

*Revised*

**Packwood Lake Entrainment Study Plan  
for  
Energy Northwest's Packwood Lake  
Hydroelectric Project  
FERC No. 2244  
Lewis County, Washington**

Submitted to



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## **1.0 INTRODUCTION**

Energy Northwest's Packwood Lake Hydroelectric Project, FERC No. 2244, received its initial license in 1960. The majority of the Project is located in the Gifford Pinchot National Forest. The Project consists of an intake canal, a concrete drop structure (dam) and intake building on Lake Creek located about 424 feet downstream from the outlet of Packwood Lake, a 21,691-foot system of concrete pipe and tunnels, a 5,621-foot penstock, a surge tank, and powerhouse with a 26,125 kW turbine generator.

The source of water for the Project, Packwood Lake, is a natural lake situated at an elevation of approximately 2,857 feet above mean sea level (MSL), about 1,800 feet above the powerhouse. Water discharged from the Project is released to the Cowlitz River via a tailrace channel. Power from the Project is delivered over an 8,009-foot 69 kV transmission line to the Packwood substation.

During the recreation season, May 1 through September 15, Packwood Lake is maintained at its approximate natural elevation (2,857 feet MSL). During the remainder of the year, the existing FERC license allows lowering the lake level not more than eight feet below the summer lake level down to an elevation of 2,849 feet MSL.

An entrainment study at the intake structure commenced during October, 2004. The results were very preliminary and additional sampling is required before conclusions regarding the efficacy of the screens and the potential impacts of entrainment can be determined. This study is proposed to more comprehensively examine entrainment potential at the intake structure.

### **1.1 Study Plan Goals and Objectives**

The goal of this study is to identify relative abundance, age/sex, timing and species composition of fishes entrained, impinged or otherwise affected by the Packwood Lake Hydroelectric intake structure. This information will improve the knowledge base and develop an understanding of the options for natural resource protection, mitigation and enhancement.

Objectives of the Packwood Lake Hydroelectric Project Entrainment Study include:

- Determine species relative abundance, age/size, timing and composition at the intake structure.
- Evaluate the effectiveness of the Project's screens in terms of protecting fish.
- Assess the potential entrainment or impingement impacts from the lake elevation and Project flow fluctuations.
- Develop a rule curve for lake level elevation and diversion rate, since approach velocities may exceed the state criteria of 0.33 fps at some operating scenarios.

## **2.0 AGENCY AND TRIBE RESOURCE GOALS AND OBJECTIVES**

The Washington Department of Fish and Wildlife (WDFW) and the US Fish and Wildlife Service (USFWS) requested this study (WDFW 2005, USFWS 2005). These agencies submitted their resource management goals and objectives, which are provided below.

### **2.1 WDFW Resource Management Goals**

WDFW stated in the Entrainment Study Request that the goal of their management policy is no net loss of existing or potential habitat. WDFW's Management objectives for the Packwood Lake rainbow trout population were described as follows:

- Continue to manage for wild production of these unique native rainbow trout. WDFW currently has no plans to plant any additional rainbow or any other type of trout in the future.
- WDFW will continue to monitor spawning annually for changes in population size.

Genetic diversity within and among stocks will be maintained or increased to encourage local adaptation and sustain and maximize long-term productivity. Conditions will be created that allow natural patterns of genetic diversity and local adaptation to occur and evolve (WDFW 1995).

The objectives of fish access and passage stated in the WDFW Salmonid Policy include: 1) to ensure salmonids are protected from injury or mortality from diversion into artificial channels or conduits, and 2) to ensure natural fish passage barriers are maintained where necessary, to maintain biodiversity among and within salmonid populations and other fish and wildlife.

The goals of the Wild Salmonid Policy include: 1) to ensure that usable or restorable habitat is accessible to wild salmon, and 2) screen all water diversions with state-of-the-art facilities designed to comply with current regional protection criteria. Achieve **No Net Impact** for each species affected by hydropower projects through a combination of: 1) project improvement measures to ensure high survival rate; and 2) compensation/ mitigation for unavoidable impacts.

The Washington Department of Fish and Wildlife Draft Hydroelectric Project Assessment Guidelines (WDFW 1995) explain fish and wildlife management objectives for hydropower projects. Studies are requested that will gather information necessary to assess potential impacts of a hydroelectric project on fish and wildlife and their habitat.

### **2.2 USFWS Service Management Goals**

As stated in their Entrainment Study Request, USFWS seeks the accomplishment of the following resource goals and objectives through the relicensing process for the Project:

#### **2.2.1 General Goals**

1. Ensure that protection, mitigation and enhancement measures are commensurate with Project effects and help meet regional fish and wildlife objectives for the basin.

2. Recover federally proposed and listed species.
3. Conserve, protect, and enhance the habitats for fish, wildlife, and plants that continue to be affected by the Project.
4. Ensure that once the licensing process is complete, there is an adaptive management plan to allow the use of new information or new management strategies over the term of the license, bringing us closer to the desired level of protection for fish and wildlife resources. The adaptive approach is particularly appropriate where there are insufficient data and/or biological uncertainties about those measures that will be most effective for meeting ecosystem goals and objectives.

### **2.2.2 *Goals for Aquatic Ecosystems***

1. Protect, enhance, or restore diverse high quality aquatic and riparian habitats for plants, animals, food webs, and communities in the watershed and mitigate for loss or degradation of these habitats.
2. Maintain and/or restore aquatic habitat connectivity in the watershed to provide movement, migration, and dispersal corridors for salmonids and other aquatic organisms and provide longitudinal connectivity for nutrient cycling processes.
3. Restore naturally reproducing stocks of native anadromous and resident fish to historically accessible riverine habitat, using stocks that are native to the Cowlitz River basin where feasible, with priority given to the restoration of listed native stocks.
4. Provide an instream flow regime that meets the spawning, incubation, rearing, and migration requirements of wild salmonids and other resident fish and amphibian species, throughout the project area.
5. Meet or exceed federal and state regulatory standards and objectives for water quality in the basin.
6. Minimize current and potential negative project operation effects on water quality and downstream fishery resources.

### **2.2.3 *Goals for Endangered, Threatened and Proposed Species***

1. Reduce project effects on bald eagles, spotted owls, and other threatened, endangered, and proposed species.
2. Explore opportunities for potential protection, mitigation and enhancement measures for threatened, endangered, and proposed species.
3. If bull trout are discovered within the Cowlitz River basin, gain a better understanding on bull trout population trends, migration, habitat loss, present usage and continuing impacts as related to the Project.

In addition, an overarching USFWS goal for the new licensing of the Project is to have the Commission include protection, mitigation and enhancement measures that sustain normal ecosystem functional processes including geomorphic, hydrologic and hydraulic patterns, and water chemical and physical parameters as license conditions. Maintaining and improving these functional processes throughout the term of the new license will, in turn, provide the habitat to support healthy fish and wildlife populations.

USFWS study requests are intended to facilitate the collection of information necessary to conduct effects analyses and to develop conservation measures, reasonable and prudent measures, and protection, mitigation, and enhancement measures pursuant to the Endangered Species Act (Act) of 1973, as amended (16 U.S.C. § 1531 *et seq.*), the Fish and Wildlife Coordination Act (48 Stat. 401), as amended, (16 U.S.C. § 661 *et seq.*), and the Federal Power Act (FPA) (16 U.S.C. § 791a, *et seq.*).

### 3.0 EXISTING INFORMATION AND NEED FOR ADDITIONAL INFORMATION

#### 3.1 Existing Information

The Project facilities section in the Pre-Application Document (Energy Northwest 2004) includes a detailed description of the intake structure. In 2004, EES Consulting began to study the presence of target species in the vicinity of the Project intake to evaluate the potential for fish entrainment at the Project intake structure. Fish entrained at the intake are removed from the lake population and no longer available for recruitment to the lake fishery. The target species for the entrainment study were rainbow trout (*Oncorhynchus mykiss*) and coastal cutthroat trout (*O. clarki clarki*). This preliminary draft report was distributed to the agencies in January 2005 (EES Consulting 2005).

##### 3.1.1 Fisheries Investigations

EES Consulting requested and was issued a Scientific Collectors Permit (SCP) for the Project in October 2004. The permit allowed the capture of fish in the vicinity of the Project intake, using an experimental, variable-mesh gillnet. The net was 150 ft (45.7 m) long and 8 ft (2.4 m) deep with variously sized meshes ranging from ¼ in (6.4 mm) to 3 in (76.2 mm) stretched mesh. From October 13-16 and October 27, the gillnet was set to intercept those fish that were traveling in the vicinity of the intake structure. Because the Project was shut down for maintenance at this time, there was no attraction flow to the intake structure during the time of sampling. Table 3-1 summarizes the fish caught in the experimental gillnet at the Packwood Lake Hydroelectric Project intake during October, 2004.

<b>Date</b>	<b>Species</b>	<b>Length (mm)</b>	<b>Water temp (°C)</b>
Oct. 13	Rainbow trout	203	13.3
	Rainbow trout	203	13.3
Oct. 14	Rainbow trout	229	13.3
Oct. 15	Rainbow trout	254	13.3
	Rainbow trout	229	13.3
Oct. 16	Rainbow trout	254	13.3
	Rainbow trout	279	13.3
	Rainbow trout	305	13.3
	Rainbow trout	305	13.3
Oct. 27	None	-	3.7

### 3.1.2 Engineering Investigations

Energy Northwest also reviewed the intake structure drawings to determine the size of the openings in the trash screen at the intake structure. The screening over the intake structure is in the configuration of a 4X4 mesh (four meshes per inch in both the horizontal and the vertical). Wire mesh diameter is 0.080 inch, leaving openings 0.17 inch X 0.17 inch between the wires (4.3 mm X 4.3 mm).

Two screens provide protection to fish for the intake structure. Both structures are 9 ft in width and exceed 28 ft in height. The base elevation of the screens is 2840 ft, with a lake elevation of 2857 ft at full pool, giving a potential screen area of 306 ft<sup>2</sup> when the lake is full. A schematic of the intake structure, showing the traveling screens and trash racks, is provided in Figure 3-1.

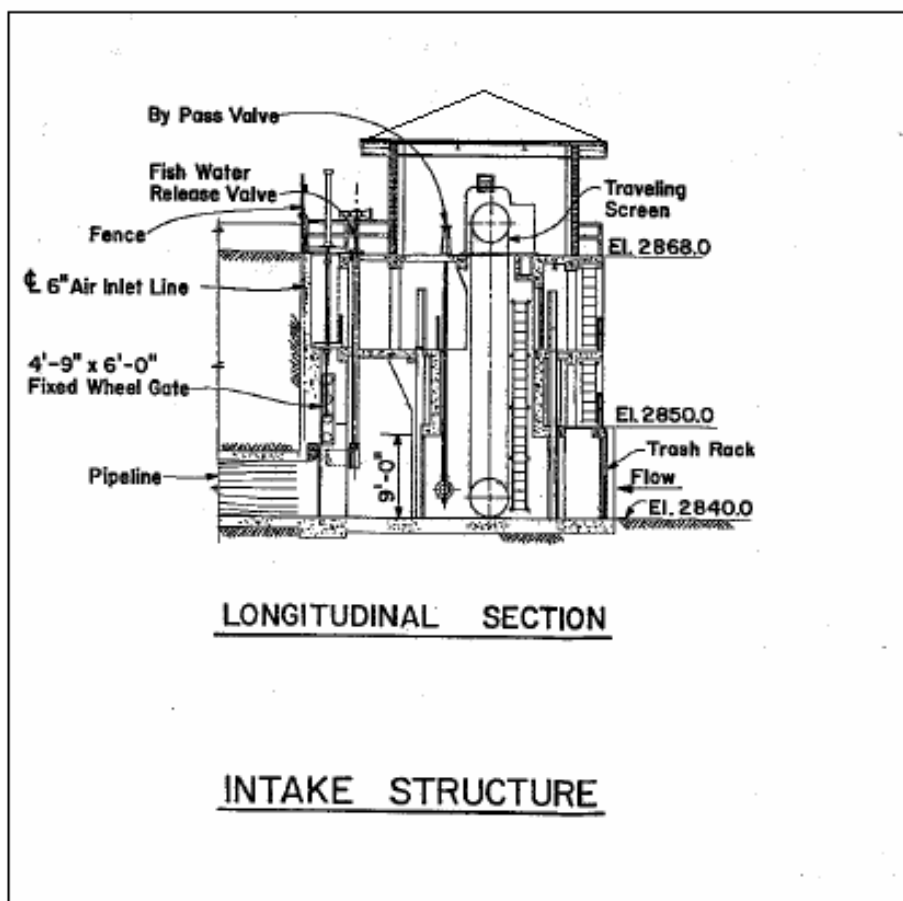


Figure 3-1 Schematic of the Intake Structure

### 3.2 Need for Additional Information

As stated in EES Consulting (2005):

*Entrainment investigations for 2004 were extremely limited, with sampling only occurring on two occasions in October. The project was not operating during the*

*sampling period, so there was no active flow towards the intake structure and the fish in effect were “milling” in the vicinity of the intake structure. At this point, the data indicate that larger rainbow trout (approximately 200 – 300 mm) are found in the general area (i.e., within 15 m – 25 m) of the intake structure. The data, however, do not consider: 1) the time of year that the fish would be migrating and could most likely be found in the vicinity of the intake structures; 2) the size of the fish traveling in the area of the intake structure; 3) lake elevation, and 4) project flows (i.e., flows used to produce power). Since project flows and lake elevation directly affect the mean approach velocity at the screens, it is important to understand the timing of the fish population migration in the vicinity of the intake structure as well as the lake level and project flows in order to estimate the potential impact to the resident fish population. Although the gillnet has small mesh panels, it is most likely not effective in capturing fry.*

The USDA Forest Service Gifford Pinchot National Forest Existing Information Analysis for Aquatic Biological Resources (December 2004) identifies entrainment as a potential issue. “Water diversion operations may have direct impact to fish through physical processes such as impingement and entrainment. The proposed study plan should include an assessment of dam operations that may harm or disturb fish.”

Additional entrainment and fish presence information in the vicinity upstream of the drop structure needs to be collected, in particular to determine the number, size, and timing of fish in the vicinity of the intake at Packwood Lake. This information will increase the understanding of the Project effects on fish in the vicinity upstream of the drop structure.

#### **4.0 NEXUS BETWEEN PROJECT OPERATIONS AND EFFECTS ON RESOURCES**

Site-specific entrainment studies for the Project conducted in 2004 provided limited data. There is a need to develop a rule curve for lake level elevation and diversion rate; depending upon the lake elevation and Project flows, approach velocity may exceed the state criteria of 0.33 fps.

Historically, there most likely were no permanent fish passage barriers between Packwood Lake and the uppermost section of Lake Creek. Low flow conditions may have restricted fish access between the Lake and the Creek during certain times of year. The presence of a log jam at the Lake outlet most likely did not pose a barrier to fish passage. In general, log jams have numerous water routes over, around, and through, that allow fish to migrate past. In addition log jams are constantly changing, with wood lost and new wood added during high flow events.

The Project began operation of the drop structure in 1964 in order to divert flow from Packwood Lake into a pipeline and the powerhouse. The drop structure currently has a bypass pipe that allows water to flow from Packwood Lake into Lake Creek. However, the inlet of the bypass pipe is located on the downstream side of the intake debris/fish screen; therefore no fish currently can pass downstream of the drop structure except possibly during spill events.

Spill events occur on a sporadic basis when lake elevations exceed 2,858.5 ft. Study results would determine the number, age/size, and timing of fish attempting to outmigrate from Packwood Lake. As mentioned above, these fish currently cannot access Lake Creek except

during sporadic spill events. Outmigrants from Packwood Lake may be an important recruitment source for trout and other fish populations within Lake Creek, particularly the isolated reach immediately downstream of the drop structure. Entrainment or impingement at the Project intake may affect species abundance, fishing opportunity, and potentially genetic diversity within the fish populations in Lake Creek and Packwood Lake.

## **5.0 STUDY AREA AND METHODS**

### **5.1 Study Area**

The study area will be in the vicinity of the intake structure for the Packwood Lake Hydroelectric Project.

### **5.2 Methodology**

The study will determine the effectiveness of the existing screens at various flows, taking into account site-specific conditions of quantity and movement of bed load and debris. A description of how the screens are cleaned and the effects on screen approach velocity and control system logic when screens are partially plugged will be provided.

#### ***5.2.1 Approach Velocities at the Intake***

In order to measure velocities in front of the intake screen, an Acoustic Doppler Current Profiler (ADCP) will be used, if this method proves feasible; the proximity of the enclosure around the screens may interfere with the signal from the Doppler. If the Doppler will not work in such a confined area, measurements will be taken horizontally and vertically across the intake screens using a Swoffer digital velocity meter.

Measurements will be taken at a range of lake elevation and flow levels in order to collect velocity arrays vertically and horizontally across the screen. These velocities will then be compared to the WDFW Screening Requirements for Water Diversions, as referenced in the Fish Passage Barrier and Surface Water Diversion Screening Assessment and Prioritization Manual, August 2000; and the WDFW Draft Fish Protection Screens for Washington State (2000).

#### ***5.2.2 Fisheries Investigations***

An experimental, variable-mesh gillnet at the intake structure will be deployed 3 to 4 times per month at a minimum of 2-day intervals from March through September, 2006 to monitor fish activity and behavior around this facility. The net will be checked periodically (e.g., every 3 to 4 hours) during the daytime period every day that the net is deployed and in the morning hours after each nighttime set. If mortalities are observed in the net, the protocol will be changed to monitor the nets at least hourly during the day while deployed to minimize harm to fish; the nets will be pulled (e.g. tying the lead line to the float line so that the net does not fish) at night and reset in the morning. The results will be used to determine the timing, species composition, and size of the fish that would be migrating near the vicinity of the intake.

Lake levels and Project flows will be recorded daily. The traveling screens will be set to “Off” mode during the study. Energy Northwest staff will check the screens during the March through September period weekly. The traveling screens will be rotated and any fish impinged on the screens will be collected to determine the species, length, and condition (e.g. descaling, etc), which will be recorded. Representative samples of fish mortalities will be preserved. The trash racks will be raised monthly for inspection to determine if any fish have been impinged.

Energy Northwest will discuss with the agencies and tribes a protocol to mount underwater video cameras at the intake to observe fish behavior at the screens. The effectiveness of this as a tool is dependent upon water clarity; if visibility is poor because of high turbidity, the results during that period of time may be of limited use.

The efficacy of the Doppler and the underwater cameras will be tested during summer 2005. Energy Northwest will then report the results to the agencies and tribes and any modifications necessary due to field trials.

Although there is a small platform located behind the screens, there is no place to anchor a net. Nor is there sufficient area where the net could be pulled out of the water to examine it. If a net were to be employed and become dislodged, it would be swept directly into the pipeline and the turbine downstream. Therefore, it is not feasible to place a net in this location.

Background information will include any written or oral historic information on entrainment that has been collected by Energy Northwest personnel.

### **5.3 Products**

The products of the Packwood Lake Entrainment Study will be draft and final reports discussing the results of the velocity distributions across the intake screens at a range of flows and lake levels, as well as fish behavior, distribution and mortalities, if any. Preliminary data collected will be reviewed periodically (initially bi-monthly) by the agencies and tribes to determine if modifications to the study design are necessary. Data will be provided via email unless circumstances indicate a need for meeting. Draft copies of the Entrainment Study will be provided to the agencies and tribes for review and comments. The final study report will be provided to the agencies and tribes.

### **5.4 Consistency with Generally Accepted Scientific Practice**

The survey protocol proposed by Energy Northwest is essentially the same as outlined in the WDFW and the USFWS requests, with two differences. Energy Northwest does not think that netting behind the screens is feasible due to the potential hazard to the plant if the net were to be swept into the pipeline. Rather than monitoring the gillnet continuously, this study proposes to monitor the gillnet at a frequency of approximately every 3 to 4 hours during the day shift and in the morning hours after each nighttime set. If mortalities are observed in the net, the protocol will be changed to monitor the nets at least hourly during the day while deployed to minimize harm to fish; the nets will be pulled (e.g. tying the lead line to the float line so that the net does not fish) at night and reset in the morning.

## **6.0 CONSULTATION WITH AGENCIES, TRIBES AND OTHER STAKEHOLDERS**

Energy Northwest initiated agency consultation in December 2003. A Water Quality and Aquatic Resources Committee was formed in March 2004. Representatives include Energy Northwest, EES Consulting, WDFW, USFWS, NOAA-Fisheries, Department of Ecology, the USDA Forest Service, the Cowlitz tribe, and the Yakama Nation. Updates will be provided and preliminary data collected will be reviewed periodically with the agencies, tribes, and other interested stakeholders (initially bi-monthly) to determine if modifications to the study design are necessary. Draft copies of the Entrainment Study will be provided to the agencies and tribes for review and comments. The final study report will be provided to the agencies and tribes.

## **7.0 PROGRESS REPORTS, INFORMATION SHARING, AND TECHNICAL REVIEW**

Technical reports, including the draft and final Entrainment Study Plan will be shared with stakeholders and will discuss the progress of the studies. Energy Northwest and its consultant will also report on the methods, progress, and results of the entrainment study at the Water Quality and Aquatic Resources Committee meetings.

Energy Northwest will provide copies of the draft entrainment report to interested stakeholders for review. Review periods will be 30 days, after which Energy Northwest and its consultant will take review comments into consideration when making revisions and producing a final report.

## **8.0 SCHEDULE**

During the summer of 2005, Energy Northwest and its consultant will work with the agencies and tribes to finalize the study protocol and use of a camera at the intake. We will attempt to calibrate the ADCP to the screens in 2005. Data collection will be from March through September 2006. A draft entrainment report for the 2006 season will be completed and distributed to the agencies and tribes for review and comment for a 30 day period, after which the report will be finalized. The draft report for the 2006 field season will be completed by November 15, 2006.

## **9.0 LEVEL OF EFFORT AND COST**

Study efforts outlined above are intended to provide relevant information regarding the potential for entrainment at the Project intake. Efforts will include ground testing the ADCP; developing deployment structures for the Doppler velocity measurements and data analysis; net deployment and sampling; camera mounting, operation and data reduction; development of interim reports for the agencies and tribes; and draft and final report submittal.

The level of effort given below is for seven months of sampling. This task will require approximately 2 person days for deployment and testing of equipment, 42 person days of sampling (at 2 days, 3 times per month for 7 months), 2 person days of project management, and 11 person days for interim, draft, and final reports for a total of 57 person days. It is assumed

that other tasks will be incorporated with these visits, so that expenses (mileage, hotel and per diem and travel time) can be shared. Costs will also include ADCP and camera rental charges and miscellaneous expenses. Estimated costs for the study plan are approximately \$56,501.

## 10.0 LITERATURE CITED

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