Revised

Stream Connectivity in Packwood Lake Tributaries Study Plan for Energy Northwest's Packwood Lake Hydroelectric Project FERC No. 2244 Lewis County, Washington

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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.

From 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.

1.1 Study Goals and Objectives

The goal of the study is to evaluate the connectivity of Packwood Lake tributaries to the reservoir considering the seasonal drawdown and fluctuating water level of the reservoir and the erosive potential of the stream channel and reservoir shoreline. See Figure 1-1 for a map showing the tributaries.

The objective of this study is to determine if the periodic drawdown of reservoir water surface elevation between 2857 ft MSL and 2849 ft MSL modifies aquatic connectivity and transport potential to the tributaries of Packwood Lake. The study will evaluate the capacity of the channel to pass fish, transport sediment, and provide functional habitat for aquatic organisms.

2.0 AGENCY AND TRIBE RESOURCE MANAGEMENT GOALS AND OBJECTIVES

The USDA Forest Service requested this study (USDA Forest Service 2005). Their resource management goals and objectives, provided by the Forest Service, are listed below.

Figure 1-1. Map of Tributaries to Packwood Lake

2.1 Forest Service Resource Management Goals and Objectives

As stated by the Forest Service, the Gifford Pinchot National Forest Land and Resource Management Plan (1990), as amended by the Northwest Forest Plan in 1994, provides the management direction for all National Forest System lands and their associated resources directly affected by or within the project vicinity of the Packwood Lake hydroelectric system. The Aquatic Conservation Strategy (ACS), a core component of the Northwest Forest Plan, provides management direction aimed at maintaining or restoring the ecological health and function of watersheds and the aquatic ecosystems contained within them. ACS objectives which are most relevant to this study proposal are:

> *Objective 1 – Maintain and restore the distribution, diversity, and complexity of watershed and landscape-scale features to ensure protection of the aquatic systems to which species, populations, and communities are uniquely adapted.*
>
> *Objective 2 – Maintain and restore spatial and temporal connectivity within and between watersheds. Lateral, longitudinal, and drainage network connections include floodplains, wetlands, upslope areas, headwater tributaries, and intact refugia. These network connections must provide chemically and physically unobstructed routes to areas critical for fulfilling life history requirements of aquatic and riparian-dependent species.*
>
> *Objective 3 – Maintain and restore the physical integrity of the aquatic system, including shorelines, banks, and bottom configurations.*
>
> *Objective 4 – Maintain and restore water quality necessary to support healthy riparian, aquatic, and wetland ecosystems. Water quality must remain within the range that maintains the biological, physical, and chemical integrity of the system and benefits survival, growth, reproduction, and migration of individuals composing aquatic and riparian communities.*
>
> *Objective 5 – Maintain and restore the sediment regime under which aquatic ecosystems evolved. Elements of the sediment regime include the timing, volume, rate, and character of sediment input, storage, and transport.*
>
> *Objective 6 – Maintain and restore in-stream flows sufficient to create and sustain riparian, aquatic and wetland habitats and to retain patterns of sediment, nutrient, and wood routing. The timing, magnitude, duration, and spatial distribution of peak, high, and low flows must be protected.*
>
> *Objective 7 – Maintain and restore the timing, variability, and duration of floodplain inundation and water table elevation in meadows and wetlands.*
>
> *Objective 9 – Maintain and restore habitat to support well-distributed populations of native plant, invertebrate and vertebrate riparian-dependent species.*

3.0 EXISTING INFORMATION AND NEED FOR ADDITIONAL INFORMATION

3.1 Existing Information

Packwood Lake is fed by at least seven fish-bearing tributaries which totals approximately eight miles of fish accessible habitat important for reproduction and rearing for a native strain of uniquely adapted Packwood rainbow trout (*Oncorhynchus mykiss*) and cutthroat trout (*O. clarki*). Isolated fish populations above the existing Packwood Lake intake structure are believed to have evolved in the Upper Lake Creek basin and have maintained a self-sustaining population whose life cycle depends on the lake environment for adult holding and foraging and the tributaries for spawning and rearing habitat (USDA Forest Service 2004).

The fish-bearing tributaries of Packwood Lake include Upper Lake, Beaver Bill (a tributary of Upper Lake), Muller, Crawford, Trap, Osprey, and unnamed tributary SE of Trap creeks, which have never been the subjects of a Level II stream survey (refer to Figure 1-1). Upper Lake Creek is a glacial-fed system which provides most of the lake inflow. The other tributaries are typically small spring-fed drainages (400-700 acres) that descend in steep mountain headwall channels. The lower 0.25 - 0.75 river miles transition to a moderate gradient (< 4%) and are accessible to fish. These small streams have a bankfull width typically < 10 ft, and low flow at an estimated volume of 3-6 cfs. Abundant overhanging vegetation, fallen logs, and undercut banks provide plentiful hiding habitat. Isolated pockets of gravel provide necessary spawning substrate for resident trout (USDA Forest Service 2004). Table 3-1 summarizes rainbow trout spawning observed in tributaries to Packwood Lake.

Table 3-1. Adult rainbow trout count from annual spawning surveys in major tributaries to Packwood Lake between 1979 and 2004 (WDFW 2004)

Year	Osprey Creek	Trap Creek	Muller Creek	Crawford Creek*	Beaver Bill Creek (Tributary to Upper Lake Creek)	Tributary SE of Trap Creek	Total
All 1979	-	-	194	-	-	-	194
06/18/81	16	18	67	5	-	-	106
06/29/82	-	0	0	0	-	0	0
06/20/83	0	-	0	-	-	-	0
All 1984	-	-	55	317	-	40	412
06/26/85	3	0	14	200	-	0	217
06/27/86	-	-	13	112	-	-	125
06/09/87	-	-	78	332	-	-	410
06/16/88	-	180	61	721	-	4	966
06/14/89	490	160	180	405	82	5	1322
06/15/90	24	5	149	60	-	-	238
06/19/91	314	94	399	363	-	0	1170
06/20/95	1	0	86	166	-	-	253
06/28/96	0	3	299	238	-	-	540
06/25/97	29	13	590	214	-	-	846
06/24/98	28	9	374	220	-	-	631

Table 3-1 (Continued). Adult rainbow trout count from annual spawning surveys in major tributaries to Packwood Lake between 1979 and 2004 (WDFW 2004)

Year	Osprey Creek	Trap Creek	Muller Creek	Crawford Creek*	Beaver Bill Creek (Tributary to Upper Lake Creek)	Tributary SE of Trap Creek	Total
07/06/99	19	30	155	107	-	-	311
06/29/00	355	27	249	153	-	-	784
06/25/02	138	60	414	265	-	8	885
06/25/03	181	6	201	305	-	0	693
06/29/04	37	17	245	485	3	0	787
Total	1,635	622	3,823	4,668	85	57	10,890
Mean	109	39	182	246	43	6	519
Minimum	0	0	0	0	3	0	0
Maximum	490	180	590	721	82	40	1,322

*Crawford Creek has at times been a tributary to Upper Lake Creek.

Energy Northwest conducted a preliminary study to evaluate the effects of the drawdown on upstream fish passage into these lake tributaries (EES Consulting 2005). The study examined the potential for passage in a number of the creeks, but did not address all fish-bearing streams.

Operation of the Packwood Lake Hydroelectric Project results in fluctuations of the lake levels. During the summer months, lake levels are held at the license-requirement of 2,857 ft MSL plus or minus 6 inches. From May 1 to September 15, the Project operates with Project generation flow adjusted to match lake inflow to hold the lake elevation relatively constant. After mid-September, the lake level may be drawn down 8 feet to a level no lower than 2,849 feet MSL. The 8 feet of vertical storage allows the Project to store and utilize winter runoff for power generation. When seasonal high runoff exceeds the Project capacity and the ability of the lake to absorb peak discharges, the drop structure is overtopped (at elevation 2,858.5 feet MSL) and excess runoff is directed down Lake Creek. During times when the lake is drawn down, tributaries entering the lake temporarily experience a lower base level. If flows are low in these tributaries during the drawdown, the tributaries can incise into the deltas and lake bed, potentially causing fish passage issues. If tributary flows are high during drawdown, erosion and headcutting in the tributaries upstream of the lakeshore may occur.

Figure 3-1 shows the average monthly lake surface levels and average monthly inflows for Packwood Lake between 1999 and 2003 based upon information provided by Energy Northwest (2004). The majority of inflow is from Upper Lake Creek, which has some glacial inflow and has a different runoff pattern than the other tributaries. Therefore this figure may not reflect inflow timing from the smaller tributaries.

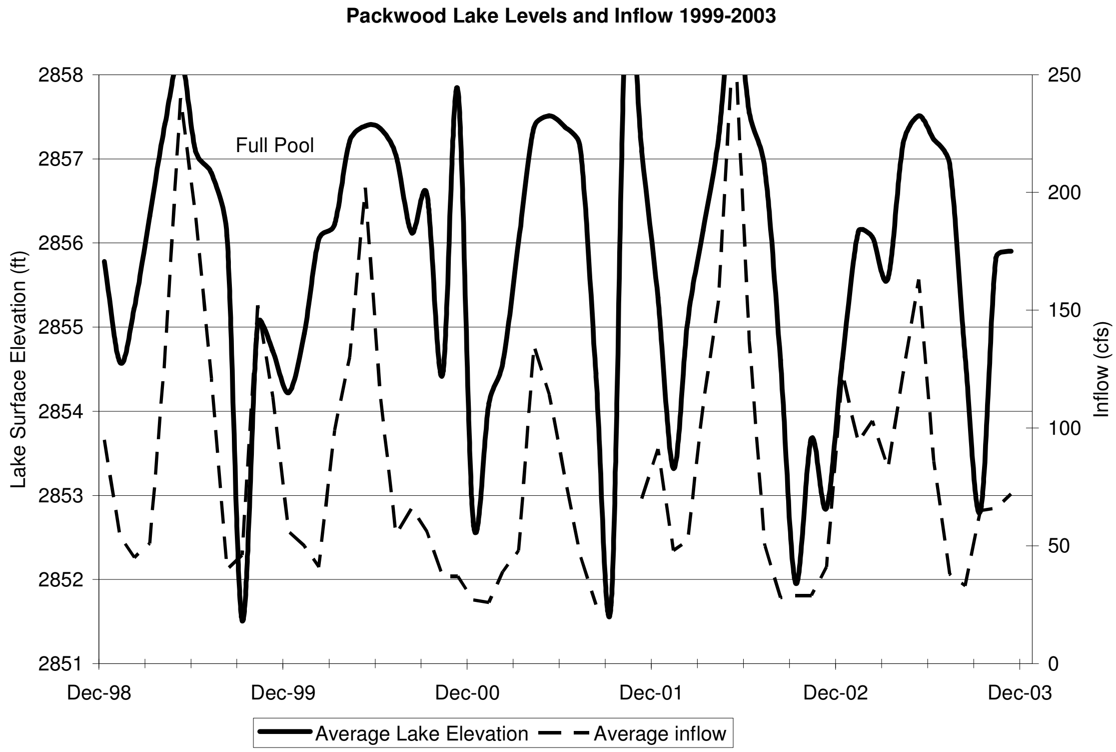

Figure 3-1. Packwood Lake Levels and Inflow, 1999-2003.

Drawdown of Packwood Lake occurs each year in late September-October prior to plant shutdown for maintenance. This coincides with the fall low-flow period, so flows in tributary streams are low. The lake slowly fills during the time the Project is shut down. During the winter months, periods of lowest lake levels coincide with periods of low inflow from upper Lake Creek. By May 1, the pool must be at elevation 2857 feet plus or minus six inches; therefore the Project begins storing water to meet lake level beginning in late winter or early spring. As shown in Figure 3-1, whenever the lake levels are low, and headcutting in tributaries could occur, inflows in Upper Lake Creek are also low, which limits stream power available for headcutting and erosion in Upper Lake Creek. Whenever inflows increase, lake levels also rise. As a result, extensive headcutting in Upper Lake Creek above the lakeshore may be limited. The inflow timing of other tributaries likely do not reflect these same trends, and they may have high flows during periods when the lake levels are low, resulting in a different response than Upper Lake Creek and a higher potential for headcutting. The study will evaluate the capacity of the channel to pass fish, transport sediment, and provide functional habitat for aquatic organisms.

Some erosion and downcutting likely occur in tributary channels within the lake each year as the streams flow across the exposed lake shoreline and deltas. Since these areas do not have established channels, it is likely that the stream channels are wide and shallow and may affect fish movement.

3.2 Need for Additional Information

The Existing Information Analysis for Aquatic Biology (USDA Forest Service 2004) concluded that the following information is needed in order to answer key questions:

1. How does drawdown of the lake influence fish passage?
2. How much habitat is affected?
3. What is the location and type of natural and artificial fish barriers present in the Upper Lake Creek basin?
4. How are stream process and function impacted by lake level fluctuation?

The Forest Service also discussed possible impacts to water quality resulting from lake level manipulation. Water quality is addressed in the Water Quality Study Plan.

4.0 NEXUS BETWEEN PROJECT OPERATIONS AND EFFECTS ON RESOURCES

Fluctuating Packwood Lake water level resulting from hydroelectric operations may promote channel incision through erosional process (e.g., headcutting of channels as they cross the exposed lake shoreline and upstream headcutting) thereby altering fish passage capability and available habitat in tributaries across the exposed lake bottom. The proposed study plan will identify the potential geomorphologic impacts of reservoir level drawdown and associated impacts to fish passage and available habitat.

5.0 STUDY AREA AND METHODS

5.1 Study Area

The study area will encompass the channels of tributaries to Packwood Lake from El 2846 ft MSL and a distance up each tributary until a permanent grade control or geological nick point is encountered with the exception of Upper Lake Creek and Mueller Creek. For Upper Lake Creek and Mueller Creek, the survey will extend 300 feet upstream from the upper limit of headcutting (limit of headcutting will be based on a field evaluation of the channel condition as described in Section 5.3 and Castro 2003).

5.2 Summary of Modifications to Study Methods Requested by the USFS

A survey of stream channels within the drawdown zone of Packwood Lake is necessary to identify potential fish passage barriers, quantify the extent of erosion, and evaluate connectivity during times when the lake level is lowered. The Forest Service proposed a survey of 4.7 miles of tributary streams. The survey will proceed upstream until a permanent grade control or geologic nick point or upstream end of headcutting is reached (see Section 5.1) which may not be a total of 4.7 miles.

Issues relating to fish population and habitat assessment in the Packwood Lake tributaries are found in the Fish Distribution and Species Composition Study Plan. Effects of potential erosion from lake drawdown are addressed in the Packwood Lake Drawdown Study.

5.3 Methodology

This proposal will evaluate how hydroelectric operations which lower the reservoir level increase the risk of increased erosional forces promoting channel incision. Stream impacts from channel incision are commonly discussed in the literature (Shumm, Harvey, and Watson, 1984; Simon and Rainaldi 2000). This study proposal will evaluate Packwood Lake tributary channel evolution and potential risk of channel regrade using methods described by Castro (2003). Castro describes channel headcut evolution as follows:

1. Headcut migration upstream and subsequent deepening of stream channel
2. Relatively higher channel banks that may result in bank failure
3. Addition of sediment to the stream system due to erosion of the channel boundary
4. Disconnection of floodplains from active stream channel
5. Prematurely dewatered or disconnected backwater habitat
6. Locally increased channel slope and loss of pool habitat
7. Drainage of shallow aquifers which affects riparian vegetations
8. Deposition of large masses of sediment causing localized channel braiding and instability of streambanks.

An evaluation of the extent of erosion associated with tributaries to Packwood Lake will take place while the lake is drawn down for Project maintenance in the fall since this is when the lake is lowest and the most shoreline is exposed. The following information will be collected along each tributary that enters the lake:

1. A survey of each tributary channel will be made from approximately El 2846 upstream until a permanent grade control or geologic nick point is encountered, or in the case of Upper Lake Creek and Muller Creek, 300 feet upstream of the point where field evidence indicates the channel is not incised (as described below). Prior to the survey on Upper Lake Creek and Muller Creek, a reconnaissance-level walk of the low gradient portion of the creek will be made, noting any indicators of incision, to determine how far upstream the survey will extend. Indicators of incision include the items listed in #6 (below) and width:depth ratios of the top of bank that indicate incision or widening of the channel.
2. The channel survey will include a profile surveyed with a stadia rod, tape, and level as described in Harrelson et. al (1994). Data to establish a profile of the thalweg, water surface, bankfull, floodplain, and terrace will be collected to provide information on channel incision.
3. At each thalweg profile station, water depth and channel width will be measured to provide information on hydraulic characteristics. The width and depth to thalweg of the following channel features will also be measured: wetted channel, bankfull channel, top of bank, and any recent terraces.
4. At each thalweg profile station, dominant and sub-dominant substrate size will be noted to provide information on channel substrate composition.
5. Photos will be taken of each tributary to document the drawdown zone and any channel incision features noted.
6. An assessment of channel incision will be made based on a description of the following field indicators which may indicate channel incision at various stages of channel evolution:

a. Headcuts or nick points – vertical drop or off-set in the channel bed (measured as part of longitudinal profile)
b. Channel incised into floodplain
c. Young terraces (note that there may be some evidence of very old terraces resulting from glacial history of valley)
d. Steep, unstable and eroding stream banks as a result of channel incision
e. Deposition of large masses of sediment in a widened channel causing localized channel braiding and instability of streambanks
f. Reduced pool frequency – describe pool:riffle ratio and note long reaches of riffle or run, no pool areas.
g. Riparian or floodplain vegetation indicators – identify dead, dying or loss of riparian vegetation due to lowering of shallow aquifer or inundation by braided or aggrading channels.
h. Upland plant species encroaching into floodplain – identify plant species composition.

The survey information will be used to plot the longitudinal profile of each tributary across the drawdown zone and upstream surveyed area and to show bank heights, flow width and depth, and substrate characteristics. An assessment of channel erosion in the drawdown zone and at each tributary will be made.

Once field reconnaissance and survey are completed a risk assessment of future channel incision and stability will be conducted. The assessment will consider issues and concerns raised with channel regrade as discussed by Castro (2003). The risk assessment will include the following characteristics if data are available:

1. Potential for lost instream and terrestrial habitat
2. Loss of riparian vegetation
3. Downstream flooding
4. Channel widening
5. Increased turbidity and suspended sediments
6. Mid-channel bar formation due to increased sediment load
7. Deceased bank stability
8. Loss of wetlands

An assessment of potential problems related to fish passage through stream channels in the drawdown zone will also be made.

5.4 Products

The products of the Stream Connectivity Study will be draft and final reports that includes maps, and tables and graphs of analysis portraying the following (if data are available): location of expected fish distribution, location of channels incision, location of permanent grade control, location of high risk headcut susceptible channels, historic and current riparian vegetation demonstrating potential shifts in riparian water regime, graph displaying each channel longitudinal profile, graph displaying widths and depths of channel features, and graph displaying downstream changes in grain size. Preliminary data will be reviewed by the agencies and tribes. Draft and final study results will be provided to the agencies and tribes for review and comment.

5.5 Consistency with Generally Accepted Scientific Practice

The information on tributary erosion is similar to that collected during reservoir erosion surveys for relicensing of the Cowlitz River Hydroelectric Project and the Lewis River Hydroelectric Project.

5.6 Relationship with Other Studies

The connectivity study will be implemented in coordination with the lake drawdown study. The thalweg profiles surveyed as part of this study will be added to the database for mapping the drawdown zone in the lake and maps for both studies will be referenced to the same spatial coordinates. The volume of material eroded by streams within the drawdown zone can be added to the calculations for erosion rates for other shorelines that are being investigated in the drawdown study. Calculations of the amount of aquatic habitat affected by the drawdown will be coordinated so that lacustrine and stream habitats are distinquished and not duplicative. The point of distinction between stream habitat and lacustrine habitat will be based on topography of adjoining shorelines; i.e. that portion of the stream channel that is backwatered by the lake at the natural, full pool elevation that is upstream of the lake shoreline contour will be considered to be part of the stream environment. These data will also be used in coordination with the Revised Draft Fish Distribution and Species Composition Study. In this study, the stream-dwelling salmonids found in Packwood Lake tributaries during the drawdown will be monitored to determine if the drawdown potentially affects their out-migration.

Information from the stream connectivity study will contribute to the understanding of Project effects on fish populations, fish migration, and spawning habitat, which are addressed in other study plans.

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 Forest Service, the Cowlitz tribe, and the Yakama Nation. The integrated licensing process plan provides for numerous meetings with stakeholders during the months of May through August of 2005 to discuss, revise and finalize the proposed study plans. Updates will be provided and draft and final reports will be provided to the agencies and tribes for review and comment.

7.0 PROGRESS REPORTS, INFORMATION SHARING, AND TECHNICAL REVIEW

Technical reports, including the draft and final Stream Connectivity Study reports will be shared with agencies, tribes, and 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 study at the Water Quality and Aquatic Resources Committee meetings.

Energy Northwest will provide copies of the Stream Connectivity in Packwood Lake Tributaries 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

Numerous meetings are planned from May through August 2005 to finalize the study plan. During this time Energy Northwest and its consultant will work with the agencies and tribes to finalize the study protocol.

If study approval is obtained in time, data collection efforts will be initiated during late September 2005 when the lake is drawn down to its lowest level. If approval is not obtained by then, the study will commence in 2006. The draft report will be completed and distributed to the natural resource agencies and tribes following completion of the field effort. The final report will be completed after the 30-day review period.

9.0 LEVEL OF EFFORT AND COST

The level of effort includes finalization of the study plan, study implementation, and report preparation as well as consultation with agencies, tribes and stakeholders. The level of effort for the field portion of this study is 5 days each for 2 field personnel (12 hour days are assumed for field work). This study will require use of a hip chain, measuring tape, auto level, and stadia rod. Additional costs include equipment purchase or rental, mileage, travel and per diem costs. When possible, other activities will be scheduled concurrent with this study to maximize efficiency. Travel costs have been reduced under the assumption that the field work will take place in conjunction with other field work for the project.

Data analysis, preparation of a draft and final report, and stakeholder consultation is estimated to take 8 days.

Preliminary studies conducted in 2004 cost approximately $5,325. Total estimated costs for this study plan are $20,483.

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