially, and modify capture methods based on capture results. In the weeks prior to tagging, the capture method can be tested to ensure that the sample target will be achieved. Regardless of the capture method employed, we have developed a tagging schedule based on the migration timing for 90% of the adult lamprey passing Rocky Reach Dam in 2003 (Figure 1). In 2003, the middle ninety percent of adult lamprey passed Rocky Reach Dam from 31 July to 30 September. The proposed tagging schedule is based on that passage distribution and has weekly quotas for the tag and release of lamprey (Figure 2).
Figure 1. Daily ladder counts of Pacific lamprey migrating past Rocky Reach dam, 2003. The yellow area indicates the period (July 31 to Sept. 30) when 90 percent of the lamprey past the project.

Figure 2. Proposed schedule for the number of lamprey to be tagged and released each week at Rocky Reach dam, 2004. Blue and red bars indicate the number of lamprey released into the tailrace and fishway of Rocky Reach dam, respectively.
4.3 Tag Description
For this study, we propose to use a digitally-encoded transmitter developed by Lotek Engineering, which can be encoded to omit a signal on any 1 of 5,300 unique channel/code combinations. This type of transmitter is compatible with all radio telemetry equipment owned by Chelan PUD. The transmitter type will be the NTC series, better known as the nano-tag. The largest transmitter within this series (model NTC-6-2) weighs 4.5 grams in air, has a diameter of 9.1mm, and a length of 30.9 mm. For this transmitter with a burst rate of one pulse every five seconds, the typical operational life is 237 days.

The physical properties of the NTC-6-2 transmitter fall within the criteria identified by Close et al. (2003) as having minimal effects on the physiology and swimming performance associated with the surgical implantation of radio transmitters into the peritoneal cavities of Pacific lamprey. However, we recommend the use of a smaller transmitter within the NTC series. Results from the 2002 telemetry evaluation of Pacific lamprey at Priest Rapids Dam indicate that there was varying passage success of lamprey tagged with two different tags (different in size and weight; Tom Dresser, personal comm.). Therefore, we recommend the use of the smallest transmitter possible that will provide the desired typical operational life.

4.4 Tagging Techniques
After collection, test animals will be transported to the tagging facilities where they will be held briefly until tagging. Tagging will be conducted first thing each morning for fish captured the previous night. At this time, we propose using the existing tagging facilities located under the roadway near the ladder exit since it is outfitted with all necessary plumbing and power. Also, since personnel who will be conducting the tagging have previously used the facilities to tag both adult bull trout and steelhead, they are familiar with all aspects of the facilities.

Implantation of transmitters into Pacific lamprey will be accomplished surgically, using techniques described by Close et al. (2003), with some modifications based on methods described in Stevenson et al. (2002). Lamprey will be initially anesthetized in a buffered solution of tricaine methanesulfonate (MS-222), at a concentration of 80 mg/L. After anesthetization, and prior to the surgical procedure, each fish will be weighed and measured (length and maximum girth). The fish will then be placed into a PVC cradle on top of a towel to prevent movement during surgery (see Close et al. 2003 for details regarding the PVC cradle). During the surgical procedure, the fish will be supplied with a 40 mg/L solution of MS-222, and its respiratory rate monitored. If necessary, the concentration of the MS-222 solution can be increased or decreased as necessary. The transmitter will be inserted into a 1.5 to 2.0 cm incision located ventrally along the mid-line of the fish, and a cannula will be used to thread the transmitter antenna through the musculature of the fish approximately 1 cm distal to the incision. To help prevent infection, the incision area will be treated with oxytetracycline, and the incision site closed with 3 to 4 internally-knotted absorbable sutures. After surgery, each fish will be held for a minimum of two hours prior to release to allow adequate recovery from the effects of surgery.

Due to the location of the tagging facility, the transfer of tagged fish to the transportation vessel will not be a simple matter. Since, the tagging site is located under a roadway, it will be necessary to first transport the tagged fish to the roadway, and then to the transport vessel. For this task, we propose to use the methods that we employed in the evaluation of adult steelhead in 2002.
In that study, tagged steelhead adults were placed into a water filled PVC vessel that was lined with a dense foam material, and which had holes drilled in the top to facilitate water flow. The vessel containing the tagged fish was lifted to the upper roadway by rope, and placed into a 52 quart cooler that was filled with fresh river water. The cooler was transported to the transport vessel by hand cart, which was located at the south end of the Visitor Center parking lot. The transport vessel was mounted on a PUD trailer and was supplied fresh water from the adult fishway. In that study, the adult steelhead were then released into the transport tank. For this study, we propose that the tagged lamprey remain within the PVC vessel until release. This strategy will alleviate two concerns. First, by keeping tagged lamprey in the PVC vessels there will not be the possibility of transmitter antennas becoming entangled. Second, lamprey will not attach to the release tank and become dehydrated at the time of release.

After tagging and transport to the release vessel, lamprey will be held throughout the day to facilitate recovery. Based on a morning tagging schedule, this should provide six to seven hours of recovery time.

### 4.5 Release of Tagged Fish

For the downstream release site, we propose three options. The first option is to release tagged fish about 1 km downstream of the project on the right bank. The second option is to release the tagged fish at Confluence State Park, located about 8 km downstream of Rocky Reach Dam near the Wenatchee River confluence. The third option is to release equal numbers of lamprey along the east and west shore downstream near Confluence State Park. The purpose of releasing the fish well downstream (options 2 and 3) of Rocky Reach Dam is to ensure that they have opportunity to distribute horizontally within the river channel. Adequate mixing horizontally within the channel as fish approach the project is necessary to eliminate potential bias associated with entrance selection, and possibly migration rate through the fishway. Regardless of site selection, fish will be transported to the release site via the holding/transport vessel, which will provide compressed oxygen. Due to the short transport time (approximately 20 minutes), water temperature will not be a concern. At either site, fish will be released near shore in an area of limited current.

For the fishway release, fish within the PVC vessel will be placed back into the 52-quart cooler and transported by hand cart to the release location. Fish will simply be lowered back into the fishway by rope with the vessel door open and allowed to volitionally exit the vessel.

### 4.6 Monitoring

To assess passage of Pacific lamprey through the Rocky Reach fishway, we will use telemetry systems currently deployed as part of the adult bull trout study. As noted previously, these systems will provide tailrace residence time, migration rate through the ladder, and identify fallback through the project. However, to better identify areas of delay within the ladder system, should it occur, it may be necessary to modify or add telemetry systems. Modifications to the telemetry systems will be made in consultation with Chelan PUD. The following is a description of the telemetry systems that are currently deployed at Rocky Reach Dam, as well as systems that we propose to install.

#### 4.6.1 Tailrace

Currently, there is a single aerial array consisting of two 6-element Yagi antennas located about 300 meters downstream of the powerhouse on the right bank of the river. These antennas are combined
together to monitor a single detection field with a one SRX receiver. However, since lamprey lack a swim bladder and migrate upstream near the river bottom, we propose to install a second tailrace array on the left bank across the river from the existing system. Doing so will increase the likelihood of detecting fish migrating near the left shore. This system will be configured identically to the existing system. That is, it will consist of two 6-element Yagi antennas, with one antenna pointed downstream at an angle of 40 degrees to the shoreline, and the second pointed upstream at the same angle. The antennas will be combined, and will be monitored by a single SRX receiver. It should be noted, however that the installation of this system is dependent on the ability to locate a secure site.

4.6.2 Spillway Entrance
The spillway ladder entrance is located between spillbays 8 and 9, and extends into the tailrace of the project. At this site, we will install two underwater antennas outside the entrance that are combined as a single antenna to establish the approach of tagged lamprey. These antennas are not currently deployed due to high flows and turbulence associated with spill during previous studies. However, since no spill is likely to occur during the lamprey study, it will be possible to install antennas at this location. A second antenna is currently deployed within the ladder about 8 m upstream of the spillway entrance, and a third antenna about 8 m upstream of the second antenna. A fourth antenna will monitor the transition between the entrance channel and spillway transport channel. Collectively, this system will provide the time of entrance at this location, and passage time through the spillway transport channel to the trifurcation pool.

4.6.3 Left Powerhouse Entrance
The left powerhouse entrance is situated where the powerhouse and spillway meet. At this site, two separate ladder entrances are available for migrating lamprey to enter. At each location, underwater antennas will be located outside and within the entrance to establish time of approach and entry. In addition, we will deploy two bared coax antennas within the channel, with one about 15 m upstream of the entrance, and another about 30 m upstream of the entrance. These two antennas will be used to assess if there is any delay once the lamprey enter the ladder.

4.6.4 Right Powerhouse Entrance
The right powerhouse entrance is located at the downstream end of the collection channel and consists of a single entry. At this location, a total of three underwater antennas will be deployed. Consistent with other ladder entrances, antennas both outside and inside of the ladder entrance will be deployed to assess time approach and entry. A third antenna will be located about 25 m upstream of the entrance at the location where the collection channel begins.

4.6.5 Collection Channel Entrances
The collection channel extends the length of the powerhouse from the right powerhouse entrance to the trifurcation pool. Along the entire course of this channel, a series of 22 orifices (O.G. gates) provide access to the collection channel for migrating adults. Of the 22 orifices, all but six will be closed. For the operational O.G. gates (1-3; and 14, 16, and 20), we currently have antennas deployed both inside and outside of the gates to monitor passage. These systems will be used to identify time of entrance by gate and to partition migration time through the collection channel.
4.6.6 Trifurcation Pool
The trifurcation pool is located at the north end of the powerhouse, and is the structure where the spillway entrance, the left powerhouse entrance, and the collection channel meet. Currently, a series of underwater antennas are deployed at the upstream end of each route that enters the trifurcation pool. Collectively, these antennas will identify the migration rates through these routes and determine when tagged lamprey enter the trifurcation pool. In addition to these antennas, two others are currently located within the transport channel upstream of the trifurcation pool, with one located downstream of a series of diffusers, the other above. These antennas will be used to assess potential delay at this location.

4.6.7 Transport Channel
From the trifurcation pool, the transport channel runs along the base of the powerhouse to the southwest end of the project. Within this area, we currently have four antennas deployed. The first antenna is located about halfway between the trifurcation pool and the end of the powerhouse. The second antenna is located further upstream, about 2/3 the distance from the trifurcation pool to the fish ladder, and is located immediately downstream of the first ladder weir during typical ladder operation. The third and fourth antennas are about 50 and 75 m upstream of the second antenna, respectively, and are located within ladder weirs. Because there are a series of diffusers located downstream of the second antenna, we propose to install a new antenna at the downstream end of the diffusers to assess potential delay.

4.6.8 Ladder Exit
At the exit of the fish ladder, we currently have antennas deployed at five locations. The first antenna is located about 80 m downstream of the ladder exit immediately below a diffusion weir. A second antenna is located in the weir immediately upstream of the diffuser and will allow us to assess possible delays associated with the diffuser. A third antenna is installed in the weir downstream of the observation window, and a fourth in the weir above the window. Finally, there are two underwater antennas located outside of the ladder exit that are combined together, which provide the time of exit from the fishway.

4.6.9 Powerhouse
The powerhouse at Rocky Reach Dam consists of 11 turbines, each with three intakes. Each intake has a headgate slot, which is used to dewater the turbine units, and as such, has rails that extend from the deck surface to the intake floor. Within each headgate slot we will deploy two underwater antenna trolleys, one on each side of the headgate slot, which were developed by BioAnalysts to assess juvenile passage. These trolleys are already constructed, and all of the telemetry wiring is currently installed. This system will be used to assess fallback of radio-tagged lamprey through the powerhouse and will be able to identify the specific turbine unit where the fish passed. Currently the system is configured to monitor turbine units 1, 2, and 6-11 separately, and turbine units 3-5 collectively. However, it is possible to modify this system to identify unit of passage separately for all 11 turbine units.
4.6.10 Spillway
The spillway consists of 12 spillbays that are perpendicular to the river channel. During typical spillway operations, only 7 of the spillbays are used to pass water (spillbays 2-8). Currently, we have a total of 14 underwater antennas deployed at these spillbays, with two antennas deployed at a depth of 30 feet on the inside of each opposing pier-nose of each spillbay. The two antennas for each spillbay are combined and will allow us to identify the specific spillbay a tagged fish passes in the event fallback occurs at this location.

4.7 Tributary Monitoring
While tributary monitoring is not an objective of this study, we propose to monitor both the Wenatchee and Entiat rivers. These systems are currently installed to monitor bull trout migration, and require little effort to maintain. The primary purpose of these systems is to provide a better accounting of tagged fish. The Wenatchee River site will provide detection histories of fish that migrate upstream into the Wenatchee basin and reject migration to Rocky Reach Dam. The Entiat River site will simply provide detection of fish that enter that basin, which may clarify detection histories at Rocky Reach.

Wenatchee River – Currently, two 4-element Yagi antennas are deployed near the town of Monitor (R.K. 8.7), with one antenna aimed downstream and the other upstream. The antennas are combined to provide a single detection field. However, it may be necessary to relocate this system further downstream to detect lamprey destined for spawning areas downstream of the existing site.

Entiat River – Currently, a single telemetry site is located at R.K. 4.8, which has the same design as the Wenatchee River site. The location of this site will likely not change, but we will review existing data on lamprey spawning to determine if relocation is necessary.

4.8 Mobile surveys
Mobile surveys of the study area are also not an objective of the study. However, we propose to conduct occasional boat surveys within the Rock Island and Rocky Reach reservoirs to locate tagged fish that have not been detected by fixed-telemetry sites, or those that may have questionable detection histories at the project. We envision three to four surveys that will include all of the Rock Island reservoir and the Rocky Reach reservoir upstream to Daroga State Park. These surveys may be instrumental in confirming or refuting potential fallback at the project.
SECTION 5: DATA ANALYSIS

The initial phase of data processing will be conducted by Dr. John Skalski with the University of Washington. Data will be imported into a computer program designed to process telemetry data. The program filters out all noise events based on threshold criteria developed within the program using known noise data and provides threshold criteria for each antenna used in the study. The program rapidly identifies fish with obvious detection histories and other individuals that need to be individually critiqued and evaluated. Antenna fields can be reconfigured to allow for alternative analyses and evaluation which provides robustness of results. The program has been used to analyze six major telemetry studies in past years, evaluating the complex detection histories of over 7,000 fish. The advantage of the program is that it will provide concise results for data collected in-season and show a variety of indices such as passage rates through various segments of the Rocky Reach project.

A crucial component to data analysis will be the design of the telemetry system and how it monitors the movement of lamprey at the project. Deployment of an intensive telemetry systems at Rocky Reach Dam will enable us to document the number and length of time lamprey spend within various segments of the project. The most important general indices of passage for lamprey may be project and fishway passage rates. Passage rate can also be applied to various passage routes available at the project or within the different segments of the passage route. Indeed, these evaluations may help identify areas of concern along the passage route, especially at entrances, diffusers, or at the counting station. We will not only be able to determine the various passage rates, we will also be able to assess passage efficiency. Passage efficiency is expressed as a percent and is the number of tagged lamprey detected in the tailrace that passed the project. Below we provide an evaluation matrix to assess the passage of Pacific lamprey at the Rocky Reach project. For clarity, we define the following terms in the table provided.

We will report the elapsed time and number of lamprey for each segment of the project evaluated. The segments will be described by the minimum, maximum and median passage times for different segments and to describe the overall project and fishway passage at the project. Further statistical analysis will largely depend on the number of lamprey encountered at each area of interest. Moser et al. (2002b) provide a template for more robust analysis. Dr. Skalski will provide input on the most appropriate analysis. We will then compare the estimates of passage rate and efficiency to other studies conducted in the Columbia Basin.
## EVALUATION MATRIX

<table>
<thead>
<tr>
<th>Location</th>
<th>Release Site</th>
<th>Tailrace</th>
<th>Entrances</th>
<th>Trifurcation Pool</th>
<th>Transport Channel</th>
<th>Counting Station</th>
<th>Exit</th>
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<td>A-B,C</td>
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<td>C-C</td>
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<td>C-D</td>
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<td>C-G</td>
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<td>F-G</td>
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### Segments Definition

- **B C** Tailrace residence is the elapsed time between detection in the tailrace and detection by the underwater antennas located inside any ladder entrance.
- **C G** Fishway passage time is the elapsed time between detection inside any of the ladder entrances to detection at that ladder exit.
- **B,C G** Project passage efficiency is the proportion of the fish that approached the dam and successfully pass the project.
- **B G** Project passage time is the elapsed time at the dam and is the sum of the tailrace and fishway times.
- **A B,C** Release site to tailrace compares the number of fish at the release site to the number detected in the tailrace.
- **C C** Entrances can be evaluated to assess the number of lamprey detected at each entrance and the time spent at each entrance. Here, we use detection on the outside entrance antennas to those inside the entrance.
- **C D** Available entrances to trifurcation pool is the elapsed time from detection on the inside entrance antennas to the trifurcation pool antenna.
- **D E** Trifurcation pool to transport channel is the elapsed time from trifurcation pool through the transport channel.
- **E E** Transport channel compares elapsed time within specific segments of the channel with and without diffusers.
- **E F** Transport channel to counting stations is the elapsed time through fishway weirs that do not contain diffusers.
- **F F** Counting station is the elapsed past the counting station.
- **F G** Counting station is the elapsed time from the upstream counting station antenna to the ladder exit.
- **G B,C** Fallback will be assessed for fish that are detected exiting the ladder system and are later detected at a location in the tailrace or at an entrance location.
SECTION 6: REPORT WRITING

The report will be prepared by BioAnalysts, with assistance from Dr. John Skalski. At this time we envision preparation of an initial draft that will be submitted to Chelan PUD for internal review. A second draft, edited to reflect comments provided by the PUD, will be submitted approximately two weeks later for distribution to outside parties. Upon receipt of comments on the second draft, we will prepare the final report. At this time, delivery dates for the initial, secondary and final reports have not been defined by the PUD. We have developed a preliminary schedule for these and other activities that will be discussed in consultation with the PUD.
SECTION 7: PROJECT SCHEDULE

Below we provide a preliminary project schedule that outlines some of the steps needed for successful completion of the proposed study. January to March includes a period devoted to contractor selection, meetings and discussion of the workplan. In this period, types of capture methods employed, sampling permits, radio tag selection and telemetry design will be discussed. Study implementation will proceed from March to October. During this period we will also order tags and finalize the telemetry design. Necessary materials (mounts, antennas, equipment, etc.) will be constructed or ordered and will be available by end of June. In June and July, the telemetry system will be setup and tested. From August to September, we will capture and release lamprey and begin monitoring. At the end of September the tagging phase will be complete, but monitoring will continue possibly into November. The study will end by late December, when the final report is submitted and approved.

<table>
<thead>
<tr>
<th>Preliminary Project Schedule</th>
<th>Details</th>
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<tbody>
<tr>
<td>Date</td>
<td>Contractor Selection and Work Plan</td>
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<tr>
<td>January-March</td>
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<tr>
<td>January 23</td>
<td>Submit Study Plan</td>
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<tr>
<td>January 26 - 30</td>
<td>Selection of Contractor</td>
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<tr>
<td>January 26 - 30</td>
<td>Kickoff Meeting / work plan</td>
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<tr>
<td>February 2 - 13</td>
<td>Meet with study team to discuss work plan</td>
</tr>
<tr>
<td>February 16 - 18</td>
<td>Modify work plan (identify capture methods, tagging schedule, etc).</td>
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<tr>
<td>February 20</td>
<td>Finalize Work Plan</td>
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<tr>
<td>March - October</td>
<td>Implement Study</td>
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<tr>
<td>March</td>
<td>Submit Tag Order</td>
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<tr>
<td>June-July</td>
<td>Telemetry Design Setup and testing</td>
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<tr>
<td>July</td>
<td>Test capture method</td>
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<tr>
<td>August-September</td>
<td>Capture, tag and release lamprey</td>
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<tr>
<td>August-October</td>
<td>Monitoring</td>
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<tr>
<td>October - December</td>
<td>Report Preparation</td>
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<tr>
<td>November 19</td>
<td>Internal Draft Report</td>
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<tr>
<td>December 3</td>
<td>Second Draft Report</td>
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<tr>
<td>December 31</td>
<td>Final Report</td>
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SECTION 8: PROJECT PARTICIPANTS

Dr. Tracy W. Hillman is certified ecologist with over 15 years experience studying the effects of land uses such as forestry, grazing, mining, and hydroelectric development on streams and fishes. He has studied extensively the summer and winter ecology, habitat use, and behavior of fish in western streams. He has written several articles on the ecology of both resident and anadromous salmonids including one that was ranked by the American Fisheries Society as one of the most significant papers published in 1997. Dr. Hillman has written technical reports on Pacific lamprey, bull trout, steelhead, and chinook salmon. He also provided Chelan PUD with a status review of Pacific lamprey in the Mid-Columbia region. He has also written several biological assessments, evaluations, and recovery plans. He served on the editorial board of the North American Journal of Fisheries Management with the task of evaluating reports. In addition, Dr. Hillman has conducted extensive research in the mid-Columbia Basin. His role in this study will be to direct all phases of work. He will be largely responsible for evaluating existing information, data analysis, and report writing.

Dr. Albert E. Giorgi has been conducting research on Pacific Northwest salmonid resources since 1982. His research specializes in migratory behavior, juvenile salmonid survival, biological effects of hydroelectric development and operation, and population modeling. His research has included the use of radio telemetry and PIT-tag technology. In addition to his research activities he acts as a technical analyst and advisor to public agencies and private parties. His clients have included: the Bonneville Power Administration; U.S. Army Corps of Engineers; Chelan, Douglas, and Grant County Public Utility Districts; and a number of engineering firms including: CH2M Hill, Dames and Moore, Harza, HDR, INCA, and Montgomery Watson. Dr. Giorgi regularly teams with structural and hydraulic engineers in the design and evaluation of fish bypass systems in the Columbia Basin. He has been involved in a variety of formal consultations with federal agencies regarding ESA issues.
Dr. John R. Skalski Dr. Skalski has been a research scientist and professor of biological statistics for 26 years. He was a research scientist at Battelle Pacific Northwest Laboratory for 9 years in the Aquatic, Terrestrial, Quantitative Ecology, and Marine Sciences division. Since 1987, he has been a professor at the University of Washington, School of Aquatic and Fishery Sciences. He has over 50 peer-reviewed publications and books on the statistics of analyzing animal tagging studies. Research he has directed has led to the statistical models used throughout the Columbia Basin to analyze PIT-tag, radio-tag, acoustic-tag, and balloon-tag studies. He has been principal investigator or co-principal investigator on over 45 tagging studies in the Columbia Basin, including 7 radio-telemetry studies. The telemetry studies include developing the study designs, analysis of the raw signal data, parameter estimation, and report preparation.

Mr. Peter Westhagen has been software engineer at the University of Washington, School of Aquatic and Fishery Sciences for 14 years. During that time, he has developed the statistical and data processing software used to analyze PIT-Tag (i.e., Program SURPH 2.1, PitPro) and radio-tag (Program Telem, Program USER 1.1) data used by NOAA Fisheries, the US Geological Survey, the Nez Perce Tribe, the Mid-Columbia public utility districts, and sponsored by the Bonneville Power Administration. Having helped create the software packages for the tag analyses, he is intimately familiar and facile with their use. Mr. Westhagen has processed 100,000’s PIT-tag capture histories and 10,000’s radio-tagged fish, providing pivotal summaries and analyses of the data. In 2003, he provided near real-time analysis of radio-telemetry data from 2,400 tagged smolts monitored at Rocky Reach and Rock Island dams to estimate fish passage performance.

Mr. John R. Stevenson is an experienced fisheries biologist who has extensive knowledge in evaluating the behavior and survival of salmonids within the mid-Columbia using radio-telemetry techniques. He has served as project leader for several juvenile survival and behavior telemetry studies and adult passage conducted by Chelan PUD since 1996. He has surgically and gastrically implanted radio transmitters into literally thousands of juvenile salmonids and monitored the movements of these fish through the mid-Columbia hydroelectric system. In addition to serving as project leader, he is an expert on the surgical implantation of radio transmitters, the design, setup, operation and diagnosis of telemetry systems, and mobile tracking. He was responsible for the design and set up of telemetry system used to assess project effects on bull trout. He also has extensive telemetry experience studying large mammals using telemetry techniques. In this study, Mr. Stevenson will be involved in all aspects of the study. His primary responsibilities will be in design and setup of telemetry systems as well as data analysis, and report writing.

Mr. Mark D. Miller is an experienced fisheries biologist who has extensive knowledge in evaluating the behavior and survival of juvenile salmonids within the mid-Columbia area using radio-telemetry techniques. He has supervised juvenile survival telemetry studies conducted by Grant PUD and PacifiCorp, and has surgically implanted radio transmitters into thousands of juvenile salmonids. He is experienced in telemetry designs that were used to assess juvenile salmonid survival and behavioral and bull trout monitoring studies for Chelan PUD. His primary role will be to assist in research, data analysis, and report writing for this project.

Mr. Dennis J. Snyder is an experienced fisheries biologist with extensive knowledge in the design, setup, operation, and trouble shooting of complex radio telemetry systems, mobile tracking, and the surgical implantation of radio transmitters in juvenile salmonids. He has served as field supervisor...
on the telemetry studies conducted by Chelan PUD since 1996 and has supervised the setup of telemetry systems and field crews. Because of his extensive telemetry experience, Mr. Snyder will be involved in all aspects of the field study. The fact that Mr. Snyder resides in the Wenatchee area and has an extensive knowledge of the Rocky Reach project and a close working relationship with Chelan PUD personnel (biologists, mechanics and fishway attendants), makes him ideally suited to assist in the field component of this study.

Mr. Jeff T. Reeves is a fisheries technician who has been involved with telemetry studies evaluating the survival of juvenile salmonids as they migrate past Rocky Reach and Rock Island dams in 1999 to present. He has extensive experience in surgically implanting radio transmitters into juvenile salmonids and adult bull trout. He also has experience with the setup and operation of complex telemetry systems and the monitoring of telemetry equipment that has been used at Chelan PUD projects. In this study, Mr. Reeves will be involved in tagging and telemetry setup and maintenance. Mr. Reeves also lives in the Wenatchee area and has worked closely with Chelan PUD personnel.
SECTION 9: REFERENCES


Bell, M. 1990. Fisheries handbook of engineering requirements and biological criteria. Fish Passage Development and Evaluation Program, Corp of Engineers, North Pacific Division, Portland, OR.


