ENERGY NORTHWEST
PACKWOOD LAKE HYDROELECTRIC PROJECT

DRAFT STUDY PLAN
LAKE CREEK INSTREAM FLOW STUDY AND HABITAT ASSESSMENT

401 WATER QUALITY CERTIFICATION

Prepared for

Energy Northwest
For the Packwood Lake Hydroelectric Project
(FERC No. 2244)

Prepared by

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1.0 INTRODUCTION

Energy Northwest, a municipal corporation and joint operating agency of the State of Washington, operates the Packwood Lake Hydroelectric Project (Project) near the town of Packwood in Lewis County, Washington. The Federal Energy Regulatory Commission (FERC) licensed the Project on July 7, 1960 (effective March 1, 1960), designated as Federal Power Commission License No. 2244. As owner of the Project, Energy Northwest intends to file an application for a new license pursuant to the regulations issued by FERC in 2003, which established the Integrated Licensing Process (ILP). Under the ILP regulations, a license applicant must file a Notice of its Intent (NOI) to file a license application no less than five years before the current license expires. At that time, the licensee must also submit to FERC and the resource agencies, a Pre-Application Document, containing existing, relevant, and reasonably available information describing the existing environment and the potential effects of the licensee's intended project proposal, including proposed project facilities and operations. Based upon resource information and potential impacts, the licensee must provide a preliminary list of studies that relate to the identified resource issues.

Among the purposes of the ILP is to foster an efficient and collaborative approach to determining project effects and appropriate protective measures. In that spirit, Energy Northwest has taken a proactive approach to relicensing its Packwood Lake Hydroelectric Project by initiating collaborative scoping of studies to develop the data and analyses that will be required for issuance of the water quality certification by the Washington Department of Ecology (WDOE) under Section 401of the Clean Water Act.

The Project is located east of the community of Packwood in the Cascade Mountains. Packwood Lake lies within the Gifford Pinchot National Forest. The Project includes: a drop structure, which regulates lake surface elevation and is located a short distance downstream from the natural outlet of the Lake; an intake structure; an approximately 23,000 ft-long, partially subterranean flowline; a surge tank; a 6,000 ft-long penstock; and a powerhouse (turbine-generator rated at 27,500 KVA). The powerhouse is located at the base of the mountain adjacent to the community of Packwood. The powerhouse tailrace flow discharges into a constructed stilling basin. It then travels through a lined tailrace channel about 8,000 ft in length to its confluence with the Cowlitz River. The tailrace includes a 200 ft highway culvert and 360 ft flume over Hall Creek.

The project is operated in a baseload manner depending upon water availability and power contracts. The Project has a water right for 260 cfs but the Project does not operate at capacity at

all times. Average power production is 10 Mw relative to a turbine generator rated at 27,500 KVA).

The total area drained by Lake Creek and Packwood Lake amounts to approximately 12,288 acres (19.2 square miles) at the drop structure and 16,960 acres (26.5 square miles) upstream of the confluence of Lake Creek and the Cowlitz River. The total surface area of the lake is 452 acres (0.7 square miles). The natural lake elevation (El) is 2,857 ft MSL, which is approximately 1,800 ft above the powerhouse. The Project seasonally regulates the lake level so that it is at El 2,857 ft ±6″ in summer recreation months and drawn down to no lower than El 2,849 ft MSL during winter months. This provides 8 ft vertical storage usable by the project. When lake level rises above the drop structure crest elevation and the intake is at capacity (or not operative), the flow passes over the drop structure into Lake Creek downstream of the lake. Currently, the FERC license for the Project requires a minimum instream flow of 3 cfs, at the drop structure immediately downstream of the outlet of Packwood Lake. There is also an instream flow requirement of 15 cfs at the confluence of Lake Creek with the Cowlitz River. Energy Northwest is not currently required to measure this flow.

1.1 Study Purpose

The purpose of this study is to develop information to support the 401 water quality certification, to be issued by the Washington Department of Ecology (WDOE), necessary for operation of the Project under a new FERC license. The Parties taking part in this collaborative scoping process will use the results of these studies to evaluate, recommend, and propose appropriate instream flows for Lake Creek below the Project drop structure for incorporation into the subsequent FERC license for the Project.

1.2 Study Consultation

This study plan is prepared for the Packwood Lake Hydroelectric Project Fish, Aquatics, and Instream Flow Committee (Committee), which is an informal group formed to collaboratively design and implement aquatic studies that will support the application for 401 water quality certification of the Project. Table 1-1 lists Committee members and their respective representatives. Membership of the committee is composed of technical representatives who can commit to attend planned meetings. Other representatives will be informed of all technical meetings and are invited to attend.

Table 1-1
Packwood Lake Hydroelectric Project Fish, Aquatics and Instream Flow Committee

Organization	Representative
Energy Northwest	Ms. Laura Schinnell
	Ms. Bernice Kasko
U.S. Forest Service (USFS)	Mr. John Roland
	Ms. Ruth Tracy
	Mr. Carl Corey
	Mr. Ken Wieman
	Ms. Margaret Beilharz
	Mr. Dean Grover
Washington Department of Fish and Wildlife (WDFW)	Ms. Lauri Vigue
	Dr. Hal Beecher
Washington Department of Ecology (WDOE)	Ms. Deborah Cornett
	Mr. Rusty Post
NOAA-Fisheries	Mr. Blane Bellerud
US Fish and Wildlife Service	Ms. Lou Ellyn Jones
Cowlitz Tribe	Mr. Mike Iyall
Confederated Tribes and Bands of the Yakama Nation	Mr. George Lee
FERC	Mr. Ken Hogan
	Dr. Frank Winchell
EES Consulting (EESC)	Mr. John Blum
	Mr. Kent Doughty

1.3 Existing Relevant Information

1.3.1 Packwood Lake/Lake Creek Watershed

The natural elevation of Packwood Lake lies at 2,857 ft, approximately 1,800 ft above the Project powerhouse. Packwood Lake and Lake Creek are bounded on the southwest by Snyder Mountain, elevation 5,030 ft, and on the northwest by mountain ridges with elevations ranging to 5,300 ft (Washington Public Power Supply System 1971).

Originating as rainfall and snowmelt in the Goat Rocks Wilderness Area and the Cascade Mountains draining into Packwood Lake (surface area of 452 acres), Lake Creek flows to the northwest approximately 5.3 miles to the upper Cowlitz River, Lewis County, Washington. Lake Creek empties into the upper Cowlitz River at approximately River Mile 129.2. The Packwood Lake drainage is mostly contained within the Gifford Pinchot National Forest boundary (the first 0.7 miles are private lands).

The gradient of Lake Creek is relatively high, averaging about 6.3% from the lake to its confluence with the Cowlitz River. Segment gradients range from a low of about 2% immediately upstream the confluence of Lake Creek with the Cowlitz River to 20% in the canyon reach (Figure 1-1).

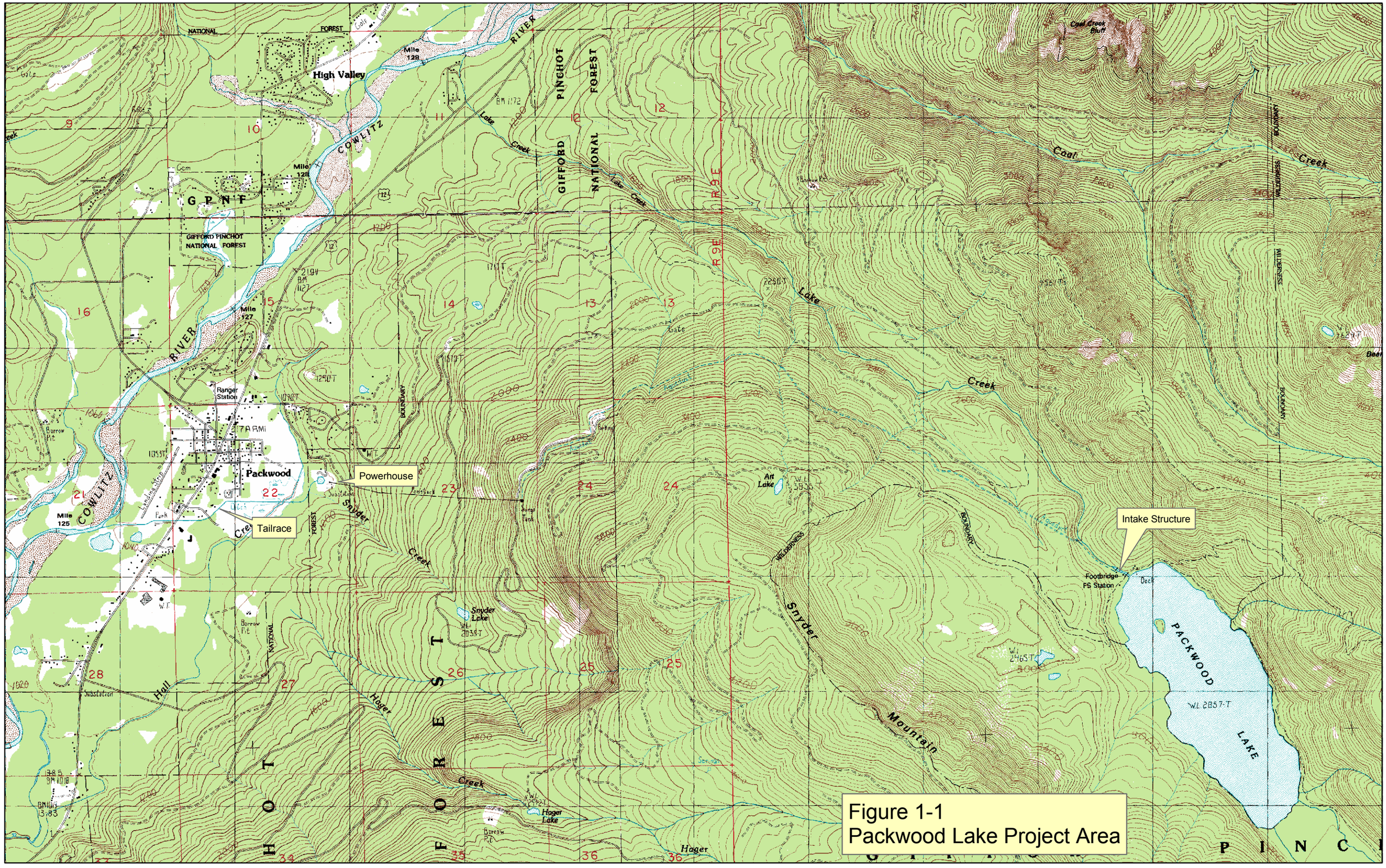

Figure 1-1
Packwood Lake Project Area

1.3.2 Lake Creek Hydrology

Two USGS gaging stations have been operated on Lake Creek. The gage immediately downstream of the drop structure (No. 14225500 – El. 2,844.62 ft – 18,555 daily flows) operated from October 1, 1911 through September 30, 1980, with a drainage area of 12,288 acres (19.20 square miles). Another gage was operated from September 1, 1907 through November 22, 1977, upstream from the confluence of Lake Creek with the Cowlitz River (No. 14226000 – El. 1,190.0 ft – 7,798 daily flows), with a drainage area of 16,960 acres (26.50 square miles). Mean annual flow as measured at the drop structure was 101.5 cfs. Details concerning hydrology for Lake Creek are included in a separate hydrology report published in June 2004.

1.3.3 Physical Habitat Surveys

In 1993, the USFS conducted physical habitat surveys of Lake Creek from the outlet of Packwood Lake downstream to its confluence (USFS 1993). USFS divided Lake Creek into six reaches based upon the geomorphology of the creek. In the surveys, the USFS indicated the presence of numerous falls (11) and chutes (23) throughout the entire reach. The USFS determined that Lake Creek has 1.9 miles of potential anadromous habitat, and 5.4 miles of resident rainbow habitat.

Table 1-2 summarizes study reach meristics as evaluated by the Forest Service. Figure 1-2 depicts the longitudinal gradient of Lake Creek from its mouth to Packwood Lake.

Table 1-2
Lake Creek Meristics per USFS Survey, 1993

Meristic	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6
Length (miles)	0.7	0.9	0.9	0.9	1.8	0.5
Gradient (%)	3	10	8	8	5	8
Bankfull Width (ft)	10.81	15.63	17.62	28.91	10.90	23.64
Substrate	Sm. Bldr, cobble	Sm, Lg bldr.	Sm bldr, gravel	Lg bldr, cobble	Cobble, gravel	Cobble
Pools/Mile	37.1	40.0	28.9	41.1	31.7	44.0
LWD/Mile	0.0	6.3	9.2	18.1	16.5	7.4
Fish Species	Rainbow Tr.	Rainbow Tr.	Rainbow Tr.	Rainbow Tr.	Rainbow Tr.	Rainbow Tr.

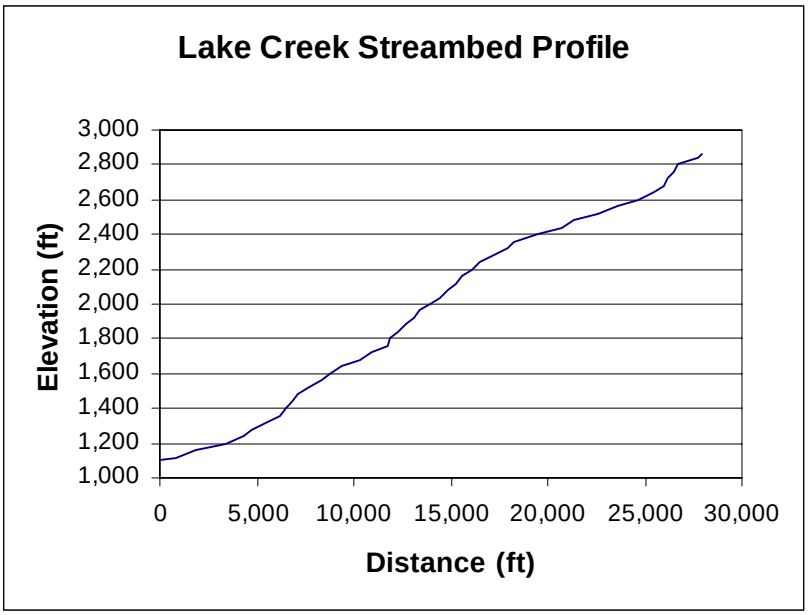

Figure 1-2. Lake Creek Longitudinal Profile

1.3.4 Fish Species Composition and Abundance Surveys

The USFS, as part of the physical habitat surveys, conducted snorkeling surveys of Lake Creek in 1993. Results indicated that only rainbow trout (*Oncorhynchus mykiss*) were present in Lake Creek, with a total of 464 observed (28% adult; 72% juvenile). Table 1-3 summarizes the results of this survey. Surveys by the USFS and others were conducted prior to the reintroduction of anadromous salmonids in the upper Cowlitz River watershed. Information regarding the current distribution and species composition of the fish assemblages downstream of the anadromous barrier is lacking.

Table 1-3
Lake Creek Relative Fish Abundance by Reach[1/]

Reach	Species	Adult	Juvenile	Total
1	Rainbow	3	1	4
2	Rainbow	14	40	54
3	Rainbow	16	39	55
4	Rainbow	52	116	168
5	Rainbow	28	90	118
6	Rainbow	18	47	65
Total		131	333	464

[1/] From USFS snorkeling surveys 1993

WDFW has also conducted rainbow trout spawner surveys in tributaries to Packwood Lake. These include Osprey Creek, Trap Creek, Muller Creek, and a tributary to Upper Lake Creek (WDFW 1999, 2000). Table 1-4 summarized information from WDFW regarding rainbow trout spawner surveys of tributaries to Packwood Lake from 1979 – 2003.

Table 1-4
Rainbow Trout Spawner Surveys, Tributaries to Packwood Lake[1/]

Date	Osprey Creek	Trap Creek	Muller Creek	Upper Lake Creek	Beaver Bill Creek	Small Trib.SE of Trap Creek	Total
1979	-	-	194	-	-	-	194
6/18/81	16	18	67	5	-	-	106
6/29/82	-	0	0	0	-	0	0
6/20/83	0	-	0	-	-	-	0
1984	-	-	55	317	-	40	412
6/26/85	3	0	14	200	-	0	217
6/27/86	-	-	13	112	-	-	125
6/9/87	-	-	78	332	-	-	410
6/16/88	-	180	61	721	-	4	966
6/14/89	490	160	180	405	82	5	1322
6/15/90	24	5	149	60	-	-	238
6/19/91	314	94	399	363	-	0	1170
6/20/95	1	0	86	166	-	-	253
6/28/96	0	3	299	238	-	-	540
6/25/97	29	13	590	214	-	-	846
6/24/98	28	9	374	220	-	-	631
7/6/99	19	30	155	107	-	-	311
6/29/00	355	27	249	153	-	-	784
6/25/02	138	60	414	265[2/]	-	8	885
6/25/03	181	6	201	305	-	0	693

[1/]From WDFW spawner surveys
[2/]An estimated 150 were grouped at the mouth; these were not counted.
A dash indicates no survey

1.3.5 Cowlitz River Settlement Agreement

Tacoma Public Utilities entered into a Settlement Agreement on August 10, 2000, to resolve natural resource issues associated with the relicensing of its Cowlitz River Project (consisting of Barrier, Mossyrock and Mayfield dams), located downstream of the Packwood Lake Hydroelectric Project. Parties to the Settlement Agreement include the City of Tacoma, Washington, Department of Public Utilities, Light Division; Washington Department of Fish and Wildlife (WDFW), Washington Department of Ecology (WDOE), Washington State Parks and Recreation Commission; United States Fish and Wildlife Service (USFWS), National Marine Fisheries Service (now NOAA Fisheries), United States Forest Service (USFS) - Gifford Pinchot National Forest, Interagency Committee for Outdoor Recreation (IAC), Lower Columbia Fish Recovery Board, Lewis County, Confederated Tribes and Bands of the Yakama Nation (CRITFC), Trout Unlimited, and American Rivers.

As part of the Cowlitz River Project Settlement Agreement, anadromous fish are to be reintroduced into the upper Cowlitz River above Barrier, Mayfield, Mossyrock and Cowlitz Falls

dams via trap-and-haul. The target species are Chinook (*O. tshawytscha*) and coho (*O. kisutch*) salmon, and steelhead trout (*O. mykiss*). There are also plans to release cutthroat trout (*O. clarki*) above the dams. Fish are also passed above the Cowlitz Falls Hydroelectric Project, owned and operated by Lewis County PUD.

1.4 Relation to Other Studies

Information relevant to evaluating instream flow issues for this reach will also be incorporated into the 401 Water Quality Certification Study.

Information on rainbow trout spawning timing and access to habitat in Packwood Lake tributaries can be gathered while collecting Packwood Lake water quality data.

2.0 STUDY OBJECTIVES

Currently, the FERC license for the Project requires a minimum instream flow of 3 cfs, at the drop structure immediately downstream of the outlet of Packwood Lake. There is also an instream flow requirement of 15 cfs at the confluence of Lake Creek with the Cowlitz River. Energy Northwest is not currently required to measure the instream flow. The overall objective of this study is to develop information that supports the continuation of these instream flow requirements (issued as part of the 401 certification) for Project operation under a new FERC license. Specific study objectives are:

- Document the location and physical attributes of the most downstream barrier in Lake Creek to upstream anadromous fish passage.

- Quantify the rate of water elevation (stage) change in the Cowlitz River side channel that receives the Project tailrace flow resulting from Project startup and shutdown as well as variable flows due to normal project operations, and document the associated rate of change in stage and other key physical attributes of this side channel, and

- Quantify the relationship between flow and habitat for all life stages of target species by conducting an instream flow study. In order to quantify this relationship, Energy Northwest will:

    - Use existing hydrologic records for Lake Creek downstream of Packwood Lake to define the seasonal and annual hydrologic regime, including estimates of accretion.
    - Use existing habitat survey data and data from supplemental habitat surveys to define study reaches and study transects that are representative of the habitat variability within Lake Creek downstream of the drop structure at the lake outlet.
    - Use existing information and supplemental surveys to document the relative abundance, distribution and species composition for resident and anadromous fish in Lake Creek between the outlet at Packwood Lake and the stream's confluence with the Cowlitz River.

- Identify target species for conducting instream flow studies in Lake Creek downstream of the drop structure at the lake outlet.

- Evaluate the effect of Project manipulation of the level of Packwood Lake on aquatic habitat in lake tributaries and aquatic connectivity between the lake tributaries.

3.0 STUDY AREA

The Lake Creek Instream Flow Study Area will extend from the drop structure, a short distance downstream of Packwood Lake (RM 5.3) downstream to the confluence of Lake Creek with the Cowlitz River (approximate RM 129.2). This study will also address ramping rates for the Project tailrace (including the backwater slough). The tailrace carries water about 8,000 ft from the Powerhouse to where it joins the Cowlitz River at approximately RM 125.2.

Rainbow trout are known to inhabit Lake Creek and Packwood Lake. The Cowlitz River Project Settlement Agreement includes the upstream passage of spring Chinook and coho salmon, as well as steelhead and cutthroat trout to areas above the City of Tacoma and Lewis County PUD dams. Currently, only rainbow trout are known to utilize Lake Creek. Coho salmon a have been observed in the Project tailrace and salmonid fingerlings were observed in Lower Lake Creek during an April 22 site visit.

The study area for Lake Creek includes only Lake Creek and its associated habitats (i.e., edge and mid-channel). This study area does not encompass any of Lake Creek's tributaries or their associated habitats.

3.1 Study Reaches

As mentioned above, USFS conducted physical habitat surveys of Lake Creek in 1993. The information was very detailed and provided baseline data from which to compile habitat frequencies for the instream flow study transect selection and study site and transect weighting. Physical habitat surveys were conducted in April and May of 2004; a physical habitat assessment report was published in June 2004.

Energy Northwest has segmented Lake Creek below the drop structure into five study reaches:

- Reach 1: Lake Creek from confluence of the Cowlitz River upstream to RM 0.7 (FS boundary)
- Reach 2: From the FS boundary upstream to RM 1.3 (upper end of lower canyon)
- Reach 3: RM 1.3 – 3.5
- Reach 4: RM 3.5 – RM 4.9, and
- Reach 5: RM 4.9 to the Packwood Lake drop structure

Reach segmentation is described in physical habitat assessment report distributed in June 2004.

4.0 METHODS

The methods for the instream flow study are designed to compile and acquire information on:

- Hydrologic regimes in Lake Creek downstream of Packwood Lake
- Distribution of geomorphic channel types and meso-habitat types and barriers to upstream migration of anadromous and resident species
- Fish relative species composition, distribution and abundance including life history periodicity of rainbow and cutthroat trout*, spring chinook and coho salmon* and steelhead trout* (*depending upon species reintroduction per the Cowlitz River Project Settlement Agreement).
- Hydraulic and habitat geometry relationships (stage, depth, wetted perimeter, velocity, substrate and cover as a function of discharge) over the range of flows modeled and habitat suitability indices (HSI) for salmonid species/life stage of interest (depth, velocity, substrate, cover)

4.1 Characterization of Reach Hydrology

Hydrologic records and project operations will be analyzed to create hydrographs showing baseflows and effects of project operation by season. Overlapping data from both the upper gage station (No. 14225500) and the lower gage station (No. 14226000) will be correlated to determine the relative rate of inflow through the study reach.

4.2 Physical Habitat Assessment

4.2.1 Physical Habitat Survey

Physical habitat data are used to designate stream reaches and study transects. The habitat survey data also provide a basis for weighting the results from individual transects and study reaches when compiling habitat – flow relationships for the study stream.

Table 4-1 Habitat Type Coding and Description		
Code	**Habitat Name**	**Habitat Description**
1	Pool	Slower velocity and deeper, non-turbulent flow with a strong hydraulic control.
2	Lateral pool	Pool formed on the margin of the stream as a result of structural element, substrate composition, or thalweg location. (Generally, at least ½ of the pool perimeter interfaces with the adjacent habitat unit).
3	Plunge pool	Flow at head is vertical passing over an obstruction: fast, turbulent often with a bubble plume down the center.
4	Glide	Smooth, generally unbroken surface, generally laminar flow, moderate to shallow depth, often-smaller substrates.
5	Riffle	Shallow with moderate velocities (less than run), lateral bottom profile is usually uniform; surface is broken but not turbulent like a run, gradient <4%.
6	Run	Like a glide except faster velocities and somewhat more turbulent; surface may be broken by protruding rocks.
7	Boulder garden	A run with lots of randomly placed large boulders causing flow irregularities; flow is not necessarily turbulent.
8	Chute	All the flow is concentrated in a narrow area. Flow is fast to very fast.
9	Rapid	Water (rough, turbulent surface, usually with standing wave at the hydraulic jump that occurs at the bottom as the flow rapidly decelerates into a pool, although it could merge into a riffle; water surface slope 2.5-4%.
10	Cascade	Turbulent flow with pronounced vertical drops causing a stepped gradient, substrate often boulders and cobble.
11	Braided channel	One or more divisions of the stream channel separated by islands of substrate not well vegetated.
12	Split channel	More than one permanent channel.
13	Side Channel	A flow dependant channel separate from the permanent channel.
14	Plunge Pool Tailout	A transitional area where turbulent water from a plunge pool begins to settle out. Typically preceding a run or glide.
15	Falls	A large vertical drop. Water typically plunges into a pool, substrate often bedrock or large boulders.

The USFS surveyed habitat in this reach in 1993. Data from this survey, along with a ground-truthing, verification survey will be used to refine the descriptions of the physical habitats and the study reaches. Table 4-1 describes habitat type coding used in this survey.

The purpose of the habitat assessments is to provide data in order to stratify the stream into study reaches and to select transects that represent the habitat types found within Lake Creek below the drop structure. A limited physical habitat survey of Lake Creek, beginning at the drop structure and proceeding downstream for the purpose of verifying current habitat condition was conducted in April and May 2004. Habitat was sampled every 150 ft down the stream thalweg. At each station, the following information was collected:

- Habitat type and description of sampled site
- Wetted channel width
- Bank full channel width
- Mean depth (sampled at ¼, ½, and ¾ of the width)
- Dominant and subdominant substrate
- Photographs of each habitat sampled
- Distance along stream (measured from drop structure or from the Lake Creek confluence with the Cowlitz River)
- Notations or comments of interest (i.e., presence of spring or inflow into creek)

Information gathered will be used in conjunction with the USFS sampling, stream profile maps, hydrology and location of anadromous barriers to segment the stream into study reaches, select potential transects, and determine study reach and transect weighting.

Anadromous Barrier Survey and Confirmation

Under the Settlement Agreement for the Cowlitz River Projects, anadromous salmonids are currently being re-introduced into the upper Cowlitz River. There is the potential for anadromous salmonids to utilize the lower portions of Lake Creek. A barrier survey was conducted concurrently with the physical habitat surveys to identify barriers to upstream passage for anadromous salmonids. The criteria, as established by Powers and Orsborn (1985) are proposed for use. Using the criteria in Powers and Orsborn (1985), steelhead trout have the greatest leaping ability, followed by Chinook and coho salmon.

The first total barrier to anadromous fish will be surveyed, photographed and measured, and its location noted. Other barriers (i.e., falls and chutes) will be documented on the physical habitat surveys; measurements of these barriers were previously collected by the USFS. Results will be presented to the Committee for review and approval.

Transect Selection and Segment Consolidation

Consolidation of stream segments is necessary to integrate the physical and biological attributes identified in the physical habitat surveys and to define a reasonable number of study sites for instream flow analysis.

Transect selection will be based primarily upon the results of habitat surveys. Transects are used to model fish habitat available or habitat important or critical to a species or life stage of interest. Criteria for transect selection include the following:

a) The transect is representative of habitat types, respective micro-habitat features and/or critical habitat for target species and life stages within the study reach;

b) Presence of physical features, such as vertical banks, which may hinder or facilitate measurements;

c) Stream hydraulics amenable to accepted computer modeling methods; and

d) Accessibility and safety.

A map showing stream reach delineations and transect locations is included in the physical habitat assessment report distributed in June 2004.

4.3 Fisheries Population Assessment

The Committee will consider the needs of the anadromous and resident salmonid species present in the Lake Creek and Project tailrace areas. Target species, or species of specific concern, and associated life stages of interest, have not yet been identified by the Committee.

The USFS snorkeled Lake Creek in 1993. Rainbow trout was the only species observed above and within the diversion reach of Lake Creek during snorkeling surveys. These surveys, however, were conducted before the Settlement Agreement was implemented for the Cowlitz River Project. Energy Northwest proposes to verify the presence (absence) of salmonids below the drop structure on Lake Creek.

Table 4-2 is a *preliminary* identification of fish utilization within the study area as well as target species and life stages for which flow-habitat relationships will be quantified. Target species, life stages and life-stage periodicity will be finalized after completion of population surveys and consultation with the natural resource agencies and tribes.

Table 4-2
Preliminary Fish Utilization and Target Species and Life Stages by Location Within the Packwood Lake Study Area[1/]

	Species Present		Target	
Location	**Species**	**Life Stage**	**Species**	**Life Stage**
Packwood Lake and Tributaries	Rainbow Trout	Juvenile/adult Rearing Spawning	N/A	
Lake Creek from first anadromous barrier upstream to drop structure	Rainbow Trout	Juvenile/adult Rearing Spawning	Rainbow Trout	Juvenile/adult Rearing Spawning
Lake Creek from Cowlitz Confluence to first anadromous barrier	Rainbow Trout Coho Salmon[2/] Steelhead Trout [2/] Cutthroat Trout [2/] Spring Chinook Salmon [2/]	Juvenile/adult Rearing Spawning Juvenile Rearing [2] Spawning [2/] Juvenile Rearing [2/] Spawning [2/] Juvenile/adult Rearing [2/] Spawning [2/] Juvenile Rearing [2/] Spawning [2/]	Rainbow Trout	Juvenile/adult Rearing Spawning
Project Tailrace [3/]	Rainbow Trout	Juvenile/adult Rearing Spawning	Rainbow Trout [3/]	

Table 4-2
Preliminary Fish Utilization and Target Species and Life Stages by Location Within the Packwood Lake Study Area[1/]

	Species Present		Target	
Location	**Species**	**Life Stage**	**Species**	**Life Stage**
	Coho Salmon [2/]	Juvenile Rearing [2/] Spawning [2/]		
	Steelhead Trout [2/]	Juvenile Rearing [2/] Spawning [2/]		
	Cutthroat Trout [2/]	Juvenile/adult Rearing [2/] Spawning [2/]		
	Spring Chinook Salmon [2/]	Juvenile Rearing [2/] Spawning [2/]		

[1/] *Preliminary Only. Species present and target species have not been agreed to. Final target species will be determined after consultation with the natural resource agencies and tribes.*
[2/] *Subject to implementation of the Cowlitz River Project Settlement Agreement.*
[3/] *Not subject to instream flow study; will be included in ramping rate evaluation.*

A draft periodicity chart of salmonid species that may use the Project study area will be developed after consultation with the natural resource agencies and tribes.

Energy Northwest proposes to verify the presence and relative distribution of salmonids in Lake Creek downstream of the drop structure. A combination of electrofishing, snorkel surveys and spawner foot surveys will be conducted.

4.3.1 Electro-Fishing Surveys

Where the creek is accessible and conditions are conducive to sampling at and below the first anadromous barrier, Energy Northwest will use an electro-fisher to determine relative species composition, distribution and abundance of salmonids in the potential anadromous zone. Habitat types associated with salmonids captured during these surveys will also be identified. Fish will be measured to the nearest mm and released. Electrofishing surveys are contingent upon securing the necessary permits from the appropriate natural resource agencies.

4.3.2 Snorkeling Surveys

In areas above the first identified and confirmed anadromous barrier, Energy Northwest will sample accessible habitat types and estimate the length of the rainbow trout observed as well as any other identified resident salmonid species.

4.3.3 Anadromous Salmonid Spawner Surveys

After consultation with the natural resource agencies and tribes, Energy Northwest will conduct spawner surveys for anadromous species that could potentially utilize Lake Creek. The purpose of these surveys will be to document presence or absence of spring Chinook, coho salmon or steelhead trout, as well as their spawning timing, if present.

4.4 Instream Flow Study Methods

The primary method used to study the Lake Creek Study Area will be the standard USFWS Instream Flow Incremental Methodology (IFIM). Generally, instream flow study procedures will follow the WDFW Instream Flow Guidelines (WDOE and WDFW 2003). If the IFIM is found not to be applicable due to complex hydraulics, the Plunge Pool Methodology, initiated by Dr. Hal Beecher of WDFW, may be used.

4.4.1 Instream Flow Incremental Methodology (IFIM) and Measurements

The IFIM is based on the premise that stream dwelling fish prefer a certain range of depths, velocities, substrates and cover types, depending on the species and life stage, and that the availability of these preferred habitat conditions varies with stream flow. With input from stream flow, substrate, and cover type measurements, the IFIM uses a set of computer programs developed by USFWS to quantify habitat availability over a range of flows. It is important for the water manager to recognize that the result of the study is not a set value but a range of values to be used as a tool for determining relative amounts of habitat available at various stream flows.

An instream flow study utilizing the IFIM will be conducted in the applicable reaches of Lake Creek. Protocols will follow those outlined in, "A Guide to Instream Flow Setting in Washington State" (WDOE and WDFW 2003).

Once transects and study reaches are approved by the natural resource agencies, Energy Northwest will employ the "three-flow" method for evaluating transects. In the "three-flow method," three separate calibration flows are measured, with a full set of depth and velocity measurements at each flow. Water surface elevations and channel cross-sections will be surveyed, relative to benchmarks and headpins, at each flow with an auto-level and stadia rod. Where feasible, benchmarks of transects in each study site will be "tied together" by surveying their relative elevation.

Energy Northwest will hydraulically model the entire cross section of all transects in the Lake Creek Study Area. Water surface elevations will be taken at all calibration flows.

Study Reaches

Study reaches were identified subsequent to the physical habitat surveys. A physical habitat assessment report, detailing study reaches and transects, was submitted to the committee in June 2004; study reaches and transects are being selected in consultation with and the approval of these parties prior to initiation of the instream portion of the study.

Calibration Flows

Three calibration flows will be measured at each transect. Calibration flows will be referenced to releases from the drop structure located below the Packwood Lake outlet. Subject to further

review of existing hydrologic information, Energy Northwest recommends a range of calibration flows, as shown below:

High Flow Measurement:	35 – 40 cfs [1/]
Middle Flow Measurement:	15 – 18 cfs
Low Flow Measurement:	6 cfs

[1/] Flow pattern and weather dependent.

Target Modeling Range

When using the "three-flow" regression model, the goal is to be able to model 2.5 times the high-flow calibration measurement, and to 0.4 of the low-flow calibration measurement. Therefore, the target modeling range would be from approximately 3 cfs – 100 cfs at the upper end of the study reach (downstream of the drop structure); the model range would expand for downstream measurements to account for accretion. Existing hydrologic data will be analyzed to determine average seasonal accretion rates within the diversion reach of Lake Creek. Concurrent measurements will be taken at each study site during calibration flows.

Water Surface Elevations

Water surface elevations (WSE) will be measured for each of the three calibration flows at each transect. WSE will be referenced to a benchmark for each transect. A stage/discharge relation-ship for each transect will be determined by the IFIM Subroutine, PHABSIM.

Verticals/Velocity Measurements

Energy Northwest proposes three full velocity set measurements. As a general rule of thumb, there will be a minimum of 20 – 25 depth and velocity measurements taken at the low calibration flow, with correspondingly more measurements taken at both the middle and high calibration flows, due to more of the channel bed being inundated at higher flows.

Water Surface Elevations will be recorded at every flow measured, and the bottom profile will also be determined through surveying and depth measurements at each cell.

Surveying Methods

Transect measurements will be tied to a semi-permanent benchmark at each transect. Where feasible, groups of transects will be tied together and/or referenced to a USGS benchmark if any are available in the vicinity. Thalweg depth will be noted. Slope and stage of zero flow will also be determined in the field. [Note: when the IFG4 Program is given three stage/discharge measurements, the model determines the slope of the reach from these measurements rather than from the input of slope in the data deck].

Substrate and Cover Codes

WDOE and WDFW have standard substrate and cover codes in the Instream Flow Guidelines Report (2003). Energy Northwest will use these substrate and cover codes in the instream flow study and will include these in the final study plan.

Modeling Parameters

As a rule of thumb, attempts are made to generally extrapolate to 40% of the low-flow calibration measurement and 250% of the high-flow calibration measurement in order to model a range of flows sufficient for analysis. Model performance and model calibration, use and extrapolation will be approved by the IFIM experts on the Committee. Energy Northwest will use standard and approved methods to calibrate models; calibration will be approved by WDFW and WDOE instream flow experts.

4.4.2 Plunge Pool Methodology

Where possible, instream flow studies using the IFIM will be employed. Where hydraulics are complex, this method may not work effectively. One circumstance where an alternative method may prove a more effective evaluation tool, is where the habitat consists mainly of plunge pools. In some high-gradient boulder or bedrock-channel streams, the only fish habitat is found in pools. If a plunge pool study is needed to address instream flows, methods can be found in WDOE and WDFW (2003).

The basic assumptions about habitat quality in pools are described below and in WDOE and WDFW (2003).

- Surface turbulence/bubble plume should cover about half the pool surface, and as plume coverage increases beyond, or deceases below, half the pool area, habitat quality will decline rapidly;
- Pools that are not covered by surface turbulence/bubble plume are valuable as habitat when depth equals or exceeds 0.5 feet or 10% pool width, whichever is greater, but any depth over 3.0 feet should be considered usable, subject to preference curve verification; and
- Spawning habitat response to changes in flow in pools is best assessed by using standard IFIM transects with depth, velocity, and substrate measurements near the tail of the pool.

Pool habitat for juvenile and adult trout should be calculated as:

Habitat = area of calm, deep water ***X*** preference for ratio of plume area to calm, deep area.

Methods for the plunge pool study will follow protocols described in WDOE and WDFW (2003).

Targeted Measured Flows

Generally, more calibrated flow measurements are required in the field to determine habitat relationships when using the Plunge Pool Method. If the Plunge Pool method is selected as part of the instream flow evaluation, Energy Northwest proposes to target flows similar to the calibration flow measurements in the IFIM study.

High Flow Measurement	35-40 cfs [1/]
Middle – High Measurement	25 - 28 cfs [1/]
Middle Flow Measurement	15-18 cfs
Low –Mid Flow Measurement	6 cfs
Low Flow Measurement	3 cfs

[1/] Flow pattern and weather dependent.

Targeted Modeling Range

Energy Northwest proposes a similar extrapolation range as for the IFIM study. The targeted range of flows would be 3 cfs – approximately 100cfs, if a plunge pool study were to be required.

The Plunge Pool methodology is currently not being recommended for Lake Creek, since habitat types present can be effectively modeled using the Instream Flow Incremental Methodology.

4.4.3 Preference Curve Development

WDOE and WDFW (2004) require that IFIM studies attempt to verify preference curves (also known as Habitat Suitability Indices (HSI) curves) during instream flow studies. Under ideal conditions, preference curves developed on site would be utilized in conjunction with state-wide (i.e. "fallback") preference curves for species and life stages of interest.

It is anticipated that rainbow trout in the juvenile and adult life stages will be the targeted species for preference curve development, subject to consultation and agreement with the natural resource agencies and tribes. Energy Northwest will collect rainbow trout juvenile and adult rearing HSI data in Lake Creek during the summer 2004. Preference curve collection methodologies will be agreed upon by the Committee and will be presented in the Final Study Plan.

4.5 Ramping Rates for Project Tailrace

Water leaves the powerhouse and is discharged into the tailrace, which extends approximately 8,000 ft until it reaches the upper Cowlitz River at approximately RM 125.2. The majority of the tailrace is lined with asphalt, in a trapezoidal-shaped channel that is 29 ft wide at the top and 9 ft wide at the base. In 1979, the lower portion of the tailrace was washed out in a storm event, when the main river channel carved a new channel and eroded the tailrace. In recent years, the

Cowlitz reverted to its previous channel, transforming this lower portion of the tailrace into a very shallow backwater slough prior to emptying into the Cowlitz River. Screens, which had previously excluded fish from the tailrace, were washed out as well during the storm event. Coho salmon have been observed in the tailrace immediately below the powerhouse.

Plant shutdown results in significant changes in stage throughout the channelized portion of the tailrace. The changes in stage over time have not been quantified in the tailrace or in the backwater slough immediately above the confluence with the Cowlitz River. Flow fluctuations resulting in rapid decreases in stage can result in fish stranding, particularly in the slough below the channelized tailrace.

Energy Northwest proposes to conduct a ramping rate study in the slough below the channelized tailrace. In consultation with the natural resource agencies and tribes, Energy Northwest will:

- Install 2 stage recorders in the backwater slough to record changes in stage over the course of normal project operations.
- Survey transects in the vicinity of the stage recorders in order to define the bed profile.
- Water surface elevations will be surveyed and flows will be calculated at a range of discharges from the powerhouse.
- A stage-discharge relationship will be developed for each transect.
- During plants shut down for maintenance in October and other periods when flows may fluctuate significantly, rates of change in stage and wetted perimeter will be documented and examined.
- The stage recorders will be downloaded and data examined to determine rates of change in stage relative to tailrace flow and flow in the Colwlitz River.

These are the established ramping rates for systems with anadromous salmonids (Hunter 1992).

Time Period	Day Time Rates	Night Time Rates
February 16 – June 15	No ramping	2 in/hr
June 16 – October 31	1 in/hr	1 in/hr
November 1 – February 15	2 in/hr	2 in/hr

4.6 Evaluation of Packwood Lake Level Manipulations on Aquatic Habitat in Tributaries

The Project seasonally regulates the lake level so that Packwood Lake is at El 2,857 ft ±6″ in summer recreation months and drawn down to no lower than El 2,849 ft MSL during winter months. This provides 8 ft vertical storage usable by the project. Concern has been expressed that the lake level manipulation may affect aquatic habitat in lake tributaries and aquatic connectivity between the lake and tributaries. Rainbow trout are known to spawn in these tributaries to the lake. It is unknown what effect Project operations may have on the habitat within these tributaries and the movement of fish into and out of these tributaries. Questions that have been asked include:

- Are spawning and other important habitats at tributary mouths or in the fluctuation zone inundated or drained at times that may cause adverse affects to aquatic organisms?
- Does lake level manipulation restrict or prevent fish or other aquatic organisms access to and from the tributaries at times of year that are important to their life history?
- Does lake level manipulation result in excessive buildup of sediment at tributary mouths?

Energy Northwest proposes to survey the mouths of the creeks entering Packwood Lake during the first week in October when the lake is drawn down to its minimum level. Bed profiles will be surveyed from 1 ft below the minimum pool level to 4 ft above the maximum pool level to determine if upstream migration would occur if pool levels were low or intermediate. Surveyed profiles will be provided to the natural resource agencies and tribes. Energy Northwest will also note if there is excessive sediment buildup at the mouths of the tributaries that might prevent fish access to the tributaries at the range of lake levels experienced during Project operation.

5.0 ACTIONS

- Conduct physical habitat surveys (completed)
- Delineate study reaches (completed)
- Determine habitat type weighting
- Select preliminary transects for agency/tribal review (completed)
- Determine methods to be used to evaluate instream flows (completed)
- Complete draft periodicity chart
- Determine needs for site-specific HSI curves and which species
- Produce final study plan for agency and tribal approval
- Conduct instream flow studies

6.0. SCHEDULE

Milestone/Event	Date
Preliminary Agency/Tribal Meeting	March 22, 2004
Conduct Physical Habitat Surveys	April 14 – May 19, 2004
Produce final study plan	June 4, 2004
Agency Meeting to Discuss Comment Letters, Habitat Assessment; Site Visit to Approve Study Reaches and Transects	April 22, 2004
Meeting to Discuss Final Study Plans, Published Reports; site visit to Lake	June 24, 2004
Transect Setup	July 2004
High Flow Calibration Measurement (IFIM/PP*)	July 2004
Middle Flow Calibration Measurement (IFIM/PP*)	July – August 2004
Low Flow Calibration Measurement (IFIM/PP*)	July – August 2004
Ramping Rate Studies	May– October 2004
Tributary Studies	October 2004
*Dependent upon flows and operational constraints. Plunge Pool measurements may not be required, contingent upon the habitat assessment and scoping.	

7.0 REFERENCES

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