**Before the Federal Energy Regulation Commission**

# APPLICATION FOR SURRENDER OF LICENSE

# SULLIVAN CREEK HYDROELECTRIC PROJECT

# FERC NO. 2225

*Sullivan Lake Dam*

*Mill Pond Dam*

**Public Utility District No. 1 of Pend Oreille County, WA**
**Newport, Washington**

**APPLICATION APPENDICES VOLUME 3 OF 4**
**Appendix E.4-1 – Appendix E.8-1**

**March 2010**

# APPLICATION FOR SURRENDER OF LICENSE
# SULLIVAN CREEK PROJECT
# FERC NO. 2225

## APPENDIX E.4-1
### WDFW FISHERIES SURVEY OF THE LIMNETIC ZONE OF SULLIVAN LAKE

# Fisheries Survey of the Limnetic Zone of Sullivan Lake, Washington, Using Hydroacoustics and Gill Nets, September 2003

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# Abstract

We conducted a fisheries survey of the limnetic zone of Sullivan Lake, Pend Oreille County, Washington during September of 2004. The study represented one of several efforts by WDFW, the Kalispel Tribe, the U.S. Forest Service, and Eastern Washington University (EWU) to better understand the physical and biological processes affecting the status, life history, and ecological interactions of various aquatic species in Sullivan Lake.

The objectives of this study were to evaluate the species composition, depth distribution, density, and abundance of fishes in the limnetic zone.

We conducted a gill net survey between September 23-26, 2003, comprised of 51 overnight gill net sets and a hydroacoustic survey that included 27 transects on September 23. Kokanee and cutthroat trout were the dominant fish species captured in limnetic gill nets, comprising 77% and 12% of the relative abundance, respectively. Vertical distribution of acoustically detected fish was highest between 12 and 20 m depth, with relatively few fish detections below 30 m. Mean density of all acoustically detected fish (30-800 mm) was 7 fish per 10,000 $m^3$, or 409 fish per hectare. The abundance of kokanee age-1 to 3 was 67,000 (120 kokanee per hectare), with approximately 10,000 age-3 kokanee. Length-at-age and relative weight for all kokanee, and relative weight for cutthroat trout over 300 mm were below the national average, indicating that food resources may be limiting fish production. This result was consistent with the EWU analysis that showed oligotrophic conditions and a zooplankton community that had the characteristics of size selectivity and heavy predation by zooplanktivorous fishes.

This study should provide fishery managers the necessary information to make informed decisions, especially when combined with the results of other ongoing research on Sullivan Lake.

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# Introduction

A naturally reproducing kokanee (*Oncorhynchus nerka*) population currently occupies Sullivan Lake in Pend Oreille County, WA. The population was likely established from hatchery stocking. The first documented stocking of kokanee in Washington State was in Sullivan Lake in 1904 when the U.S. Bureau of Fisheries planted 10,000 fry of unknown origin (Crawford 1979). However, after examination of U.S. Fish Commission stocking records, Nine (*in prep.*) concluded that the 1904 plant of "landlocked salmon" were Atlantic salmon *Salmo salar* and the first plant of kokanee in Sullivan Lake was in 1913. Sullivan Lake was planted with kokanee on numerous occasions between 1920 and 1945 (WDFW, unpublished data; Nine *in prep.*); however, there were only two plants after 1945. The first occurred in 1976 when the Washington Department of Game planted 197,960 Lake Whatcom stock kokanee at 1,800 to the pound (WDFW, unpublished data). The Washington Department of Fish and Wildlife (WDFW) planted 43,320 Sullivan Lake origin fry in May 2003 (WDFW, unpublished data). The fry were offspring of spawning kokanee collected from Harvey Creek, a tributary that flows into the southern end of Sullivan Lake in 2002 (McLellan 2003). Based on genetic data, the current population (2003) is closely related to Lake Whatcom stock (Loxterman and Young 2003; Young 2004), suggesting that it was derived from stocking of Lake Whatcom origin fish.

At least a portion of the kokanee from Sullivan Lake spawn in Harvey Creek between the middle of October and late December and spawning was limited to an ~600 m reach just upstream from the lake-stream interface (McLellan 2003 and 2005). Sullivan Lake is drawndown approximately 6.10 m each fall, beginning on October 1, from its full pool elevation of 788.82 m above mean sea level (msl) exposing approximately 700 m of stream (P. Buckley, Pend Oreille PUD, personal communication). All of the kokanee spawning in Harvey Creek occurred in the stretch of the stream that was exposed after the drawdown (McLellan 2003). Trapping operations on Harvey Creek in 2002 revealed approximately 3,500 spawning adults (McLellan 2003).

The kokanee population in Sullivan Lake is self-sustaining through natural reproduction, whereas populations in many other lakes throughout the state require supplementation through stocking to maintain popular sport fisheries. The majority of the fish used in WDFW's statewide kokanee program are Lake Whatcom stock and they are provided by two WDFW hatcheries located on the lake, near Bellingham, WA (Parametrix 2003). Due to a proposal to establish passage for anadromous salmon to the Middle Fork Nooksack River upstream of a water diversion that connects to Lake Whatcom, the use of that stock may be in jeopardy because it will no longer meet disease policy criteria. Thus, WDFW has begun looking for other potential sources of kokanee eggs. The Sullivan Lake kokanee population that spawns in Harvey Creek was identified as a potential source of surplus eggs to supply part or all of the Region 1 demand. After completion of the Lake Whatcom replacement feasibility study it was evident that more information was needed regarding the standing stock of kokanee in Sullivan Lake.

In addition to interest in Sullivan Lake's kokanee population as an alternate brood source, there was interest in the lake's standing stock and carrying capacity and the potential to enhance the sport fishery. Local groups were particularly interested in establishing a net pen program for rearing and releasing trout, similar to other successful programs in eastern Washington lakes and reservoirs. Additional studies were planned including a Colville National Forest funded fishery and limnology project to be conducted on Sullivan Lake in 2003 by Eastern Washington University. The objectives of the EWU project were to assess the water quality, primary and secondary production, and fish populations in order to understand factors that may limit fish production (Nine *in prep.*). To compliment this study, and provide additional information on the abundance and distribution of the kokanee population, the WDFW implemented a hydroacoustic and gill net survey for September of 2003.

Hydroacoustics uses sound impulses transmitted through water to determine fish size, depth, and population density (Traynor and Ehrenberg 1979; Brandt 1996; Cryer 1996). Abundance and distribution can then be determined by expanding results from individual transects to the entire system (Thorne 1979; Levy et al. 1991; Beauchamp et al. 1997). Hydroacoustics is most effective for suspended limnetic species, such as kokanee, when surveyed with a vertically oriented transducer. However, recent advances in technology using a horizontally oriented transducer allows for fish detection within 1.5 m of the surface (Yule 2000).

Hydroacoustics cannot determine species composition; therefore, alternative methods must complement a hydroacoustic survey. Common methods for verifying acoustic targets include trawling, purse seining, and gill netting (Parkinson et al. 1994; Bean et al. 1996; Yule 2000). Homogeny in species composition and length distribution results in increased confidence in hydroacoustic estimates.

## Study Area

Sullivan Lake is located in Pend Oreille County, Washington at an elevation of 788 m above mean sea level. The surface area of the lake at full pool elevation is 558.9 hectares. The mean and maximum depths are 58.8 m and 101.2 m, respectively. Sullivan Lake has a volume of 32,853 hectare-m, a drainage area of 132.6 $km^2$, and a shoreline length of 14.3 km (WDOE 1997). Sullivan Lake has three tributaries: Hall, Noisy and Harvey Creeks. Hall and Noisy Creeks are small ($1^{st}$ and $2^{nd}$ order), intermittent streams that enter the lake on the northeast and southeast sides, respectively. Harvey Creek ($3^{rd}$ order) is the main tributary to Sullivan Lake and it enters the lake at its south end.

There is a dam at the outlet of Sullivan Lake, which is owned and operated by Pend Oreille Public Utility District (POPUD). The original log crib dam, constructed in 1910,was reconstructed in its current form in 1922 raising the lake 12.2 m from its original elevation (Bamonte and Bamonte 1996). The current lake operation is a drawdown of approximately 6.10 m each fall, beginning on October 1, and the lake refills

in the spring with the water from the spring runoff (P. Buckley, POPUD, personal communication).

Most of the property surrounding the lake is Colville National Forest, thus there is little residential development along the lake. There are developed U.S. Forest Service campgrounds and improved boat launches at both the north and south ends of the lake.

The Washington Department of Ecology (WDOE 1997) and Nine (*in prep.*) classified Sullivan Lake as oligotrophic due to the low concentrations of Total Phosphorus and Cholorphyll *a*, and the high Secchi disk depth values. Oligotrophic lakes generally have low production of algae and zooplankton and high water clarity (Horne and Goldman 1994). Aquatic macrophyte densities were low in Sullivan Lake (WDOE 1997). Native fish species known to occupy Sullivan Lake include pygmy whitefish (*Prosopium coulteri*), mountain whitefish (*P. williamsoni*), longnose suckers (*Catostomus catostomus*), redside shiners (*Richardsonius balteatus*), sculpins (*Cottus* spp.), and westslope cutthroat trout (*O. clarki lewisi*) (Washington Water Power, unpublished data; WDFW, unpublished data; Mongillo and Hallock 1995; Nine *in prep.*). Introduced fish species previously collected in Sullivan Lake include kokanee, brown trout (*S. trutta*), rainbow trout (*O. mykiss*), burbot (*Lota lota*), and tench (*Tinca tinca*) (Washington Water Power, unpublished data; WDFW, unpublished data; Mongillo and Hallock 1995; Bonar et al. 1997; Nine *in prep.*).

The Sullivan Lake fishery is currently managed under WDFW's general statewide rules, so the lake is open to fishing year round. The bag limits for trout/kokanee, whitefish, and burbot are 5, 15, and 5 fish, respectively. There are no size restrictions for those species. Sullivan Lake has been stocked with several species of trout and salmon since the early 1900s. Species planted included brown trout, Atlantic salmon, Yellowstone cutthroat (*O. clarki bouveri*), eastern brook trout (*Salvelinus fontinalis*), kokanee, westslope cutthroat trout, and rainbow trout (WDFW, unpublished data; Nine in prep.). The majority of the fish planted were cutthroat trout, presumably the westslope subspecies, and rainbow trout (WDFW, unpublished data). As of 2003, the lake does not receive any regular fish stocking.

# Methods

## Hydroacoustic Surveys

Sullivan Lake was surveyed on September 23, 2003, with an HTI model 241 echosounder with two 200 kHz transducers; a 15° split-beam transducer in vertical orientation and a 6° x 10° elliptical split-beam transducer in horizontal orientation. The transducers were clamped to a pole and mounted to the starboard side of 6.7 m vessel 1 m below the surface. Data were logged directly into a computer and unprocessed echoes were backed up using digital audiotapes. A pulse repetition rate of three pings per second was multiplexed between the transducers at a pulse width of 1.25 ms and a 10 kHz pulse width chirp. The horizontal transducer was offset by 7° and sampled fish targets from 1.5- to 8 m below the surface. Data within 10 m of the horizontal transducer and 8 m of the vertical transducer were excluded from analysis due to the narrow beam width reducing the ability to detect fish and potential boat avoidance by fish in the near field (Mous and Kemper 1996; Yule 2000).

Transects were conducted across the limnetic zone of Sullivan Lake by navigating from predetermined global positioning system (GPS) waypoints (Figure 1). Transects were conducted perpendicular to the long axis of the lake and at least 200 m separated the midpoints. The survey began approximately 90 minutes after sunset (2010), on September 23, and was completed well before sunrise at 0130 on September 24. Transect lengths ranged from 689-1037 m (mean 884) for a total survey distance of 23.9 km; and boat speed averaged 6.1 km/hr. A GPS logged the latitude and longitudes into the data files and transect distances were calculated using Terrain Navigator software version 4.05 (Maptech 1999).

A series of acoustic echoes were considered a fish if tracked for at least three consecutive pings, within 0.3 m/ping, a maximum velocity of 5 ms/ping, and target strengths between –55 and –27.7 dB (approximately 30-800 mm). Target strengths were converted to fish lengths using a formula generated by Love (1971, 1977), where TL was the fish total length (mm) and TS (dB) was the mean target strength of each tracked fish.

$$TL = [2252.1*[EXP(0.1204*TS)]$$

*Hydroacoustic fish density*.—Density (fish/10,000 $m^3$) was calculated for each transect and transect densities were averaged together for a lake-wide estimate of fish density. For each transect, individual tracked fish were verified as real within the post-processing software Echoscape 2.11 (HTI 2002). Raw fish counts were adjusted to the effective beam width within each depth strata by the equation:

$$F_1 = F_0 \bullet \left[ 1 - \left( \frac{EBW}{NBW} \right) \right]$$

where $F_1$ was the adjusted fish count, $F_0$ was the original fish count, EBW was the effective beam width for that stratum and NBW was the nominal beam width for the transducer. Density was calculated by dividing the adjusted fish count by the total swept volume for each transect. Swept volume (V) was calculated as:

$$V = \frac{1}{2} * b * h * l$$

where l was the distance (m) of the transect, h was the distance (m) from the transducer to the end of the stratum (mean bottom depth), and b was the beam diameter calculated by:

$$b = 2R \tan\left(\frac{NBW}{2}\right)$$

where R is the range (m) to the end of the stratum (mean bottom depth). Swept volume was adjusted by subtracting the un-surveyed near-field volume (0-8 m vertical transducer; 0-10 m horizontal transducer) from the total volume.

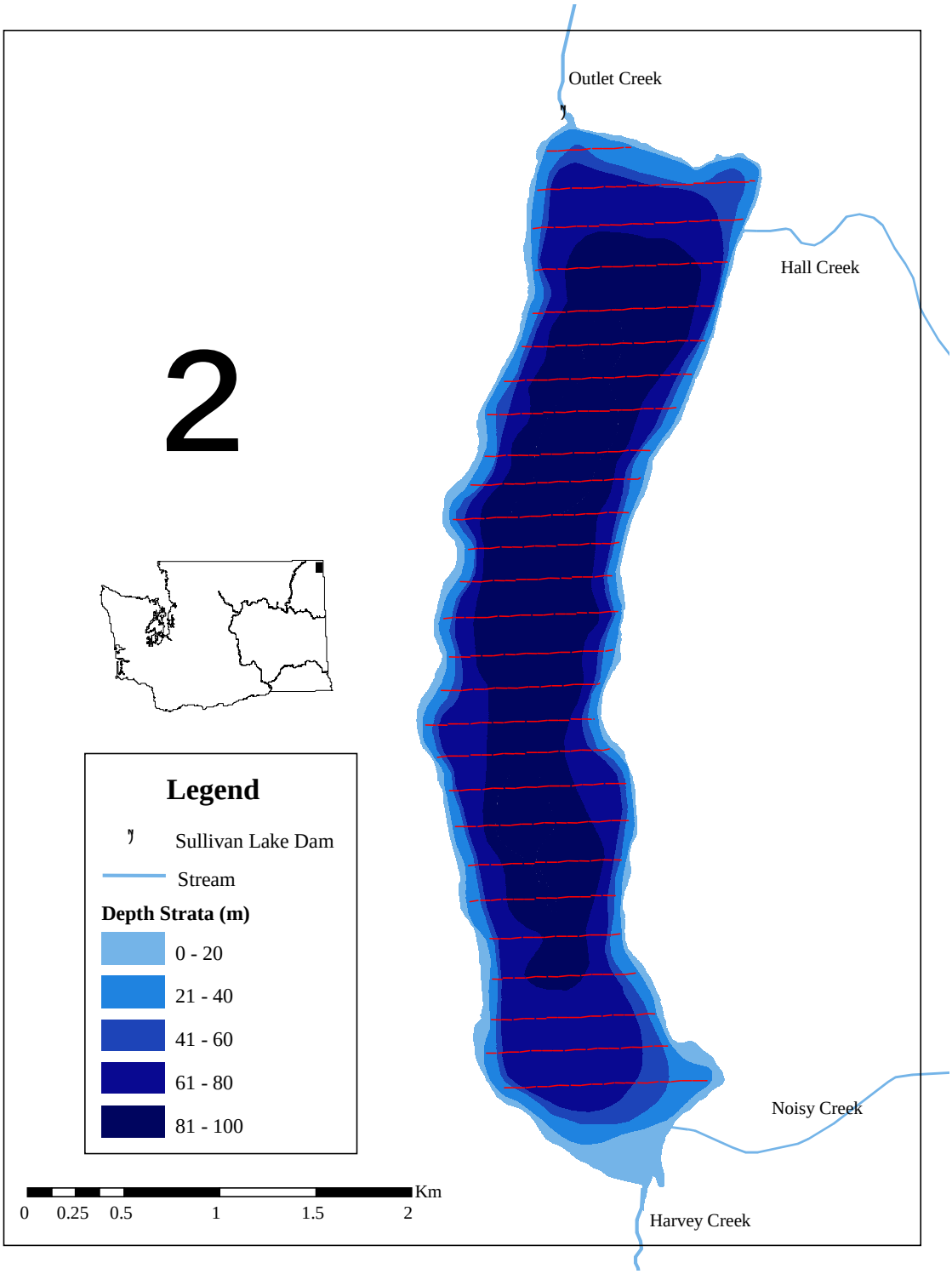


**Figure 1.** Bathymetric map of Sullivan Lake, Washington. Dashed red lines indicate hydroacoustics survey transects completed in September of 2003. Transect one was at the north end of the lake near Outlet Creek and transect 27 was at the south end of the lake near Harvey Creek.

## Gill Net Survey

Limnetic gill net surveys were used to provide species verification, depth distributions, and length frequencies of acoustic targets larger than 100 mm. Gill nets were set the night of the acoustic survey (September 23), and for two nights following the survey (September 24 and 25), with various effort allocated each night targeting randomly selected net sites. Vertical gill nets were 2.6 m wide and 46 m deep and had one mesh size throughout (25, 38, 51, 64, 76, 89, or 102 mm stretch monofilament). Horizontal nets were 2.6 m deep and 46 m long with seven panels (25, 38, 51, 64, 76, 89, or 102 mm stretch monofilament) that were each 6.5 m long. Terrain Navigator (Maptech 1999) software was used to spatially segregate the limnetic sampling sites by placing points 200 m apart along the predetermined hydroacoustic survey transects. This method provided uniform coverage of the offshore zone and a GPS waypoint for navigation and net deployment. Netting locations were then randomly selected using Microsoft® Excel 97 SR-1. Our goal was to sample over 40 % of the potential limnetic sampling sites that were deep enough (at least 20 m) and far enough from shore (~ 200 m) to be considered in the limnetic zone.

### Age, Size, and Relative Weight

All fish captured in gill nets were measured to the nearest mm and weighed to the nearest gram. Several scales were taken from just posterior to the dorsal fin and above the lateral line. Scale samples were mounted on adhesive data cards and pressed onto acetate slides using a Carver laboratory press (Fletcher 1993). Fish age was determined by the number of annuli and no back calculations were made. Relative weights were calculated using standard formulas for all cutthroat trout and kokanee captured in both nearshore and offshore gill net surveys (Anderson and Newman 1996; Hyatt and Hubert 2000).

### Limnetic Fish Abundance

Mean fish density was multiplied by lake volume to estimate abundance. Two standard errors were used to estimate the 95% confidence interval of the acoustic abundance estimate. Size-specific abundance estimates were determined by applying the percent frequency of each size class from the down-looking transducer to the total abundance estimate. We applied the length frequency from the vertical transducer to the horizontal acoustic targets because fish target echoes in horizontal aspect do not relate to fish length as they do in vertical aspect (Kubecka 1994; Yule 2000). The assumption that fish species composition and size distribution was the same from 1- to 8 m (horizontal acoustics) and from 8 m to lake bottom was validated with netting data. The coefficient of variation from the total abundance estimate was applied to size-specific abundance estimates. Species-specific abundance estimates were calculated by multiplying the species composition from the gill net survey by the acoustic abundance estimates. We

did not capture fish less than 100 mm long in the offshore zone so no estimate was made for acoustic targets corresponding to this size class.

# Results

## Hydroacoustic Density and Distribution

Lake-wide mean fish density was 7.0 (± 2 SE; 4.9) fish per 10,000 $m^3$. There was no significant difference in the mean density of fish from the horizontal transducer (0-8 m) (6.7 ± 8.6) and the vertical transducer (8 m – lake bottom) (7.2 ± 2.0)(t-test, df 26, p= 0.89); however, the horizontal transducer mean density was heavily influenced by high densities of fish in transects 1 and 2 (at the North end of the lake) (Figure 2). Fish density from the vertical transducer was more consistent throughout the lake with increases at both the North and South end of the lake (Figure 2).

Relatively few fish were distributed deeper than 30 m, with the highest densities occurring from 16-24 m (Figure 3).

## Gill Net Surveys

We sampled 41% (51 of 125) of the potential limnetic sites with a combination of vertical and horizontal gill nets. Limnetic nets caught 66 fish during three nights and kokanee dominated the species composition (77%), with cutthroat trout comprising a distant second with 12% of the species composition (Table 1). Vertical gill nets accounted for 57% of the total catch, with a catch-per-unit-effort (CPUE) of 1.00 fish per net-night (Table 2). The floating horizontal net had the highest CPUE (2.75 fish per net-night), capturing 11 fish in four net sets (Table 2). Three suspended horizontal nets failed to capture any fish when set more than 30 m below the surface (Table 2).

Fish were most commonly captured in the upper 32 m of the water column, with the majority of fish being captured between 0-16 m (Figure 4). Kokanee were captured in similar numbers throughout the upper 24 m of the water column, whereas cutthroat trout were only captured in the upper 16 m and were three times more likely to be captured in the 0-8 m depth bin, than the 8-16 m depth bin (Figure 4). Three burbot were captured in a sinking horizontal gill net that was set at 67 m.

### Age, Size, and Relative Weight

*Kokanee*.—Scale analysis revealed that age-1 kokanee averaged 172 mm and weighed 43 g, age-2 kokanee averaged 236 mm and weighed 116g, and age-3 kokanee averaged 260mm and weighed 146 g (Table 3). Kokanee relative weight was consistently below the national standard across all sizes and averaged 80 (± 9 SD) (Figure 5).

The vast majority (95%) of kokanee greater than 245 mm were showing signs of sexual maturity (Figure 6). Carcass surveys in Harvey Creek indicated that the majority of age-

2 and age-3 (Brood year ages 3 and 4) kokanee on the spawning grounds in 2002 were between 240 and 300 mm (McLellan 2003).

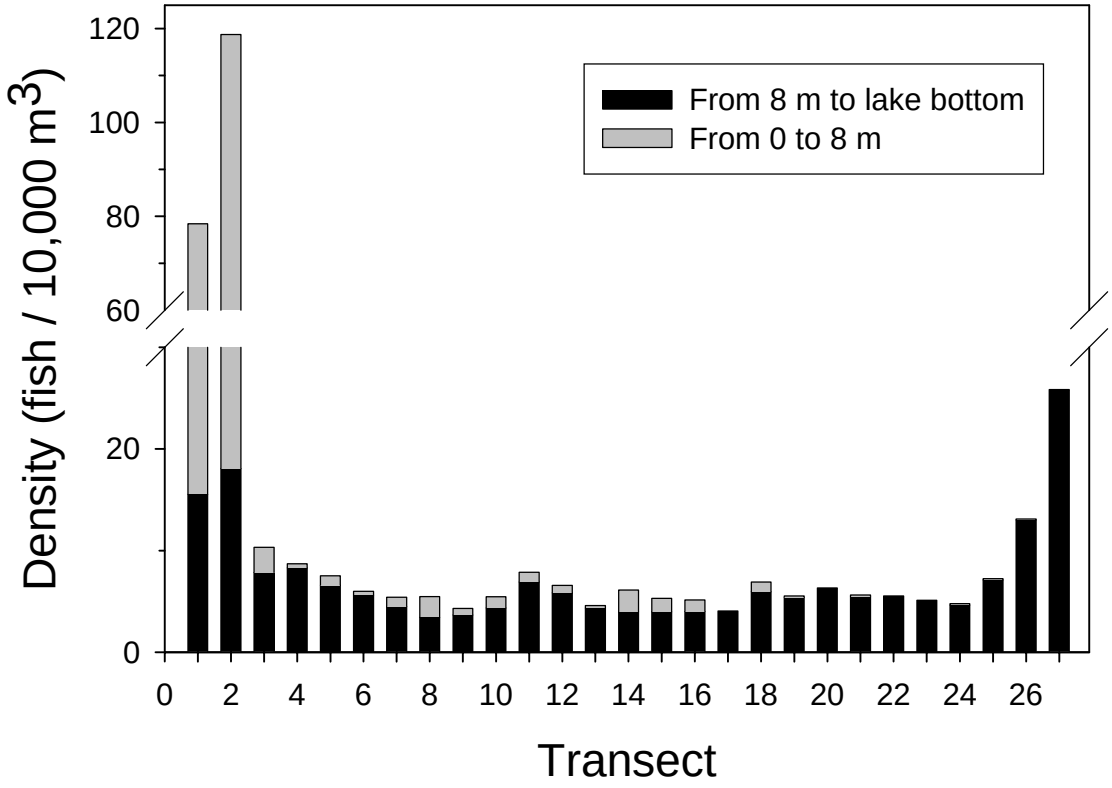


**Figure 2.** Density of target-tracked fish from a hydroacoustic survey of Sullivan Lake, Washington, in September of 2003. The horizontal transducer sampled fish between 1.5 and 8 m depth, whereas the vertical transducer observed fish from 8m to the bottom of the reservoir. Transect 1 began at the north end (near Outlet Creek) and transect 27 ended at the south end (near Harvey Creek).

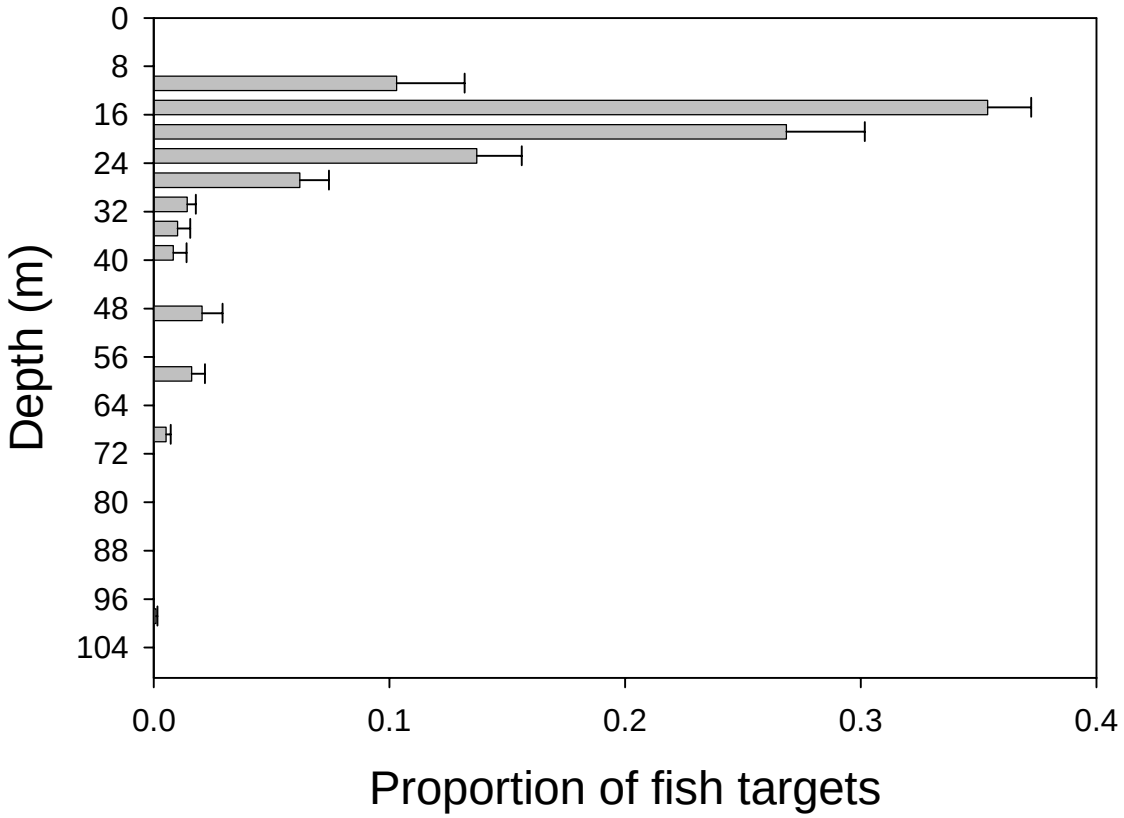


**Figure 3.** Vertical distribution of acoustically detected fish targets from the vertical transducer (from 8 m to the lake bottom) on Sullivan Lake, Washington, September 2003.

**Table 1.** Sample size (n), percent composition, and lengths of fish captured in offshore gill nets in Sullivan Lake, Washington, in September of 2003.

| | | | Length (mm) | | |
|---|---|---|---|---|---|
| **Species** | **n** | **% composition** | **Mean** | **Minimum** | **Maximum** |
| Burbot | 5 | 8% | 432 | 288 | 579 |
| Cutthroat trout | 8 | 12% | 324 | 282 | 376 |
| Kokanee | 51 | 77% | 219 | 165 | 286 |
| Pygmy whitefish | 1 | 2% | 139 | 139 | 139 |
| Redside shiner | 1 | 2% | 110 | 110 | 110 |
| Total | 66 | 100% | | | |

**Table 2.** Catch per unit effort (CPUE) for all species of fish in various net types set in Sullivan Lake, Washington, in September of 2003. Suspended horizontals were stratified into two depth categories, those set deeper than 30 m below the surface and those set less than 30 m below the surface. Each unit of effort represented an overnight gill net set.

| Net Type | Effort | Catch | CPUE |
|---|---|---|---|
| Floating Horizontal | 4 | 11 | 2.75 |
| Sinking Horizontal | 4 | 6 | 1.50 |
| Suspended Horizontal (> 30 m) | 3 | 0 | 0 |
| Suspended Horizontal (< 30 m) | 11 | 20 | 1.82 |
| Vertical | 29 | 29 | 1.00 |

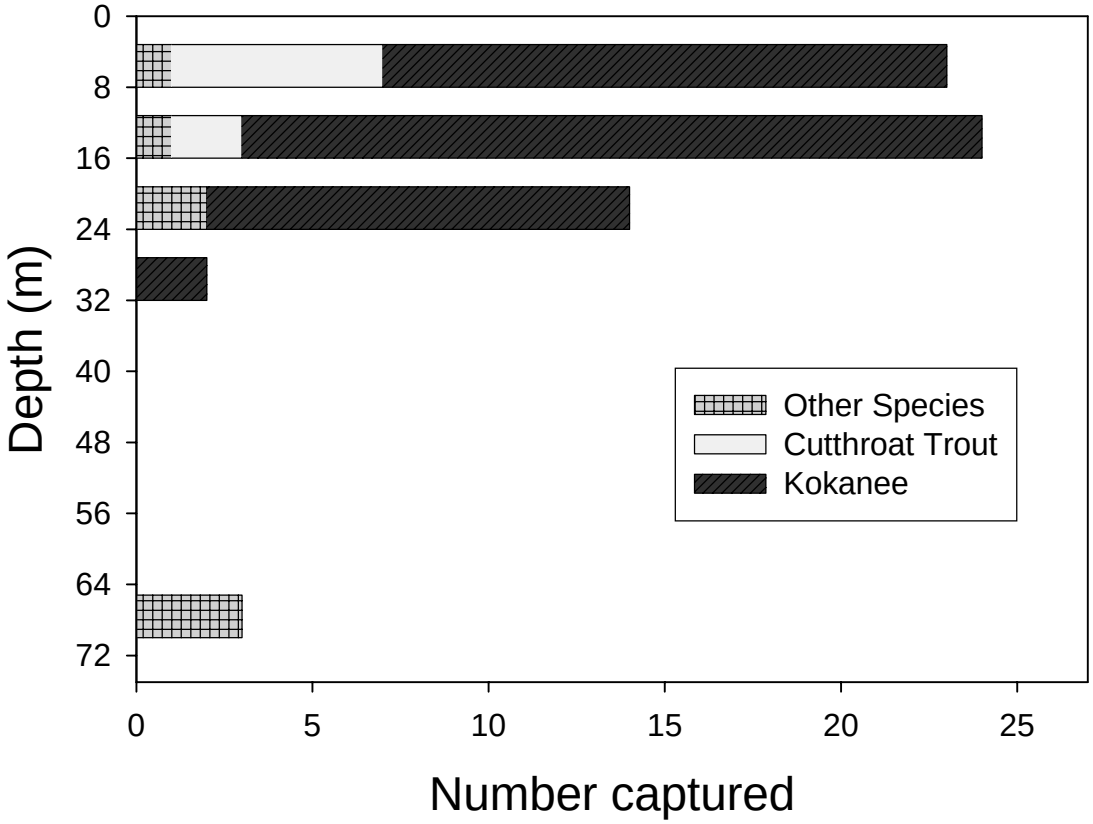


**Figure 4.** Vertical distribution of fish captured in offshore gill nets in Sullivan Lake, Washington, in September of 2003. Other species included burbot (n=5), pygmy whitefish (n=1), and redside shiner (n=1).

**Table 3.** Mean length and weight for specific age classes of fish captured in Sullivan Lake, Washington, in September of 2003. Age was determined by the number of annuli so brood year ages would be an additional year older.

| | | | Total Length (mm) | | | Weight (g) |
|---|---|---|---|---|---|---|
| **Species** | **Age** | **n** | **Mean** | **Minimum** | **Maximum** | **Mean** |
| | 2 | 4 | 300 | 284 | 311 | 296 |
| Cutthroat trout | 3 | 6 | 319 | 243 | 368 | 331 |
| | 4 | 3 | 367 | 345 | 381 | 466 |
| | 1 | 20 | 172 | 165 | 180 | 43 |
| Kokanee | 2 | 8 | 236 | 207 | 262 | 116 |
| | 3 | 15 | 260 | 239 | 274 | 146 |
| Pygmy whitefish | 2 | 1 | 139 | | | 18 |
| Rainbow trout | 3 | 1 | 373 | | | 504 |

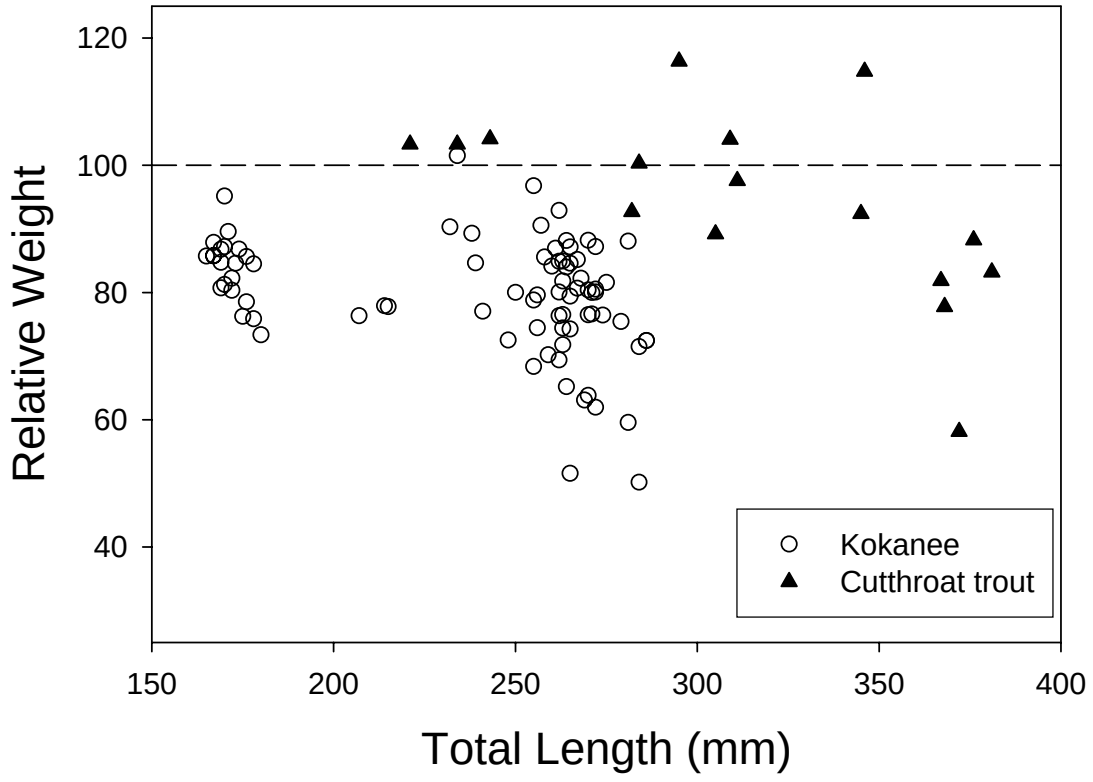


**Figure 5.** Relative weight of kokanee and cutthroat trout in Sullivan Lake, Washington, in September of 2003.

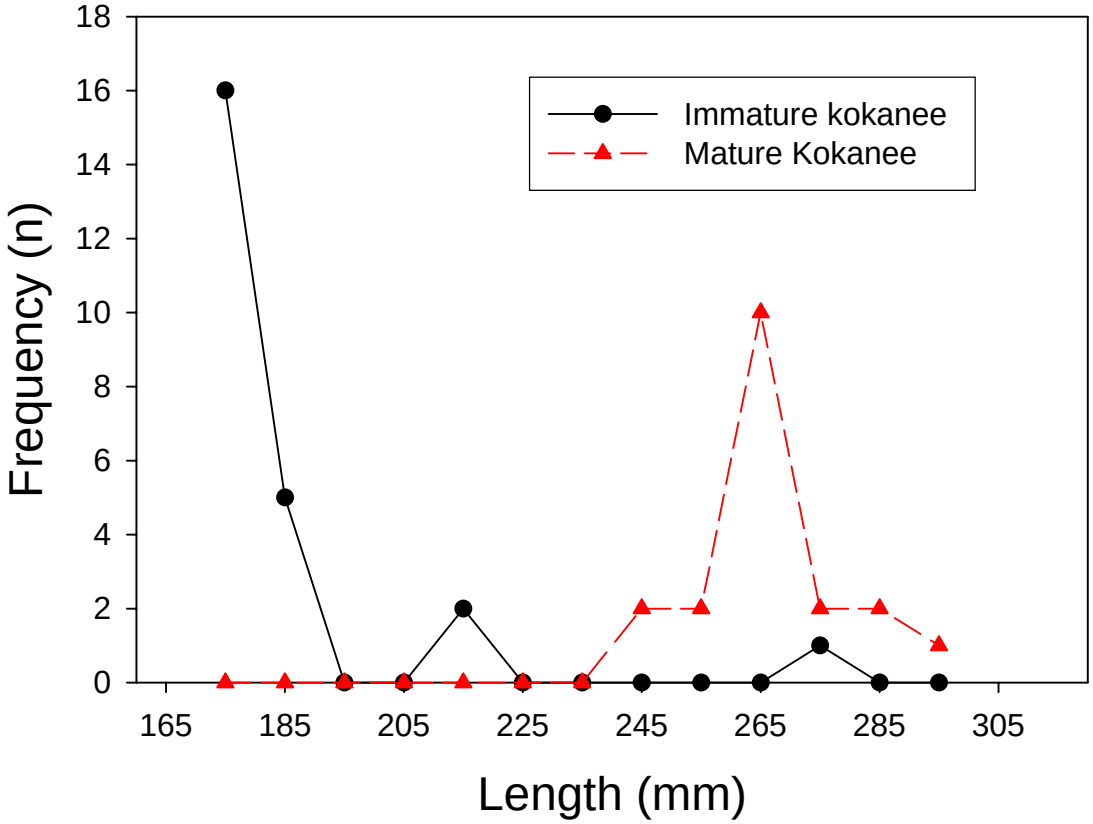


**Figure 6.** Length frequency of sexually mature and immature kokanee from an offshore and nearshore gill net survey on Sullivan Lake, Washington, in September of 2003.

*Cutthroat trout*.—Scale analysis indicated that age-2, -3, and -4 cutthroat trout averaged 300, 319, 367 mm respectively (Table 3). However, sample sizes were quite small (3-6 per age class), increasing the probability of inaccurate results. Cutthroat trout less than 325 mm total length were generally near or above the national standard for relative weight, whereas larger individuals (> 350 mm TL) were generally below the national standard (Figure 5).

## Limnetic Fish Abundance

Hydroacoustic density estimates were expanded to total lake volume resulting in a lake-wide abundance estimate of 228,667 (± 80,244 SE) fish with target strengths between –55 and –28 dB (~30-800 mm total length). Fifty-nine percent of the acoustic targets were too small to be verified by our gill net survey (< 150 mm). However, we assumed that the species composition from the gill net survey was a valid estimate of species composition for smaller targets in order to estimate the abundance of age-0 kokanee. Thirty-seven percent of the acoustic targets were in the size range (150-300 mm) of

kokanee captured in the gill nets. We used the overall species composition for all size classes of kokanee to bias due to small sample sizes within certain size classes. We partitioned the acoustic targets into four size categories that corresponded to kokanee age-0 (103,281 ± 36,243 SE), age-1 (34,460 ± 12,093), age-2 (22,220 ± 7,798), and age-3 (10,030 ± 3,520) Table 4.

**Table 4.** Abundance estimates for all acoustic fish targets and for specific age classes of kokanee in Sullivan Lake, WA in September of 2003.

| | **All Acoustic Targets** | **All Kokanee** | **Age-0** | **Age-1** | **Age-2** | **Age-3** |
|---|---|---|---|---|---|---|
| **Size Class (mm)** | **30-800** | **30-300** | **30-150** | **150-200** | **200-250** | **250-300** |
| % of Acoustic Targets | 100% | 97% | 59% | 20% | 13% | 6% |
| % Kokanee | NA | 77% | 77% | 77% | 77% | 77% |
| Abundance | 228,667 | 169,991 | 103,281 | 34,460 | 22,220 | 10,030 |
| SE | 80,244 | 59,653 | 36,243 | 12,093 | 7,798 | 3,520 |
| Fish / ha | 409 | 304 | 185 | 62 | 40 | 18 |

# Discussion

This survey of the limnetic fish populations of Sullivan Lake revealed a high-density population of kokanee distributed primarily in and above the thermocline throughout all areas of the lake. The estimate of age-3 (BY age-4) kokanee (10,030) comported well with the Harvey Creek spawning escapement estimate (9,231), especially considering that the spawning escapement estimate could not quantify the loss due to predation and scavengers (McLellan 2005). We also estimated that there were strong year classes of age-0 and age-1 kokanee that should recruit to the fishery and the spawning grounds in future years.

The low relative weight of all kokanee and low total length-at-age of mature kokanee indicated that the population density was high enough that competition for food resources was impacting the growth rate (Rieman and Meyers 1992; Teuscher and Luecke 1996). The small mean size of *Daphnia pulex* in Sullivan Lake in 2003 also suggested that competition for food resources was influencing kokanee growth. The mean length of *Daphnia pulex* in Sullivan Lake was 0.78 mm (Nine *in prep.*). In lakes with high densities of planktivores the mean size of larger species of zooplankton, such as *Daphnia* spp., declines to below 1.0 mm (Brooks and Dodson 1965; Galbraith 1967; Post and McQueen 1987). Large *Daphnia* are selectively preyed upon and smaller zooplankters, such as *Bosmina* spp. and cyclopoid copepods, dominate the zooplankton species composition.

Cyclopoid copepods had the highest density and biomass during all sampling periods at all locations in Sullivan Lake in 2003 (Nine *in prep.*).

Rieman and Myers (1992) found that density dependent reductions in growth were more prominent in oligotrophic systems, such as Sullivan Lake. A lake with high densities of small fish has the potential to yield fewer fish to the fishery due to reduced catchability of the smaller fish (Rieman and Maiolie 1995). Rieman and Maiolie (1995) found that when density of adult kokanee exceeded 50 per hectare there was no corresponding increase in catch rate or yield in the fishery. Additionally, reduced length-at-age would reduce fecundity of mature females and the ability to form redds in larger substrates would be impacted, thereby reducing the productivity of the natural population. Our hydroacoustic assessment estimated a density of 58 age-2 and age-3 (BY 3 and 4) kokanee per hectare, putting the Sullivan Lake kokanee population in the range of the ideal trade-off between density and catchability.

Given the low relative weight of age-3 and age-4 cutthroat trout, it also appeared that food resources were limited for other species that typically have a diet less dependent upon zooplankton. Limited sampling by Nine (*in prep.*) indicted that the density and diversity of benthic macroinvertebrates were low in Sullivan Lake when compared to other Northwest lakes. There needs to be more investigation into the factors limiting cutthroat trout growth in Sullivan Lake.

We assumed equal probability of gill net capture between species; however, this assumption could have overestimated abundance, if a species was more vulnerable to the gill nets. For example, if kokanee were more active than cutthroat trout, but just as likely to be retained by the net once it was encountered, then kokanee abundance was overestimated while cutthroat trout abundance was underestimated. The gill nets only captured fish greater than 100 mm (most effective > 150 mm), and larger fish have greater capture probabilities in gill nets (Hamley 1975; Rudstam et al. 1984; Henderson and Wong 1991). We applied the species composition from all fish captured in the gill nets to all acoustic targets greater than –28 dB (~30 mm). If species composition of the smaller fish (<150 mm) was different, then our acoustic estimates would be biased for the smaller size classes. There were high densities of redside shiners < 150 mm in electrofishing surveys of Sullivan Lake (Nine in prep.). If redside shiners were present in the limnetic zone, then the abundance estimate for age 0 kokanee was overestimated. Confirming targets of the smaller size classes would best be accomplished using trawling. Knowing the abundance of age 0 kokanee would improve run size predictions, calculating natural escapement numbers, and determining stocking needs if it is to be used as a brood source. We did not generate species-specific abundance estimates for fish species other than kokanee, because they were such a small proportion of the net catch.

The extremely high density of near surface fish targets in transects 1 and 2 increased the variance of the acoustic estimate (Figure 2). The coefficient of variation for the vertical transducer was considerably less (0.14) than with the horizontal transducer (0.64). However, it was necessary to combine these estimates due to the presence of kokanee in the 0-8 m depth bin from the gill net survey.

We could not determine the volume of water in the limnetic zone independently from the littoral zone. Mean density was extrapolated to lake-wide volume; therefore, we assumed that fish density in the littoral zone was equal to the limnetic zone for the species composition observed in limnetic gill nets. We recognize that species composition was different in the littoral zone and included many more species than we observed in the limnetic zone. If nearshore densities of kokanee were higher than offshore densities then we underestimated lake-wide abundance for kokanee; however, the relatively small volume of water in the littoral zone minimized the potential bias from this assumption.

The horizontal transducer could not differentiate target strength, so we could not determine the density of specific size classes for near-surface targets. We assumed that the size distribution of fish was the same from 1.5-8 m and from 8 m to the bottom. Similar mean lengths for each species and depth interval from the gill nets verified this assumption, with the possible exception of higher catches of cutthroat trout in the near surface depths which would have underestimated their contribution to the offshore abundance estimate.

This study evaluated the limnetic fish community of Sullivan Lake, as one aspect of a series of studies (by WDFW, KNRD, USFS, and EWU) with the goal of evaluating the limnology, fish resources, and species interactions in Sullivan Lake. We determined that

adult kokanee densities were in a preferred range for angler catchability, but that relative weight was below average indicating that the observed fish densities were in competition for limiting resources. Future efforts may need to determine the carrying capacity of Sullivan Lake, based on the primary and secondary productivity results of the EWU studies (Beauchamp et al. 1995; Baldwin et al. 2000). A bioenergetics analysis would allow managers to evaluate the growth versus density relationship and develop targets for recruitment of naturally produced fish versus the fry releases from those eggs removed from Harvey Creek spawning run.

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# APPLICATION FOR SURRENDER OF LICENSE
# SULLIVAN CREEK PROJECT
# FERC NO. 2225

## APPENDIX E.4-2

### RESPONSE TO FERC AIR ITEM #11 ELECTROSHOCKING SURVEY

### SEPTEMBER 1996

**Comment No. 11: You have provided a summary of species of fish in the project area from Cascades Environmental Services, Inc. (CES) and FS electroshocking surveys. In order for staff to evaluate the impacts of project operations on the Sullivan Creek fishery, the following additional information is required:**

**(a) Provide a quantification of habitat types and total area sampled for each location in the CES and FS electroshocking surveys.**

**Response:** In a letter dated April 6, 1996, CES asked the FS for the information you requested in 11a and 11b. A summary of habitat types, area and Reach Number for the FS surveys is included in Table 11-1. CES defines habitat types in Section IV of the IFIM Report. These definitions may not be exactly how the FS describes their habitat types.

CES conducted electroshocking surveys to characterize fish utilization below, within and above the diversion in 1993. CES identified habitat types for electroshocked study reaches in Appendix A of the Instream Flow Report. Table 11.2 summarizes all surveys conducted in reaches during 1993, since two surveys were conducted in Reach 2. Table 11.3 summarizes all habitat types sampled. It should be noted that Reaches 1 (below the powerhouse), 6 (Outlet Creek below Sullivan Lake Dam), and 7 (Sullivan Creek above the confluence of Outlet Creek) are located outside the bypass reach.

The purpose of the CES surveys was to able to describe relative locations, numbers, and species of salmonids found within and surrounding the Project area. Accordingly, CES measured the length of the reaches electroshocked but did not quantify the area of each habitat unit. Repetitive capture and removal techniques were not used since total population enumeration was not the objective. Total linear stream length sampled by CES was 5,450 feet (Reach 2 was sampled on two occasions). The intent of both the CES and FS surveys was to identify species composition, associated habitats and range and relative distribution, but not to estimate population numbers.

CES also conducted extensive electroshocking surveys during the summer 1994; however, these surveys were conducted to determine emergence timing of salmonid fry for back calculating spawning timing. All areas examined in 1994 were edge habitats characterized by shallow depths and slow velocities. Due to the narrow scope of these surveys and habitats sampled, the results are not included in Tables 11.2 and 11.3.

**(b) A description of the electroshocking methodology for the CES and FS surveys.**

**Response:** As provided by Tom Shuhda, Colville National Forest Fisheries Biologist, Region 6 of the FS (where Sullivan Creek is located) has a methodology for gathering fish information, found on Page 36 of the Stream Inventory Handbook (Attachment 11-1). This methodology can be used interchangeably with electroshocking, seining and snorkeling. Minimum numbers of sampling sites are given in the instructions.

Table 11.1. USFS Quantification of habitat types sampled - Sullivan Creek (provided by Tom Shuhda, Colville National Forest).

| Reach | Habitat Type | Length (ft) | Width (ft) | Area sampled (sq ft) |
|---|---|---|---|---|
| 1 | Riffle | 300 | 40 | 12,000 |
| | Pool | 45 | 45 | 2,025 |
| 2 | Riffle | 300 | 40 | 12,000 |
| 3 | Riffle | 300 | 68 | 20,400 |
| | Glide | 199 | 52 | 10,348 |
| 5 | Riffle | 300 | 25 | 7,500 |
| 6 | Pool | 70 | 35 | 2,450 |
| | Riffle | 300 | 35 | 10,500 |
| 7 | Pool | 65 | 35 | 2,275 |
| | Riffle | 300 | 55 | 16,500 |
| 8 | Riffle | 300 | 25 | 7,500 |
| | Pool | 70 | 15 | 1,050 |
| 9 | Riffle | 300 | 26 | 7,800 |
| | Pool | 45 | 23 | 1,035 |
| 11 | Riffle | 280 | 30 | 8,400 |
| | Glide | 60 | 28 | 1,680 |
| | Pool | 99 | 30 | 2,970 |
| 13 | Riffle | 300 | 25 | 7,500 |

Table 11.2. Summary of habitat types by reach, CES electroshocking, 1993.

| Reach | Location | Habitat Type | No. Units | Percent |
|---|---|---|---|---|
| 1 | Below Powerhouse | Side Channel | 2 | 14.3% |
| | | Riffle | 2 | 14.3% |
| | Length = 1500 ft | Side Channel Pool | 2 | 14.3% |
| | | Run | 1 | 7.1% |
| | | Plunge Pool/Glide | 1 | 7.1% |
| | | Side Channel Eddy | 1 | 7.1% |
| | | Boulder Run | 1 | 7.1% |
| | | Plunge Pool/Chute | 1 | 7.1% |
| | | Plunge Pool/Run | 1 | 7.1% |
| | | Boulder Run | 1 | 7.1% |
| | | Glide | 1 | 7.1% |
| | | Total | 14 | |
| 2 | Powerhouse upstream to canyon | Plunge Pool | 10 | 31.3% |
| | | Glide | 7 | 21.9% |
| | Length = 300 ft | Pool | 5 | 15.6% |
| | | Lateral Pool | 3 | 9.4% |
| | | Run | 3 | 9.4% |
| | | Boulder Pool | 2 | 6.3% |
| | | Boulder Run | 2 | 6.3% |
| | | Side Channel | 1 | 3.1% |
| | | Total | 32 | |
| 3 | Above Confluence, N.F. Sullivan Cr. | Plunge Pool | 3 | 37.5% |
| | | Glide | 2 | 25.0% |
| | Length = 1400 ft | Pool | 1 | 12.5% |
| | | Run margin | 1 | 12.5% |
| | | Riffle margin | 1 | 12.5% |
| | | Total | 8 | |
| 4 | Above Mill Flats | Riffle | 1 | 11.1% |
| | | Riffle, Side Margins | 6 | 66.7% |
| | Length = 500 ft | Plunge Pool | 1 | 11.1% |
| | | Pool | 1 | 11.1% |
| | | Total | 9 | |
| 5 | Below Mill Pond | Glide | 2 | 33.3% |
| | | Plunge Pool | 2 | 33.3% |
| | Length = 350 ft | Cascade | 1 | 16.7% |
| | | Pool | 1 | 16.7% |
| | | Total | 6 | |

Table 11.2, cont'd. Summary of habitat types by reach, CES electroshocking, 1993.

| Reach | Location | Habitat Type | No. Units | Percent |
|---|---|---|---|---|
| 6 | Outlet Creek below Dam | Glide | 1 | 33.3% |
| | | Pool | 1 | 33.3% |
| | Length = 500 ft | Lateral Pool | 1 | 33.3% |
| | | Total | 3 | |
| 7 | Outlet Creek above confluence of Sullivan Creek | Run | 2 | 66.7% |
| | | Side Channel | 1 | 33.3% |
| | Length = 600 ft | Total | 3 | |

Table 11.3. Summary of habitat types sampled by CES in 1993, Sullivan Creek drainage.

| Habitat Type | Frequency | Percent |
|---|---|---|
| Boulder Run | 4 | 5.3% |
| Boulder Pool | 2 | 2.6% |
| Cascade | 1 | 1.3% |
| Glide | 13 | 17.1% |
| Lateral Pool | 4 | 5.3% |
| Plunge Pool | 16 | 21.1% |
| Plunge Pool/Chute | 1 | 1.3% |
| Plunge Pool/Glide | 1 | 1.3% |
| Plunge Pool/Run | 1 | 1.3% |
| Pool | 9 | 11.8% |
| Riffle | 10 | 13.2% |
| Run | 7 | 9.2% |
| Side Channel | 4 | 5.3% |
| Side Channel Eddy | 1 | 1.3% |
| Side Channel Pool | 2 | 2.6% |
| Total | 76 | 100.0% |

CES electroshocked stream reaches, beginning at the downstream end of each habitat unit within a sample reach and working upstream. In a large stream with chutes and deep bedrock pools, such as Sullivan Creek, it is not possible to sample all habitats found within the reach. In many places the water is too swift or deep to electroshock effectively or safely, even at lower flows. Locations were identified as "shocking units," which we defined as a localized area consisting of a habitat type (i.e., a riffle, glide, run, etc.) in which we electroshocked. Information CES collected included:

1. Date
2. Cycles and voltage for the electroshocker
3. Beginning and ending shocking times for the reach.
4. Reach Number.
5. Habitat type sampled
6. Species of fish captured.
7. Length (mm) of fish captured.
8. Species and approximate length (if known) if the fish escaped prior to measuring.
9. Relevant comments.

**(c) A discussion of the most probable critical population limiting factors and a species/lifestage periodicity chart for trout in the Sullivan Creek bypass reach.**

**Response: Limiting Factors**

It is inherently difficult to indentify limiting factors for any particular stream. However, the Sullivan Creek diversion reach has experienced changes over the past 80 years that have degraded habitat for fish. The District believes that several factors limit fish production in Sullivan Creek. These include: 1) lack of pools in the upper half of the diversion reach (above N. Fork Sullivan Creek) which limit summer and winter rearing; 2) gold mining, which destroys spawning beds with rapid turnover of gravel; and 3) a lack of suitable spawning substrates. As discussed by the District throughout the amendment process and a letter from the FS to HDR Engineering regarding channel maintenance flows (dated February 21, 1996), the stream is heavily armored and the major supply of gravel to the diversion reach has been cut off by the presence of two dams immediately upstream.

WDFW has stated that water temperatures may also be a concern. In their letter to FERC dated June 14, 1996, WDFW states that "Water temperatures in Sullivan Creek downstream from Mill Pond are marginal for rainbow, brook and brown trout, and exceed that which is tolerated by bull trout young-of-year and juveniles" (Eldred 1996).

The District believes the most important limiting factor to fish production in the diversion reach of Sullivan Creek is the small amount of quality spawning habitat caused by the lack of substrate recruitment when the upstream dams cut off the sediment supply. Most smaller substrates have been moved downstream with high spring flows over the past 80 years. Gravel recruitment is very limited with no replenishment from the upper reaches. Trout spawning-sized gravels are in limited supply, found mostly perched high on the banks from high flow events or located behind protective structures within the stream channel (i.e., behind boulders in the stream).

For this reason, the District has previously included, as part of its preliminary instream flow package, a draft enhancement and restoration plan for the diversion reach. The District believes restoration is consistent with federal mitigation guidelines for this license amendment application. This draft plan includes both placement of structures which would scour pools for rearing and hold gravel for spawning. The District, in that draft report, also proposed to supplement, on an ongoing basis, the now depleted gravel supply in the diversion reach. As stated in Additional Information Volume II, the draft report was intended as a beginning point to initiate discussions and that the concept of mitigation be an interactive process in cooperation with the agencies and Tribe. The intent of the District has been to arrive at a satisfactory enhancement plan for the diversion reach, much like the successful habitat mitigation recently approved for the Twin Falls hydroelectric project on the South Fork Snoqualmie River in Washington. This interaction with the agencies has not occurred to date; therefore the report remains an initial draft which has not been developed beyond the conceptual stage. Similarly, it was intended the monitoring of this enhancement be incorporated into the monitoring plan for Sullivan Creek. A draft plan was presented to the agencies in September, 1994, based upon a FERC-approved plan jointly developed by WDFW and a hydropower developer for Youngs Creek, a proposed hydroelectric project in western Washington. The agencies stated that the needs for Sullivan Creek were different than Youngs Creek and that a different plan would need to be jointly developed for Sullivan Creek. To date, this collaboration has not occurred and the draft monitoring plan remains an initial first draft that has not been developed or approved for use. The Licensee is proposing that final instream flows be those flows already established under State of Washington water rights law. However, the Licensee still proposes to provide gravel and habitat enhancement measures as proposed and to provide monitoring of results as described in the amendment application.

**Periodicity**

Figure 11.1 depicts periodicity for target salmonid species in Sullivan Creek. Rainbow trout, brown trout and bull trout are shown; cutthroat and brook trout are found in Sullivan Creek, but in small numbers, and were not target species for the Sullivan Creek instream flow study. Figure 11.1 is the District's best estimate of periodicity for the target species, given site-specific studies, review of the literature and discussions with professionals in the field, but this chart has not yet been reviewed by the agencies or Tribe.

**Rainbow Trout**

Rainbow trout spawning timing is based upon an extensive spawning periodicity study conducted by CES in 1994. This report, contained in Additional Information Volume II, Attachment 4-1, was provided to the agencies in September, 1994. Details of methods and analysis are found there. From the 1994 study, CES concluded that rainbow trout spawning occurred from approximately May 15 - June 25. Trout spawning in western Washington appears to be closely tied to water temperatures. When water temperatures increase to 8°C, it is used as an indicator of the onset of trout spawning and summer rearing (Campbell and Neuner 1985). Although Sullivan Creek is located in easternWashington, the initiation of rainbow trout spawning appears to be correlated to this threshold temperature in Sullivan Creek as well as Myers Creek, an Okanogan stream also located in the eastern part of the state (CES conducted spawning periodicity studies in Myers Creek in 1994).

Incubation of rainbow trout eggs through hatching and subsequent emergence requires about 765 Daily Temperature Units (°F; DTU's) when mean daily water temperatures for the incubation period remain between 50°F and 60°F. One DTU equals 1°F above freezing (32°F) for a 24-hour period. For example, if the water temperature for the first day of incubation is 56°F, that day would contribute 24 DTU's. Temperature units required for a given species of fish are not fixed and vary with temperature and are affected by fluctuations in temperature (Piper et al. 1982).

Based upon DTU's, as well as observations of newly emerged rainbow trout fry, CES determined the central 80% emergence timing of rainbow trout in 1994 ranged from June 26 - July 25. The rainbow trout fry had moved from the stream margin shelves by early August. Since water temperatures may vary from year to year, it is recommended that rainbow trout spawning timing should bracket the period from April 1 - June 30. However, the licensee would like to explore the feasibility of an adaptive management plan with the agencies when stream flows are set by temperature. A flow release schedule, based on this premise has recently been agreed to by the agencies for Myers Creek, an Okanogan stream. CES further suggests that emergence timing extend from mid-June to the end of July.

**Brown Trout**

CES and the District conducted 12 surveys for brown/bull trout spawning during the fall, 1994. On only one survey (November 3) was a spawning pair of brown trout observed. CES suggests that brown trout spawning period bracket this observation and recommends a brown trout spawning periodicity from October 1 until November 30 with the option of conducting brown trout spawning and fry emergence surveys to more accurately reflect their spawning timing. If the results of the study indicate brown trout spawning timing differs from the general timing of October 1 to November 30, the periodicity could be changed to reflect actual timing and the flows be adjusted accordingly, if applicable.

Brown trout require 800 DTU's (°F; or 100 days) to hatch at a mean water temperature of 40°F; at a mean temperature of 45°F, brown trout require 832 DTU's (or 64 days) to hatch (Letriez and Lewis 1976 as cited in Piper et al. 1982). At the Makay Hatchery in Idaho, brown trout eggs reared in 48°F water require 768 DTU's to hatch and about 1,200 DTU's to swimup (E. Stege, pers. comm. 1995). From these data, it appears that it takes about 50% longer for fry to emerge than the incubation - hatch period.

Mean temperatures from mid-October to early April are approximately 38°F - 39°F in Sullivan Creek, using 1993/4 and 1994/95 water temperature data (data are incomplete after March 5, 1996). Based upon these calculations, CES estimates that it would take slightly more than 150 days from brown trout egg deposition to swimup. CES suggests that if brown trout spawning were to occur from mid-October to mid-November, fry emergence would occur from approximately mid-late March through late April or early May. This estimate appears consistent with fry data collected by CES in June 1994. When fry surveys began on June 6, all brown trout fry observed or captured exceeded the lengths indicative of newly emergent fry.

**Bull Trout**

CES, in cooperation with the District and the FS, conducted extensive bull trout surveys in the Sullivan Creek drainage during the fall 1995. Although no bull trout were identified in the drainage during this study, Sullivan Creek is considered potential bull trout habitat by the FS, WDFW and FWS.

There are no specific data on bull trout spawning timing in Pend Oreille tributaries in Washington, so CES conferred with Ms. Karen Pratt, an independent consultant with extensive bull trout experience on the Pend Oreille System in Idaho and with WDFW to assess spawning and emergence timing of bull trout in Sullivan Creek. In the Pend Oreille/Priest Lake systems in Idaho, bull trout spawn as early as September and as late as November; however, the principal spawning month for the "typical" bull trout is October (K. Pratt, pers. comm. 1996). Water temperatures may influence the onset of bull trout spawning (Shepard et al. 1984; Weaver and White 1985, as cited by Pratt 1992), with temperatures less than 9°C reported for the spawning period of anadromous Dolly Varden and landlocked bull trout populations, presumably in the Intermountain West of the United States and Canada (Needham and Vaughan 1952; Blackett 1968; Leggett 1969; McPhail and Murray 1979; Shepard et al. 1984; Weaver and White 1985 as cited in Pratt 1992). Using the temperature monitoring data of Sullivan Creek from 1993 to present, water temperatures decrease to 9°C near the end of October in the diversion reach. WDFW estimates that the likely period of spawning is mid-October to mid-November, although spawning could occur earlier or later than this time period (C. Vail, pers. comm. 1996). Based on water temperatures in Sullivan Creek and these consultations, CES suggests a spawning periodicity for bull trout of mid-October to mid-November.

Bull trout require approximately 350-440 °C temperature units (630 - 792 DTU °F) after fertilization to hatch (Weaver and White 1984; Gould 1987, as cited by Pratt 1992), or about 100 - 145 days from fertilization, usually at the end of January (Heimer 1965; Blackett 1968; McPhail and Murray 1979; Allan 1980; Weaver and White 1984, as cited by Pratt 1992). Anadromous Dolly Varden and bull trout alevins require at least 65-90 days after to hatching to absorb their yolk sacs, or about 820 temperature units (°C; Gould 1987 as cited in Pratt 1992). Bull trout may remain within the interstices of the stream bed as fry for up to three weeks before filling their air bladders (McPhail and Murray 1979 as cited in Pratt 1992). Using these literature sources, emergence of bull trout could be expected to occur between early May and mid June. Using the temperature unit parameters discussed above and temperature data collected in Sullivan Creek, emergence would occur from late May to late June. CES suggests an emergence timing of bull trout, if present, from early May to late June.

**(d) A discussion of potential anchor ice effects on trout populations in the diversion reach.**

**Response:** A discussion of potential anchor ice effects on trout populations in the diversion reach is presented in Attachment 9-2.

# SULLIVAN CREEK - TROUT AND CHAR PERIODICITY CHART

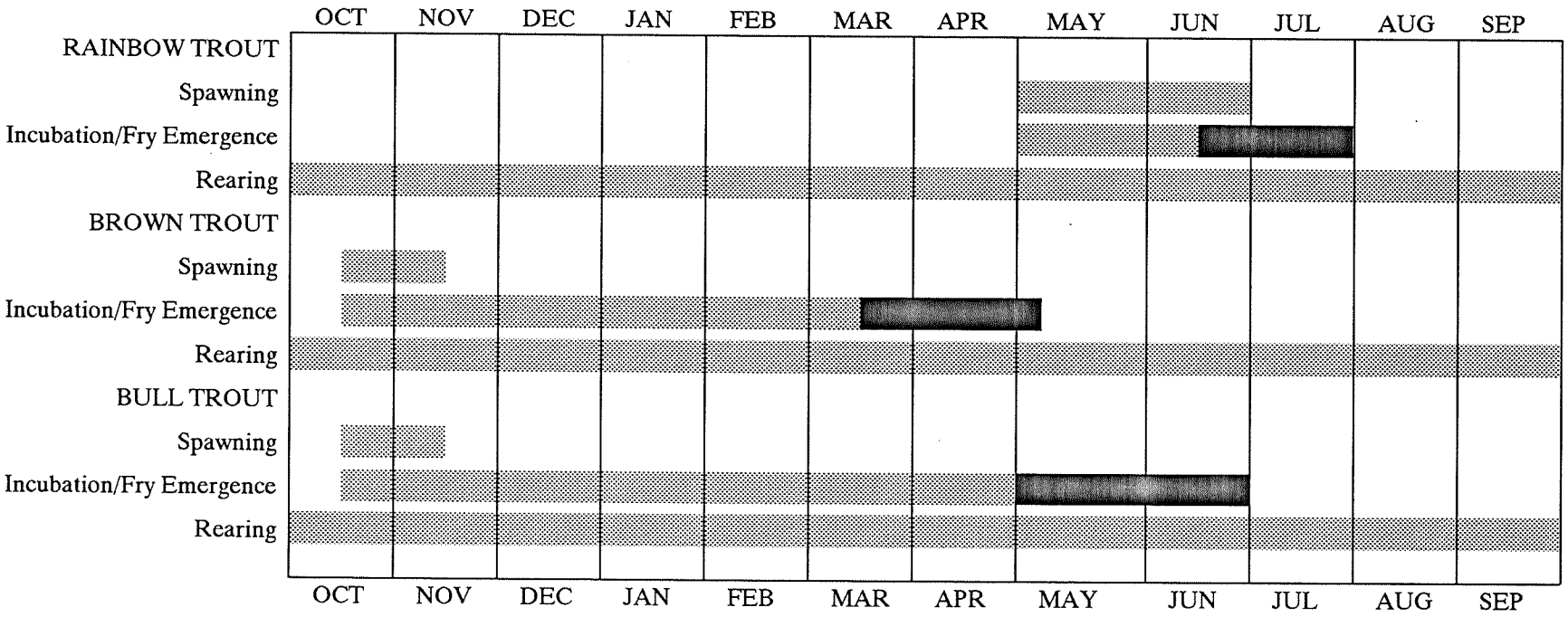


Figure 11.1

**(e) Copies of the comments from the FWS, FS, and WDFW on items (a) through (d) above.**

**Response:** Copies of agency consultation conducted to date regarding this AIR are included in Appendix A.

# ATTACHMENT 11-1

# FS STREAM INVENTORY HANDBOOK

# ELECTROSHOCKING METHODOLOGY

## FISH USE AND RELATIVE ABUNDANCE - FORM D, R6-2500/2600-30

Form D is to be used to record fish information. The survey intensity may vary between Forests/Districts. *At a minimum, fish information should be recorded at each 10th pool, 15th riffle and 20th glide and entered on Form D.* Snorkling, electrofishing, or seine methods may be used to gather this information. *NOTE*: This information will be used to identify fish species composition and range. It is not meant to provide population estimates.

**(NOTE INSTRUCTIONS FOR ATTRIBUTES, A - H ARE LISTED IN FORM B1 INSTRUCTIONS)**

## Form D Instructions

| ATTRIBUTE | MEASUREMENTS/RECORDING |
|---|---|
| I. Reach Number | Fill out only after the field survey has been completed. |
| J. Method | Enter the abbreviation for sampling technique: Seine (S), Snorkel (SN), Electroshock (E). (FL:2 (e.g., 99)) |
| 1. Natural Sequence Order (NSO) | Enter the natural sequence order as listed in Form C. (FL:4 (e.g., 9999)) |
| 2. Habitat Type and Number | Enter the habitat type and number as listed in Form C, Attribute #2. (FL:5 (e.g., 99999)) |
| 3. Species | Enter the actual count (by species) of the fish observed within adult and juvenile categories at each sampled habitat unit. Use the species codes as listed in Appendix B.<br><br>Juveniles are defined as sub-legal individuals. Adults are defined as individuals of catchable legal size. (FL=6) |
| 4. Comments | Enter comments regarding any of the above evaluations and document photos; or geomorphological, hydrologic or biological observations. |

# APPLICATION FOR SURRENDER OF LICENSE
# SULLIVAN CREEK PROJECT
# FERC NO. 2225

## APPENDIX E.4-3
### SULLIVAN CREEK FISH BARRIER ASSESSMENT

# SULLIVAN CREEK RM 0.65 FISH BARRIER ASSESSMENT

**Prepared for**

EES Consulting

**Prepared by**

Patrick D. Powers, P.E.
Waterfall Engineering, L.L.C.
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**December 2008**

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Appendix A - Survey Data and Contour Map of Falls (9/9/08)

# 1 INTRODUCTION

This report provides a fish barrier assessment for Sullivan Creek at RM 0.65. Two fields trips were conducted, one at 1528 cfs on May 21, 2008, and one at 99 cfs on September 9, 2008. The flow measurements were made at the Mill Pond Dam outlet structure by measuring the head over the weir. The 1528 cfs flow was too high to enter the stream and make measurements, so observations of depth were made by comparing photos. On the September 9, 2008 field trip, a survey was performed of the current falls. The survey data and site contour map are attached in Appendix A.

**September 9, 2008 – 99 cfs – 7.6 ft Drop**

**May 21, 2008 – 1528 cfs**

During the May 21 field trip the flow was too high to observe the current falls configurations, but during the September trip, the flow was low enough and it appeared the geometry through the reach had changed significantly from past assessments identified in the 1996 report (Final Bull Trout Report, September 1996, Cascade Environmental Services, Inc.). In the 1996 report there is a photo of Barrier 1 at 50 cfs dated 9/22/94. The falls surveyed on 9/9/08 appears in the background of this photo. It appears that the major rocks forming Barrier 1 shifted, rolled into the plunge pool and were buried in gravel and cobble, increasing the drop at the upstream falls. Much of the area surveyed on 9/9/08 was underwater during the 5/21/08 flow, and therefore it is difficult to compare photos. There were falls observed upstream and downstream of the main falls, but they did not appear to present any passage problems. The lower two falls drops 5.6 feet in a series of two falls.

## 2 PASSAGE ANALYSIS

Two separate analyses were performed to assess fish passage, one for the low flow condition and falls configuration from 9/9/08 (Figure 1), and one for the high flow 5/21/08 (Figure 2). The methods used come from Powers and Orsborn, 1985 and Powers and Bates, 2008 (In prep). The later is a fish energetics model which was modified and combined with the fish leaping data. This work was developed for the Mill Creek Fish Passage Assessment Project in Walla Walla, Washington. Bull Trout, Steelhead and Spring Chinook were analyzed for the Mill Creek study. Extensive effort went into the development of this model and the fish assessment portion is complete. Final report is due out June 2009.

### Leaping the Falls at 99 cfs

The target fish species used was an 18 inch Bull Trout. Swimming speed data, and body depth data come from the fish energetics model. The Sullivan Creek falls water surface drop was measured at 7.6 feet, the plunge pool depth was 6.5 feet and the plunge pool energy dissipation factor(EDF) was 5 ft-lbs/sec/cu ft of water. From the falls projection profile the leaping angle to reach the crest would be about 58 degrees. The fish data shows at a leap angle of 63 degrees with a burst velocity of 22.5 fps, an 18 inch Bull Trout can reach a maximum leap height of 7.9 feet (in a path over the crest).

There were three modifications used in this methodology which were different from the (Powers and Osborn, 1985) study. First, the standing wave velocity of 1.4 fps (which comes from the original WSU research measuring standing wave upwelling velocities) was included, second, the length of the fish was added to the calculation (tail is assumed effective providing propulsion while the fish is leaving the pool), and third the option for the fish to pass the falls by leaping to the crest of the falls, landing and swimming through was added. Since the analysis showed the 18 inch fish cleared the crest the analysis for passage by leaping and landing in the crest and swimming through was not performed.

## Figure 1 – Leaping Over the Crest Analysis at 99 cfs

**Fish Data**

| | | |
|---|---|---|
| Leap Angle | 63 | degrees |
| Velocity Fish | 22.5 | fps |
| Standing Wave Velocit | 1.4 | fps |
| Fish Length | 1.5 | ft |
| Max Leap Height | 7.9 | |
| Plunge Pool Depth | | |

**Passage Analysis** **99 cfs**

| | |
|---|---|
| EDF | OK |
| Plunge Pool | OK |
| Passable | yes |

**Falls Data**

| | | |
|---|---|---|
| Flow | 99 | cfs |
| Crest Width | 11 | ft |
| Hydraulic Drop | 7.6 | ft |
| Spill angle | 0 | degrees |
| Water Velocity US Crest | 6.9 | fps |
| Crest Depth | 1.3 | ft |
| Velocity Crest | 9.1 | fps |
| Plunge Pool Depth | 6.5 | ft |
| Pool Volume | 2639 | cu ft |
| EDF | 5 | |

*Note: EDF units: ft-lbs/sec/cu ft of water*

Fish Values

| t | x1 | x | y1 | y |
|---|---|---|---|---|
| 0.05 | 0 | 0.51 | 0 | 1.1 |
| 0.1 | 0 | 1.02 | 0 | 2.1 |
| 0.15 | 0 | 1.53 | 0 | 3.0 |
| 0.2 | 0 | 2.05 | 0 | 3.9 |
| 0.25 | 0 | 2.56 | 0 | 4.7 |
| 0.3 | 0 | 3.07 | 0 | 5.3 |
| 0.35 | 0 | 3.58 | 0 | 5.9 |
| 0.4 | 0 | 4.09 | 0 | 6.5 |
| 0.45 | 0 | 4.60 | 0 | 6.9 |
| 0.5 | 0 | 5.11 | 0 | 7.3 |
| 0.55 | 0 | 5.62 | 0 | 7.6 |
| 0.6 | 0 | 6.14 | 0 | 7.8 |
| 0.65 | 0 | 6.65 | 0 | 7.9 |
| 0.7 | 0 | 7.16 | 0 | 7.9 |

Falls Values

| x1 | x | y1 | y | Fall Angle |
|---|---|---|---|---|
| 0 | -0.35 | 0 | 0.0 | |
| 0 | -0.69 | 0 | -0.2 | |
| 0 | -1.04 | 0 | -0.4 | |
| 0 | -1.38 | 0 | -0.6 | |
| 0 | -1.73 | 0 | -1.0 | |
| 0 | -2.08 | 0 | -1.4 | |
| 0 | -2.42 | 0 | -2.0 | |
| 0 | -2.77 | 0 | -2.6 | |
| 0 | -3.12 | 0 | -3.3 | |
| 0 | -3.46 | 0 | -4.0 | |
| 0 | -3.81 | 0 | -4.9 | |
| 0 | -4.15 | 0 | -5.8 | |
| 0 | -4.50 | 0 | -6.8 | |
| 0 | -4.85 | 0 | -7.9 | 58 |

### Swimming the Falls at 1528 cfs

Using the low flow survey and comparing photos from both site visits, the average water depth was estimated at 6 feet, during the 1528 cfs flow. The overall channel width was measured from the survey at 21 feet. The reach length was measured at 60 feet. If fish passed this reach, there appeared to be resting areas upstream. The estimated water velocity was 12 fps. The swimming energetics model (Figure 2) shows the fish can only go 40 feet before they fail. There were no observed resting areas in this 60 foot reach at the 1528 cfs flow. Also, the water was very turbulent which likely would reduce swimming ability.

### Figure 2 – Swimming Through Falls Reach at 1528 cfs

**Energetics Swimming Model**
**Sullivan Creek Falls**
**Q = 1528 cfs**

| Sta ft | Water velocity fps | Water depth ft | Vocc fps | Swim speed V fps | Swim mode | Time to exhaust prolonged sec | Time to exhaust burst sec | Depth modifier | Time to exhaust (w/ d mod) sec | Time interval sec | Energy spent % | | Energy remaining % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 12.0 | 6.00 | 12.0 | 15.08 | B | 0.0 | 2.0 | 1.00 | 2.0 | | | 100% | 100% |
| 10 | 12.0 | 6.00 | 12.0 | 15.08 | B | 0.0 | 2.0 | 1.00 | 2.0 | 0.66 | 33% | 67% | 67% |
| 20 | 12.0 | 6.00 | 12.0 | 15.08 | B | 0.0 | 2.0 | 1.00 | 2.0 | 0.66 | 33% | 35% | 35% |
| 30 | 12.0 | 6.00 | 12.0 | 15.08 | B | 0.0 | 2.0 | 1.00 | 2.0 | 0.66 | 33% | 2% | 2% |
| 40 | 12.0 | 6.00 | 12.0 | 15.08 | B | 0.0 | 2.0 | 1.00 | 2.0 | 0.66 | 33% | 0% | 0% |
| 50 | 12.0 | 6.00 | 12.0 | 15.08 | B | 0.0 | 2.0 | 1.00 | 2.0 | 0.66 | 33% | 0% | 0% |
| 60 | 12.0 | 6.00 | 12.0 | 15.08 | B | 0.0 | 2.0 | 1.00 | 2.0 | 0.66 | 33% | 0% | 0% |

## 3 CONCLUSIONS

Two hydraulic conditions were analyzed for passage of an 18 inch Bull Trout. For the low flow condition (99 cfs), the calculations show an 18 inch Bull Trout could pass the falls by leaping. For salmonids less than 18 inches in length, the calculations show the falls would be a barrier. For the high flow condition (1528 cfs), the calculations show the reach through these falls is a swimming energetics barrier. In general, it appears this reach is passable at low flows, but becomes a barrier at high flows. The overall slope through the reach was measured at 17%. At this gradient, it is most likely that passage in the future will be mainly during low to medium flow. It is difficult to predict at which flow the falls may become impassable, but turbulence would likely become a passage hindrance at flows in the 300 to 500 cfs range.

Another important variable to consider is the geologic setting of the falls. Slopes and rocks along the canyon walls appear very unstable and there seems to be a high likelihood that over time, large boulders could move and block the channel. Fish passage could improve or a blockage could be created depending on the new geometry.

# 4 REFERENCES

P. D. Powers, J.F. Orsborn. 1985. Analysis of Barrier to Upstream Fish Migration.

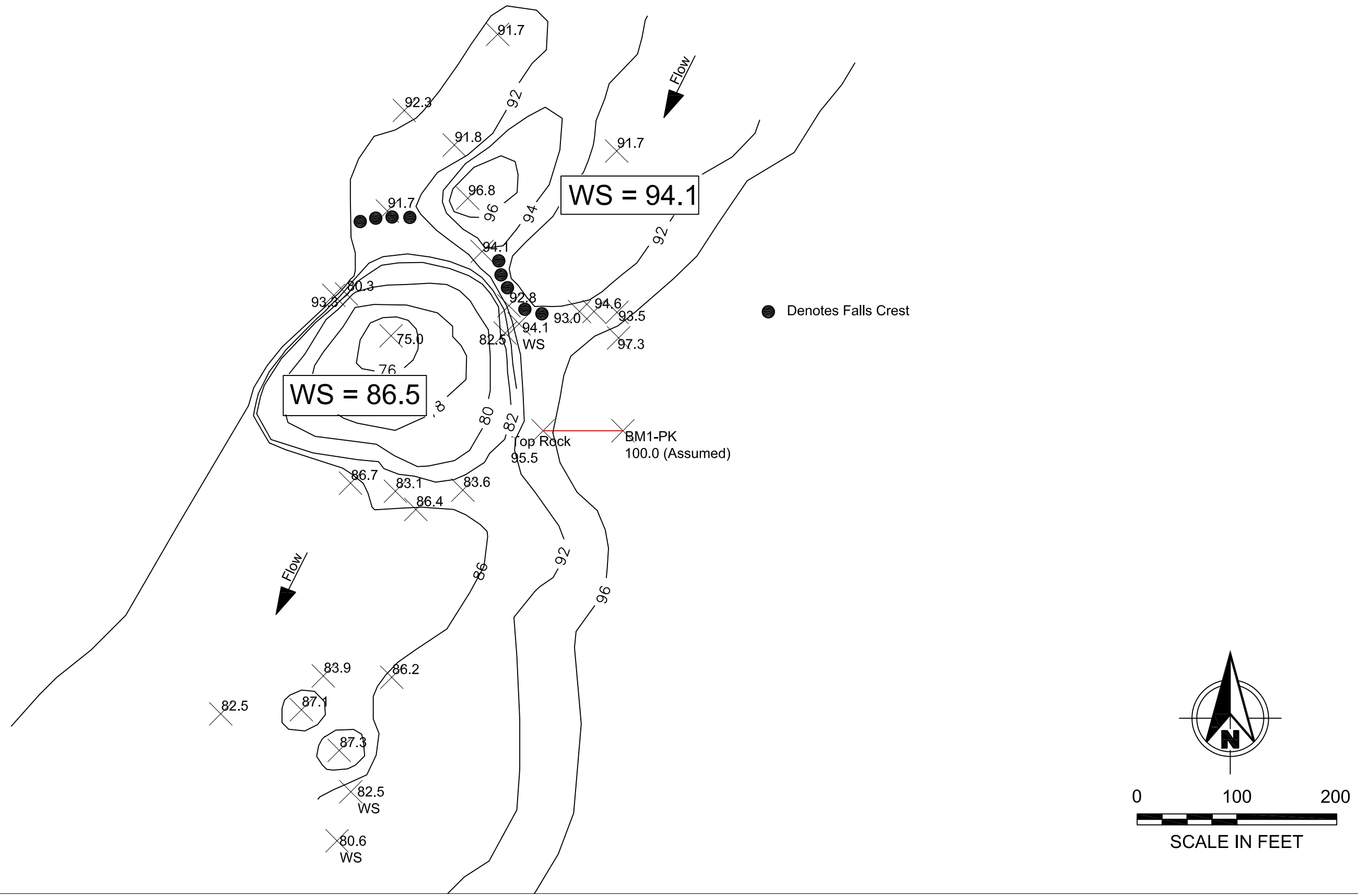
P. Powers, K. Bates, J. Kidder. 2008 In Draft. Mill Creek Fish Passage Assessment.

# APPENDIX A

# SURVEY DATA AND CONTOUR MAP OF FALLS

# Sullivan Creek Falls Survey Data

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sullivan Creek | | | | | | | | | | | | | | |
| Date: | 9-Sep-08 | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | | | | | | | | | | Gun at top rock = 95.0 | | | | |
| | | | | | | | | | | | | | | |
| pt | rod | UH | LH | dist | Horizontal Angle Right | | | | Vertical Angle | Vertical | HI | elev | | |
| | or mu | | | | Deg | Min | Sec | Fraction | % | Offset | | | ID | Comments |
| 1 | 1 | 1.04 | 0.96 | 8 | 0 | 0 | 0 | 0.00 | 16.19 | 1.30 | 99.70 | 100.00 | BM1 | BM1 PK Nail 100.0 Assumed |
| 2 | 1.00 | 1.04 | 0.92 | 12 | 309 | 6 | 30 | 309.11 | -11.48 | -1.38 | | 97.33 | SB | Left Bank |
| 3 | 4.00 | 4.08 | 3.94 | 14 | 301 | 57 | 40 | 301.96 | -15.68 | -2.20 | | 93.51 | SB | LB Notch |
| 4 | 3.00 | 3.06 | 2.93 | 13 | 293 | 7 | 20 | 293.12 | -16.15 | -2.10 | | 94.61 | SB | Top Rock Near LB |
| 5 | 5.00 | 5.06 | 4.94 | 12.5 | 286 | 57 | 30 | 286.96 | -13.84 | -1.73 | | 92.97 | SB | WTRock u water |
| 6 | 4.00 | 4.05 | 3.94 | 11 | 257 | 19 | 50 | 257.33 | -14.19 | -1.56 | | 94.14 | WS | WS |
| 7 | 16.00 | 16.05 | 15.95 | 10.5 | 248 | 45 | 30 | 248.76 | -11.5 | -1.21 | | 82.50 | SB | Plunge Pool Base, Depth = 4 ft, WS = 86.5 |
| 8 | 5.00 | 5.08 | 4.95 | 13 | 254 | 42 | 40 | 254.71 | -14.36 | -1.87 | | 92.84 | SB | Chute, RB, L Channel |
| 9 | 3.00 | 3.09 | 2.90 | 19 | 251 | 12 | 40 | 251.21 | -13.46 | -2.56 | | 94.15 | SB | SB, RB, L channel |
| 10 | 1.00 | 1.12 | 0.88 | 24.5 | 252 | 3 | 10 | 252.05 | -7.66 | -1.88 | | 96.83 | SB | Top rock, Between channels crest |
| 11 | 5.00 | 5.15 | 4.85 | 30 | 252 | 44 | 20 | 252.74 | -9.54 | -2.86 | | 91.84 | SB | SBC? R Channel, LB |
| 12 | 4.00 | 4.17 | 3.82 | 35 | 246 | 35 | 0 | 246.58 | -9.64 | -3.37 | | 92.33 | SB | RBWE, R Channel |
| 13 | 5.00 | 5.13 | 4.86 | 27 | 234 | 40 | 50 | 234.68 | -11.14 | -3.01 | | 91.70 | SB | Lip, Vh=1.4' |
| 14 | 16.00 | 16.12 | 15.88 | 24 | 214 | 49 | 30 | 214.83 | -14.12 | -3.39 | | 80.32 | SB | Base Right Wall, PP, Note Max depth = 7.5' |
| 15 | 3.00 | 3.13 | 2.88 | 25 | 212 | 54 | 30 | 212.91 | -13.56 | -3.39 | | 93.31 | SB | SB, RB (Cliff Wall) |
| 16 | 6.00 | 6.20 | 5.80 | 40 | 263 | 26 | 50 | 263.45 | -4.91 | -1.96 | | 91.74 | SB | Upstream, R Channel, PP |
| 17 | 11.00 | 11.14 | 10.85 | 29 | 284 | 43 | 40 | 284.73 | -2.81 | -0.81 | | 87.89 | SB | Upstream, L Channel, PP |
| 18 | 6.00 | 6.21 | 5.78 | 43 | 138 | 42 | 20 | 138.71 | -24.14 | -10.38 | | 83.32 | SB | Top Rock Downstream Control |
| 19 | 8.00 | 8.16 | 7.83 | 33 | 131 | 53 | 0 | 131.88 | -23.58 | -7.78 | | 83.92 | SB | Botton of DS control |
| 20 | 4.00 | 4.19 | 3.82 | 37 | 130 | 54 | 0 | 130.90 | -23.14 | -8.56 | | 87.14 | SB | SB. LB |
| 21 | 4.00 | 4.19 | 3.81 | 38 | 122 | 31 | 50 | 122.53 | -22.17 | -8.42 | | 87.28 | SB | SB, LB |
| 22 | 14.00 | 14.04 | 13.94 | 10 | 143 | 32 | 10 | 143.54 | -20.67 | -2.07 | | 83.64 | SB | DS PP/ Depth=2.8', WS = 86.4 |
| 23 | 10.00 | 10.07 | 9.92 | 15 | 148 | 16 | 50 | 148.28 | -22.2 | -3.33 | | 86.37 | SB | Top Rock, LB in channel, Width=20' of PP Below |
| 24 | 15.00 | 15.08 | 14.92 | 16 | 157 | 45 | 10 | 157.75 | -9.86 | -1.58 | | 83.13 | SB | PP Bottom |
| 25 | 11.00 | 11.10 | 10.90 | 20 | 164 | 47 | 20 | 164.79 | -9.98 | -2.00 | | 86.71 | SB | PP Bottom |
| 26 | 11.00 | 11.15 | 10.86 | 29 | 121 | 33 | 10 | 121.55 | -8.6 | -2.49 | | 86.21 | WE | SB, LB, WE |
| 27 | 10.00 | 10.20 | 9.79 | 41 | 118 | 2 | 40 | 118.04 | -17.7 | -7.26 | | 82.45 | WS | Intermediate Drop Below DS Control |
| 28 | 11.00 | 11.24 | 10.78 | 46 | 116 | 40 | 30 | 116.68 | -17.7 | -8.14 | | 80.56 | WS | Below Downstream Control |
| | | | | | | | | | | | | | | |
| Falls Drops | | 94.10 | | | | | | Main Falls | 7.6 | | | | | |
| | | 86.50 | 7.60 | | | | | DS Control | 0.3 | | | | | |
| | | 86.20 | 0.30 | | | | | DS Falls | 5.6 | over 2 steps | | | | |
| | | 82.50 | 3.70 | | | | | | | | | | | |
| | | 80.60 | 1.90 | 5.60 | | | | | | | | | | |




# Sullivan Creek Falls - Topographic Survey
# RM 0.65

| REVISIONS | | | | |
|---|---|---|---|---|
| REV | DATE | BY | APP'D | DESCRIPTION |
| | | | | |

DESIGNED BY: Waterfall Engineering, LLC
DRAWN BY:
CHECKED BY:
APPROVED BY:
FILE:
DATE: 11/16/08

Survey Date: 9/9/08 11 am
Stream Flow: 99 cfs

SHEET NO. 1 OF 1

# APPLICATION FOR SURRENDER OF LICENSE
# SULLIVAN CREEK PROJECT
# FERC NO. 2225

## APPENDIX E.4-4
### HARVEY CREEK HABITAT SURVEY

***WORKING DRAFT***

# HARVEY CREEK HABITAT SURVEY

***Prepared for:***

## Sullivan Lake Hydroelectric Project Mediation Team

And

## Public Utility District No. 1 of Pend Oreille County
## Newport, WA

***Prepared by:***

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***July 24, 2009***

# HARVEY CREEK HABITAT SURVEY

## 1.0 INTRODUCTION

Sullivan Lake is located approximately seven miles east of Metaline Falls, WA. Sullivan Lake is a glacially-sculpted lake with a surface area of roughly 1,300 acres. Its surface elevation is approximately 2,580 ft. Above Mean Sea Level (AMSL). The lake is fed by three tributaries - Harvey, Noisy, and Hall creeks. Harvey Creek is the only perennial tributary; Noisy and Hall creeks are seasonal. The lake drains into Outlet Creek, which then merges with Sullivan Creek, eventually draining to the Pend Oreille River near Metaline Falls.

Members of the Sullivan Lake Hydroelectric Project Mediation Team (Team) have expressed concerns related to Sullivan Lake elevation management and its affect on Harvey Creek. Major concerns are deposition of fine sediments, and the flows required to flush these fines from the kokanee spawning beds in lower Harvey Creek. The analysis presented in this report summarizes the results of a physical habitat survey conducted on lower Harvey Creek.

## 2.0 METHODS

The Harvey Creek habitat survey (survey) was conducted on June 23, 2009. Dave Sullivan (Pend Oreille PUD) recorded a Sullivan Lake elevation of El. 2583.51 ft MSL at 7:30 am that morning. That elevation was used as a known, and all surveying was adjusted to that lake elevation.

The District surveyed the thalweg from the bridge abutment upstream to El. 2590.0 ft MSL. Six transects were located perpendicular to the stream within this reach. Elevation and substrate were recorded at every station on the six transects. Substrate was classified using a three-digit code representing the most abundant particle size, the second-most abundant particle size, and the percentage of the most abundant particle size (Table 1 shows WDFW substrate coding). For example, a code of 73.7 would mean that the most abundant substrate was large cobble (6 to 12-inch diameter), that small gravel (0.5 to 1.5-inch diameter) was the second-most abundant substrate, and that large cobble represented 70% of dominant and subdominant substrate area. Photographs were also taken of all transects.

## 3.0 RESULTS

### 3.1 Longitudinal Profile

The District surveyed from the upstream border of the bridge crossing Harvey Creek at its confluence with Sullivan Lake to El. 2590.0 ft, a distance of 790 ft. Water surface slope for the reach was 0.80%. Figure 1 shows the longitudinal profile from the Harvey Creek Bridge upstream to El 2590. ft. MSL.

## 3.2 Cross Sectional Profiles

Six transects were surveyed in this 790 ft reach and consisted of two single-channel cross sections (Transects 1 and 6) and four multiple channel cross sections (Transects 2 – 5). Those transects within the lake inundation zone tended to be over-widened with large bankfull channel dimensions. Transect 6, located above the full pool level of Sullivan Lake, was within a well-confined single channel. Figures 2 – 7 present the cross sectional profiles of Transects 1 – 6. Distances for the locations of the transects are given in feet above the upstream border of the Harvey Creek Bridge at its confluence with Sullivan Lake. Photographs of the transects are included as Appendix A.

## 3.3 Substrate Composition

Table 2 summarizes the substrate composition of the cross sections sampled. Sand was the most common substrate observed on the cross sections, closely followed by large gravel and small cobble. Transect 4, a split channel glide, had the most sand, constituting nearly 42% of the substrate on this cross section.

## 3.4 Calculation of Bankfull Discharge and Diameter, Critical, Bankfull

EES Consulting estimated the bankfull width, area, discharge, and Dcbf (diameter, critical, bankfull), for all six transects. A summary of these factors is included in Table 3.

# 4.0 DISCUSSION

The objective of this study was to determine the flows necessary to mobilize fine sediment and flush it from the spawning gravels. For purposes of this analysis, the bankfull flows for all transects surveyed would mobilize sediment < 2.5 mm in diameter.

As can be seen in Table 3, the six surveyed transects had bankfull widths ranging from 43 ft – 160 ft. Based upon this varying geometry, bankfull discharges ranged widely, from approximately 459 cfs – 1351 cfs. The higher flows indicated by this analysis appear to be significant overestimates.

Bankfull width of these cross sections appears to be an artifact of lake level; as lake levels rose, the backwater from the lake inundated banks that had previously been located on benches above the normal lake elevations. These higher lake elevations resulted in over-widened channels in the elevation range between low pool during the winter, and high pool in the summer period (e.g., an upper level of approximately 2588 ft MSL). These over-widened channels require a much higher bankfull discharge to mobilize sediment than a smaller channel.

Gauge data on Harvey Creek is limited; however these data indicate an average annual peak of approximately 400 cfs. A bankfull discharge of approximately 400 – 500 cfs would be consistent with the average annual peak flow. These flows have a recurrence interval of 1.5 – 2.0 years, which is roughly bankfull discharge. It is our conclusion that flows of 400 – 500 cfs

would effectively mobilize fine sediments smaller than small gravel (< 2.5 mm) and flush them from the spawning sediments.

**Table 1. Substrate Coding (WDFW 2004)**

| Code | Type of Substrate | Dimensions (inches) |
|---|---|---|
| 1 | Silt, Clay, or Organic | |
| 2 | Sand | |
| 3 | Small Gravel | .1 - .5” (2.5 – 12.7 mm) |
| 4 | Medium Gravel | .5-1.5” (12.7 - 38.1 mm) |
| 5 | Large Gravel | 1.5-3” (38.1 – 76.2 mm) |
| 6 | Small Cobble | 3-6” (76.2 – 152.4 mm) |
| 7 | Large Cobble | 6-12” (152.4 – 304.8 mm) |
| 8 | Boulder | >12” (> 304.8 mm) |
| 9 | Bedrock | |

**Table 2. Substrate composition of the six Harvey Creek cross sections.**

| Substrate Code | Trans 1 | Trans 2 | Trans 3 | Trans 4 | Trans 5 | Trans 6 | All |
|---|---|---|---|---|---|---|---|
| 1 | 4.7% | 8.3% | 3.8% | 11.3% | 1.7% | 3.6% | 6.3% |
| 2 | 18.8% | 21.1% | 19.5% | 41.8% | 14.0% | 33.9% | 25.7% |
| 3 | 2.5% | 10.8% | 10.9% | 10.5% | 17.8% | 11.9% | 10.8% |
| 4 | 14.5% | 6.5% | 7.7% | 4.5% | 19.1% | 7.7% | 8.9% |
| 5 | 23.2% | 21.0% | 35.0% | 18.8% | 23.9% | 15.5% | 23.7% |
| 6 | 15.0% | 27.9% | 21.4% | 11.2% | 12.0% | 27.4% | 19.0% |
| 7 | 13.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 1.4% |
| 8 | 8.3% | 4.4% | 0.0% | 2.0% | 11.4% | 0.0% | 3.8% |
| 9 | 0.0% | 0.0% | 1.7% | 0.0% | 0.0% | 0.0% | 0.4% |

**Table 3. Summary of bankfull statistics on six cross sections, Harvey Creek.**

| Transect | Width | Slope | Bankfull width (ft) | Bankfull area ($ft^2$) | Hyd. Rad. (ft) | Dcbf (mm) | Bankfull flow (cfs) |
|---|---|---|---|---|---|---|---|
| 1 | 70 | 0.8% | 74 | 238 | 3.12 | 153 | 1351 |
| 2 | 122 | 0.8% | 122 | 180 | 1.46 | 72 | 616 |
| 3 | 154 | 0.8% | 160 | 279 | 1.72 | 84 | 1065 |
| 4 | 80 | 0.8% | 147 | 272 | 1.79 | 88 | 1066 |
| 5 | 27 | 0.8% | 98 | 170 | 1.76 | 86 | 659 |
| 6 | 40 | 0.8% | 43 | 100 | 2.27 | 111 | 459 |

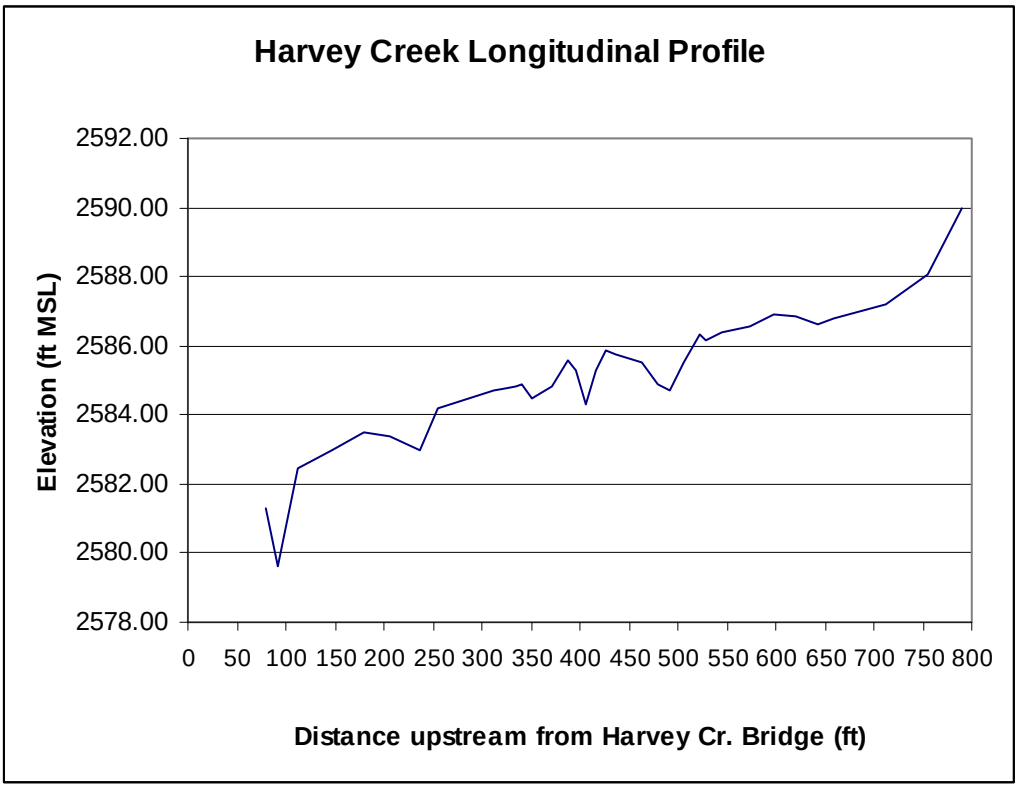


**Figure 1. Harvey Creek longitudinal survey from the Harvey Creek Bridge upstream to El. 2590 ft MSL.**

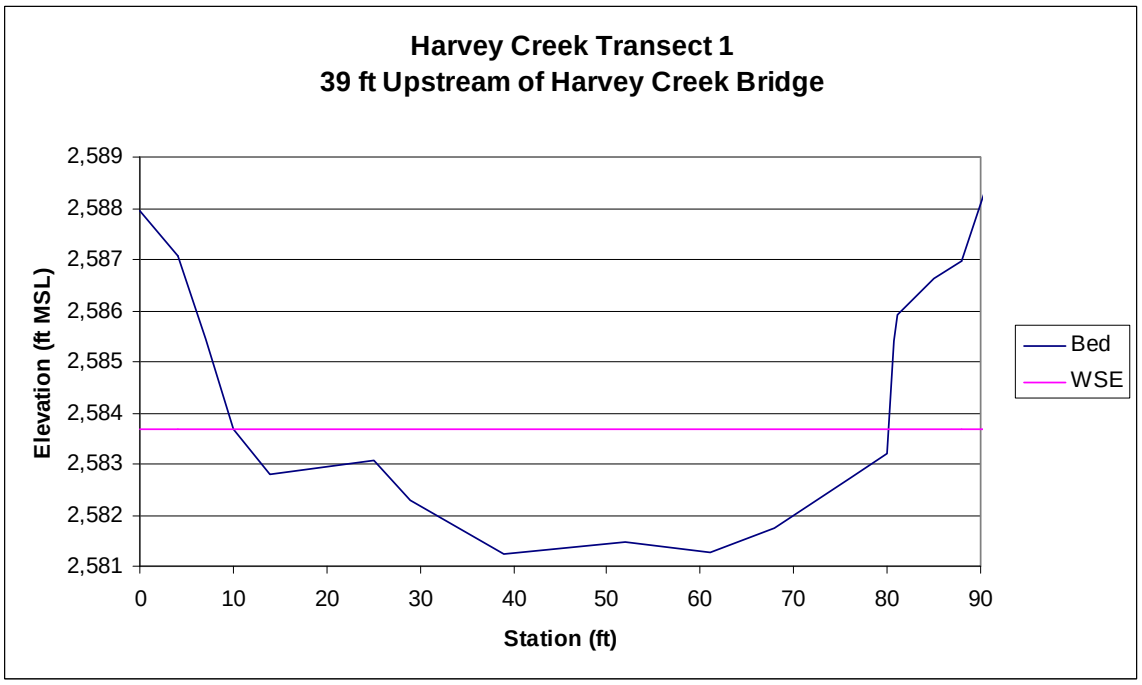


**Figure 2. Harvey Creek Transect 1 cross sectional profile.**

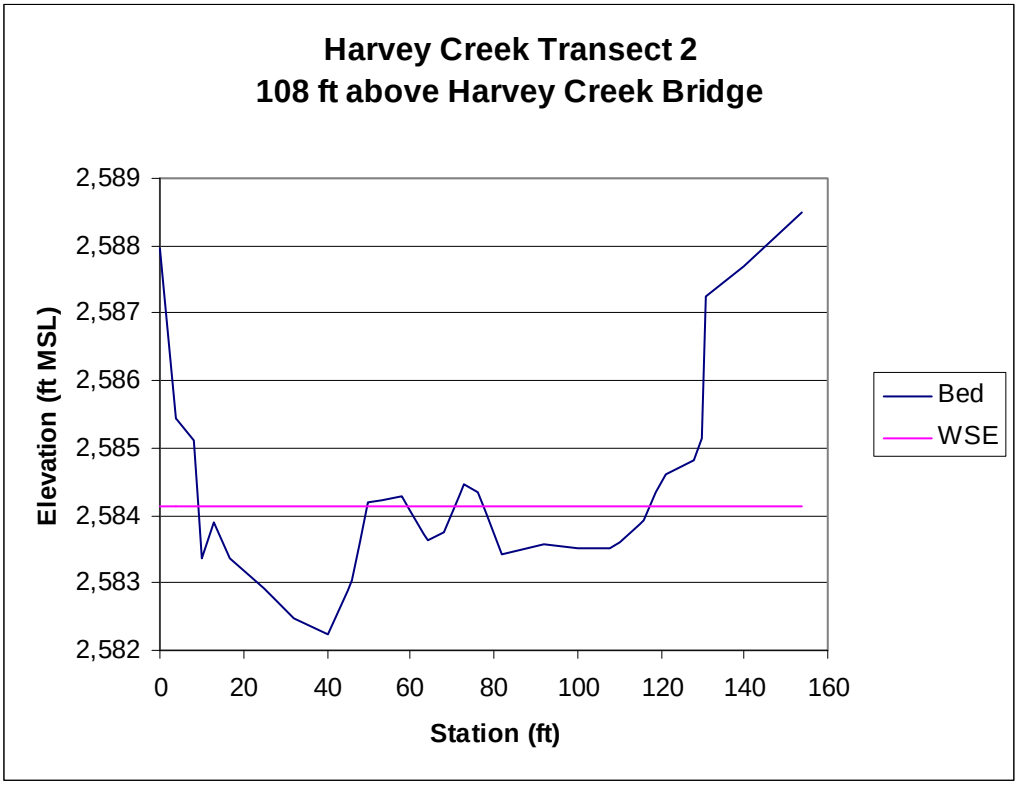


**Figure 3. Harvey Creek Transect 2 cross sectional profile.**

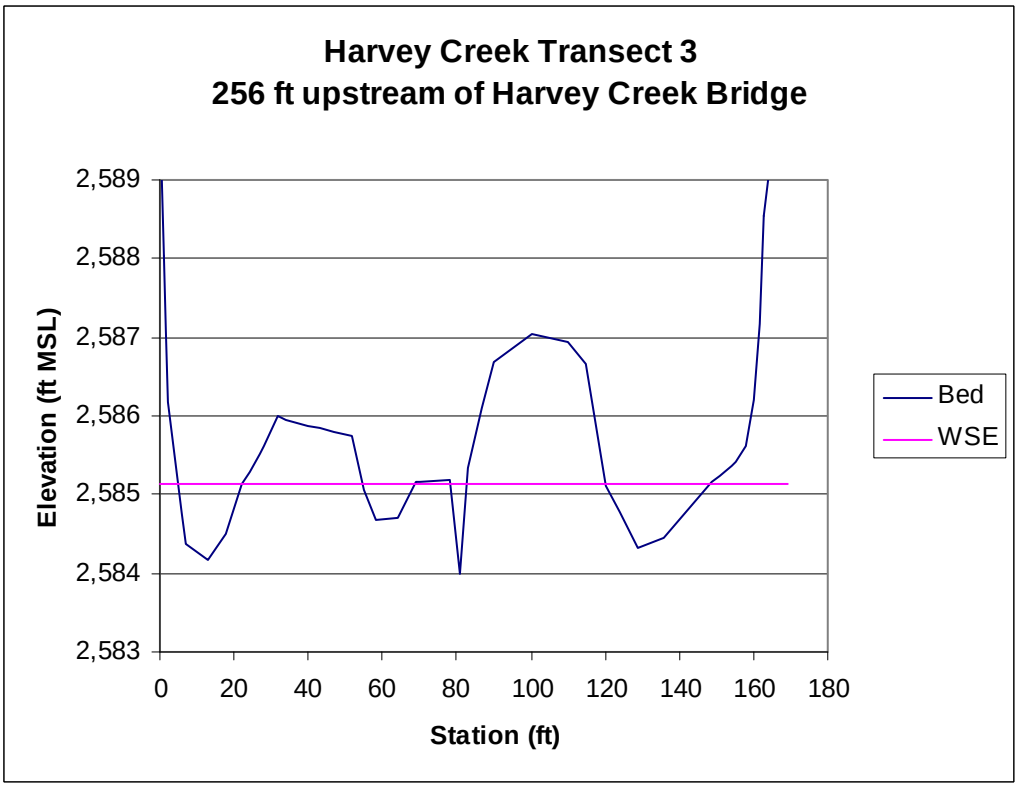


**Figure 4. Harvey Creek Transect 3 cross sectional profile.**

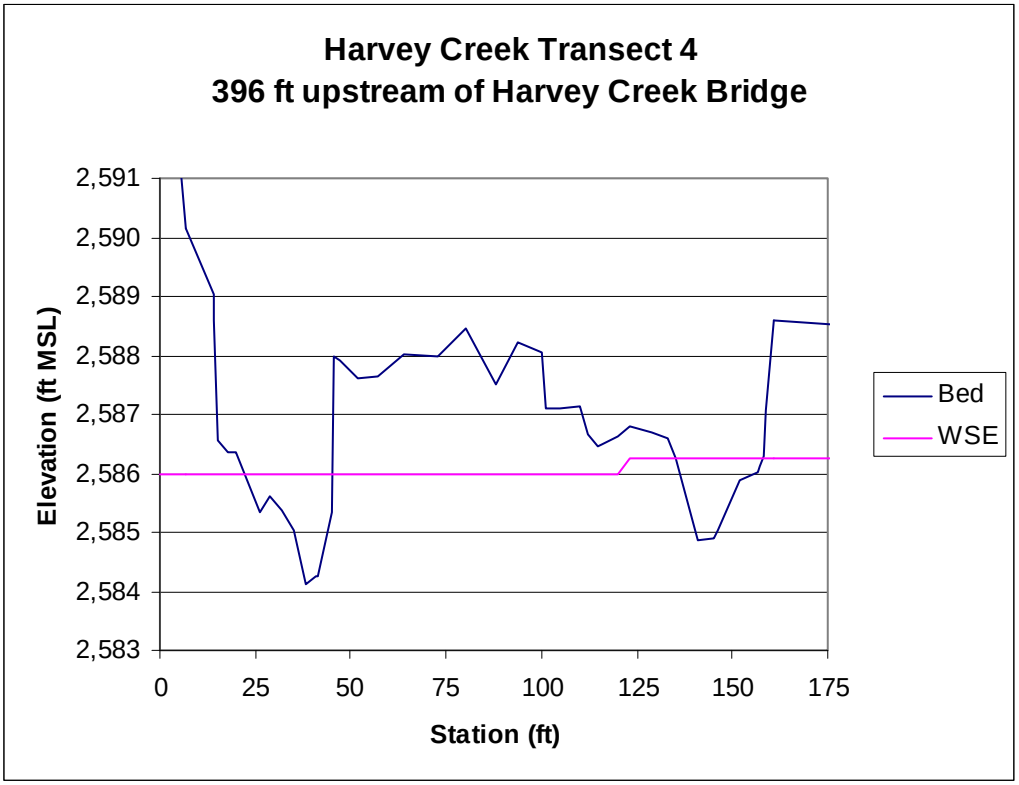


**Figure 5. Harvey Creek Transect 4 cross sectional profile.**

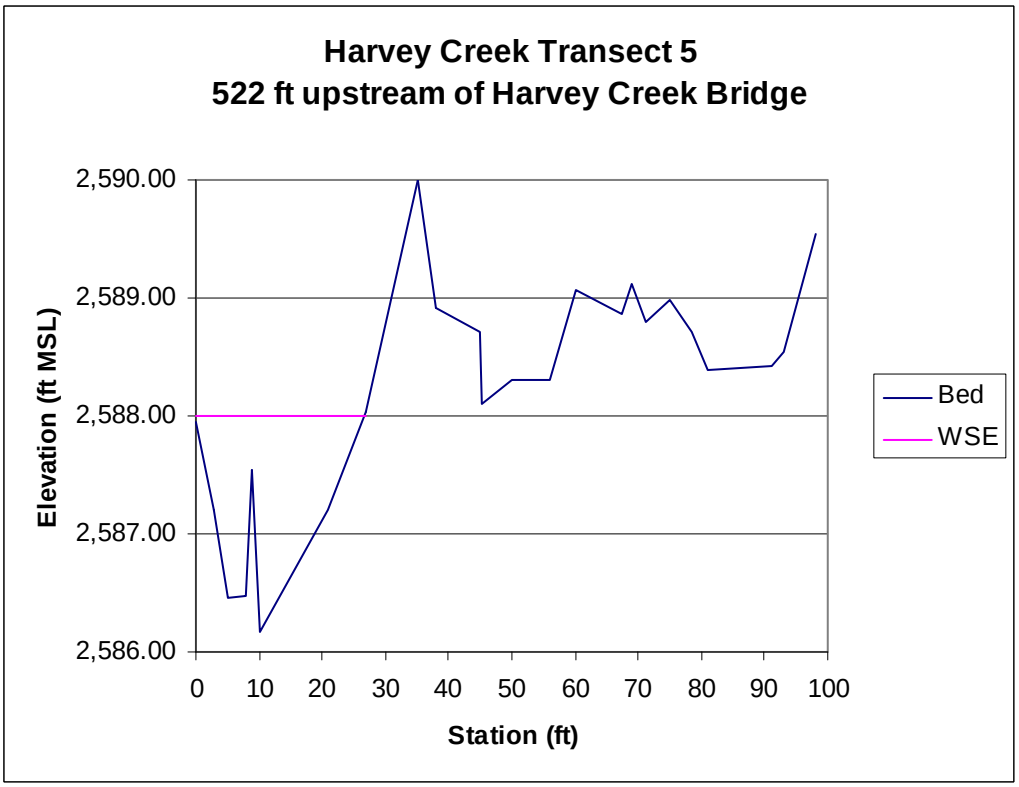


**Figure 6. Harvey Creek Transect 5 cross sectional profile.**

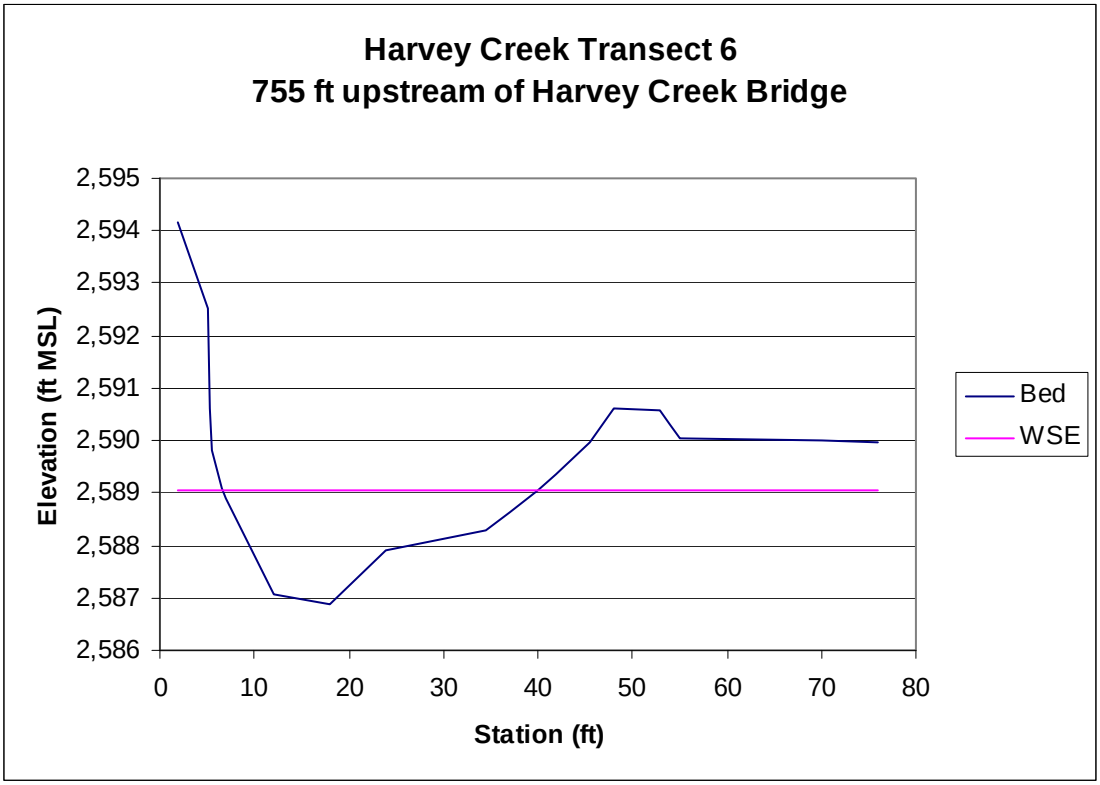


**Figure 7. Harvey Creek Transect 6 cross sectional profile.**

# APPENDIX A

# HARVEY CREEK TRANSECT PHOTOS

**Figure 1. Harvey Creek Transect 1.**

**Figure 2. Harvey Creek Transect 2, Photo 1.**

**Figure 3. Harvey Creek Transect 2, Photo 2.**

**Figure 4. Harvey Creek Transect 3, Photo 1**

**Figure 5. Harvey Creek Transect 3, Photo 2.**

**Figure 6. Harvey Creek Transect 3, Photo 3.**

**Figure 7. Harvey Creek Transect 3, Photo 4.**

**Figure 8. Harvey Creek Transect 3, Photo 5.**

**Figure 9. Harvey Creek Transect 4, Photo 1.**

**Figure 10. Harvey Creek Transect 4, Photo 2.**

**Figure 11. Harvey Creek Transect 5, Photo 1.**

**Figure 12. Harvey Creek Transect 5, Photo 2.**

**Figure 13. Harvey Creek Transect 6, Photo 1.**

**Figure 14. Harvey Creek Transect 6, Photo 2.**

# APPLICATION FOR SURRENDER OF LICENSE
# SULLIVAN CREEK PROJECT
# FERC NO. 2225

## APPENDIX E.4-5
### REVISED SULLIVAN DAM ENTRAINMENT STUDY

*Revised DRAFT REPORT*

# ENTRAINMENT INVESTIGATIONS
# AND
# STUDY OF FISH PRESENCE IN THE VICINITY OF SULLIVAN LAKE DAM

***Prepared for:***

**Public Utility District No. 1 of Pend Oreille County**
**Newport, WA**

***Prepared by:***

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~~***December 4, 2009***~~
***Revised February 2010***

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## 1.0 INTRODUCTION

The Public Utility District No. 1 of Pend Oreille County (POPUD), currently the federal Licensee of the non-generating Sullivan Lake Project (FERC No. 2225), has proposed to surrender the FERC license and continue to operate the Project under a Special Use Authorization to be issued by the USDA Forest Service. In the course of settlement discussions for these processes, the POPUD, resource agencies and other stakeholders are examining possible future operating scenarios for the Project that would differ somewhat from the way it has been operated under the FERC license. Currently, Sullivan Lake is annually drawn down approximately 20 feet each fall from its full pool elevation of 2,588.66 ft MSL, beginning October 1.

The settlement Team (Team) is examining an operating regime that would draw the lake down during the summer period, with the fall drawdown commencing either in September or October. In the process of developing this scenario for the management of Sullivan Lake, several questions were identified regarding the potential impacts of the changes. These included, but were not limited to:

- Productivity in Sullivan Lake and Outlet Creek, and potential changes in productivity due to lake operations
- Distribution of fish in the vicinity of Sullivan Lake Dam that could potentially be entrained
- Fish entrainment below the Sullivan Lake Dam during periods of spill

POPUD initiated studies to address these questions, and this report summarizes results of the study for fish entrainment; a separate report provides information on the productivity investigations. The District also conducted a hydroacoustic analysis along with a series of netting surveys in Sullivan Lake to document fish presence. Given recent agreements reached related to the license surrender, however, these results were deemed unnecessary and thus, are not included in this report.

Sullivan Lake supports a naturally reproducing population of kokanee (*Oncorhynchus nerka*), originally stemming from several different stocking efforts. The Washington Department of Ecology (WDOE 1997) classified Sullivan Lake as oligotrophic due to low concentrations of total phosphorus and chlorophyll *a* and high Secchi disk depth values. Oligotrophic lakes generally have low production of algae and zooplankton, and high water clarity (Horne and Goldman 1994). Aquatic macrophyte densities were low in Sullivan Lake (WDOE 1997).

## 2.0 METHODS

This section describes methods used to determine the level of fish entrainment immediately below the Sullivan Lake Dam in Outlet Creek. The entrainment study documented species and numbers of fish being removed from Sullivan Lake through the outlet gates at the dam into Outlet Creek.

Traps were used below the Sullivan Lake Dam concrete apron in Outlet Creek between October 1 and November 30, 2009 to determine the abundance and species composition of fish being removed from Sullivan Lake during spill.

On October 1, an Oneida trap with a 1.22 $m^2$ opening was installed approximately 65 m below the concrete dam apron (Figure 2-1). The mesh size in the net and trap was 6.4 mm. This site was selected due to extreme turbulence a previously selected site below the apron near the alarm. Due to the change in channel geometry at this alternate location, the trap could not be fished at 200 cfs as proposed, so approximately 130 cfs was released to maintain the integrity of the trap. The trap design was modified on October 29 with steel-reinforced rotating panels, with 6.4 mm mesh replacing the net. In addition, two traps were set at the downstream end: a 1.22m X 1.22m frame and a 0.91m X 0.91m frame with individual traps set up for each. Figure 2-1 shows the location of the traps.

Prior to operation of the trap, the Outlet Creek stream channel downstream of the concrete apron and upstream of the trap was electrofished by two crews to remove fish that resided in this section of Outlet Creek and to prevent double counting. Four times during the sampling period, this section of Outlet Creek was also electrofished to enumerate those fish that had not travelled downstream and been captured in the trap.

Initially, the trap was checked Monday through Friday; after the redesign of the trap, the net was checked at least once per day. Often, however, stream conditions (e.g., wind, leaf deposit, etc.) warranted the net begin checked several times per day to prevent clogging.

Data collected included:

- Species
- Length
- Condition/Health
- Comments related to any apparent injury
- Evidence of predation

**Figure 2-1. Approximate Oneida Trap Location on Outlet Creek.**

## 3.0 RESULTS

Oneida traps were used to capture fish in Outlet Creek below the concrete apron of Sullivan Dam between October 1, 2009 and November 30, 2009. A total of 1,291 fish were captured in the Outlet Creek during the netting period. This number represents a combination of fish captured in the net and via monthly electrofishing efforts. Table 3-1 displays capture information by species on a weekly basis. Forty-two percent of the total fish captured were captured during the first week of sampling (Oct. 1 - Oct. 7). The highest number of kokanee (45.7% of species total) was captured during the week of Oct. 22 – Oct. 28. It is important to note that during this week, an electrofishing survey was conducted. The number of kokanee captured during this week represents the combined total between electrofishing and netting. Red sided shiner numbers diminished significantly after the first week when 76% of the shiners were captured. The size distribution of the fish captured varied widely depending on the specific species. Figure 3-1 displays catch-per-week data for the Outlet Creek netting; Table 3-2 summarizes the size distribution of fish captured in Outlet Creek by species.

The initial net was put in place on September 29, 2009 and was fished continuously until October 29, with the exception of October 19 and 20, when the net was pushed over by an abundance of leaves and other natural debris. As previously discussed, the net configuration was modified on October 29 to facilitate higher flows down Outlet Creek. The new net fished continuously until November 30 except for November 18 and 19 when a large amount of windfall clogged the nets and required cleaning. The average flow down Outlet Creek while the

**Table 3-1. Summary of Fish Captured in Outlet Creek (Netting and Electrofishing)**

| Species | Time Period | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| | Oct 1 – 7 | Oct 8 - 14 | Oct 15 - 21 | Oct 22 - 28 | Oct 29 – Nov 4 | Nov 5 - 11 | Nov 12 - 18 | Nov 19 – 25 | Nov 26 – 30 | |
| Cut-bow | | 2 | | | | | | | | 2 |
| German Brown Trout | 27 | 23 | 27 | 22 | 5 | 5 | 4 | 10 | | 122 |
| Kokanee | 1 | 10 | 12 | 136 | 25 | 36 | 46 | 15 | 20 | 297 |
| Burbot | 8 | 14 | 36 | 39 | 21 | 10 | 6 | 4 | 10 | 148 |
| Long-Nose Sucker | 5 | 2 | 3 | | 2 | 1 | 1 | 1 | 1 | 16 |
| Pygmy Whitefish | | 1 | 2 | 4 | 1 | | 2 | 3 | 1 | 14 |
| Mountain Whitefish | | | 1 | 2 | | | | | | 3 |
| Rainbow Trout | | | | 1 | | | | | | 1 |
| Red Sided Shiner | 496 | 80 | 32 | 10 | 9 | 15 | | 6 | 2 | 649 |
| Unknown Salmonid | | | 1 | | | | | | | 1 |
| Sculpin | 2 | 1 | 1 | 11 | 2 | | | 1 | | 18 |
| Tiger Trout | | 1 | | 1 | 1 | | | | | 3 |
| Westslope Cutthroat Trout | 3 | | 5 | 6 | 1 | 1 | | | | 16 |
| **Total** | **542** | **134** | **120** | **233** | **67** | **68** | **59** | **40** | **34** | **1291** |

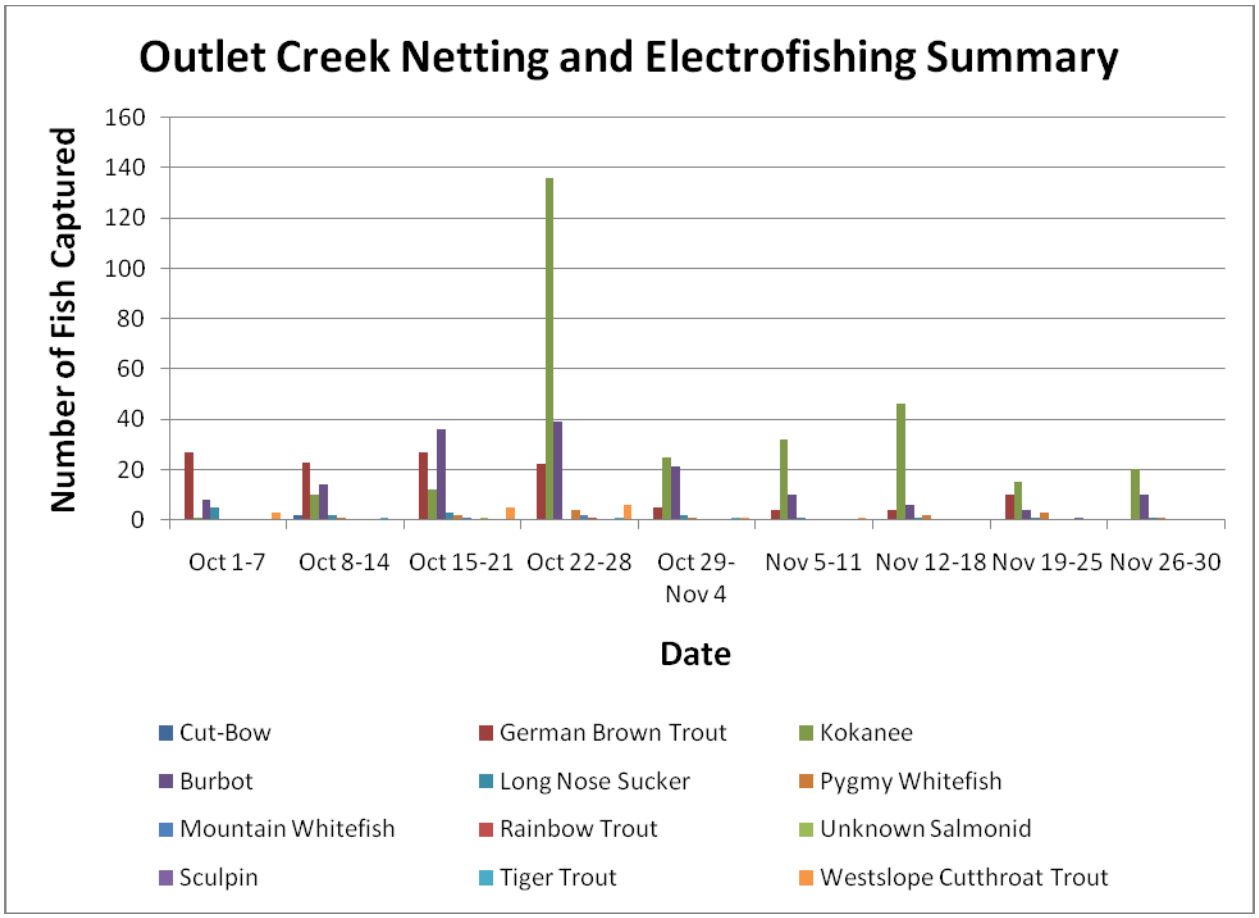


**Figure 3-1. Outlet Creek netting summary**

*[Note: Due to large sample size, Red Sided Shiners were excluded from this graph.]*

| Table 3-2. Size Distribution of Fish Captured During Netting and Electrofishing in Outlet Creek | | | | | | |
|---|---|---|---|---|---|---|
| **Species** | **Fork Length Range (mm)** | | | | | **Total** |
| | **11-30** | **31-60** | **61-120** | **121-250** | **251-500** | |
| Cut-bow | | | | 1 | 1 | 2 |
| German Brown Trout | | 3 | 75 | 40 | 3 | 122 |
| Kokanee | | 1 | | 164 | 101 | 297 |
| Burbot | | 2 | 69 | 45 | 27 | 148 |
| Long-Nose Sucker | | 1 | 9 | 3 | 3 | 16 |
| Pygmy Whitefish | | 1 | 7 | 6 | | 14 |
| Mountain Whitefish | | | | 2 | 1 | 3 |
| Rainbow Trout | | | | 1 | | 1 |
| Red Sided Shiner | 8 | 351 | 287 | 2 | 1 | 649 |
| Unknown Salmonid | | | | 1 | | 1 |
| Sculpin | | 9 | 9 | | | 18 |
| Tiger Trout | | | | 3 | | 3 |
| Westslope Cutthroat Trout | | | 4 | 9 | 3 | 16 |
| **Total** | **8** | **368** | **460** | **276** | **140** | **1291** |

first net was in place was approximately 117 cfs. Flow after the nets were installed on October 29 ranged from over 180 cfs – 200 cfs (down periods for maintenance excluded).. The District electrofished 4 times during the netting period:

- October 2nd
- October 5th
- October 28th
- November 30th

On electrofishing days, the District did not differentiate between fish captured via electrofishing and those captured in the net. The District biologist conducting the work stated that the numbers of fish in the net on the days of shocking were similar to the day before and the day after (pers. comm.., Scott Jungblom). Figure 3-1 depicts numbers of fish netted on days of shocking that are the average of the day before and the day after shocking occurred.

Since capture methodology was not differentiated during District sampling, EESC estimated the numbers of fish that were in the area between the dam and the traps. These estimates were:

- October 2: 200
- October 5: 93
- October 28: 150
- November 30. No estimates of the number of fish that were electrofished between the dam and the net were provided when the study terminated on November 30.

WDFW, however, noted more than 100 kokanee between the dam and the traps on November 16; EESC staff noted between 100 and 150 kokanee on November 20.

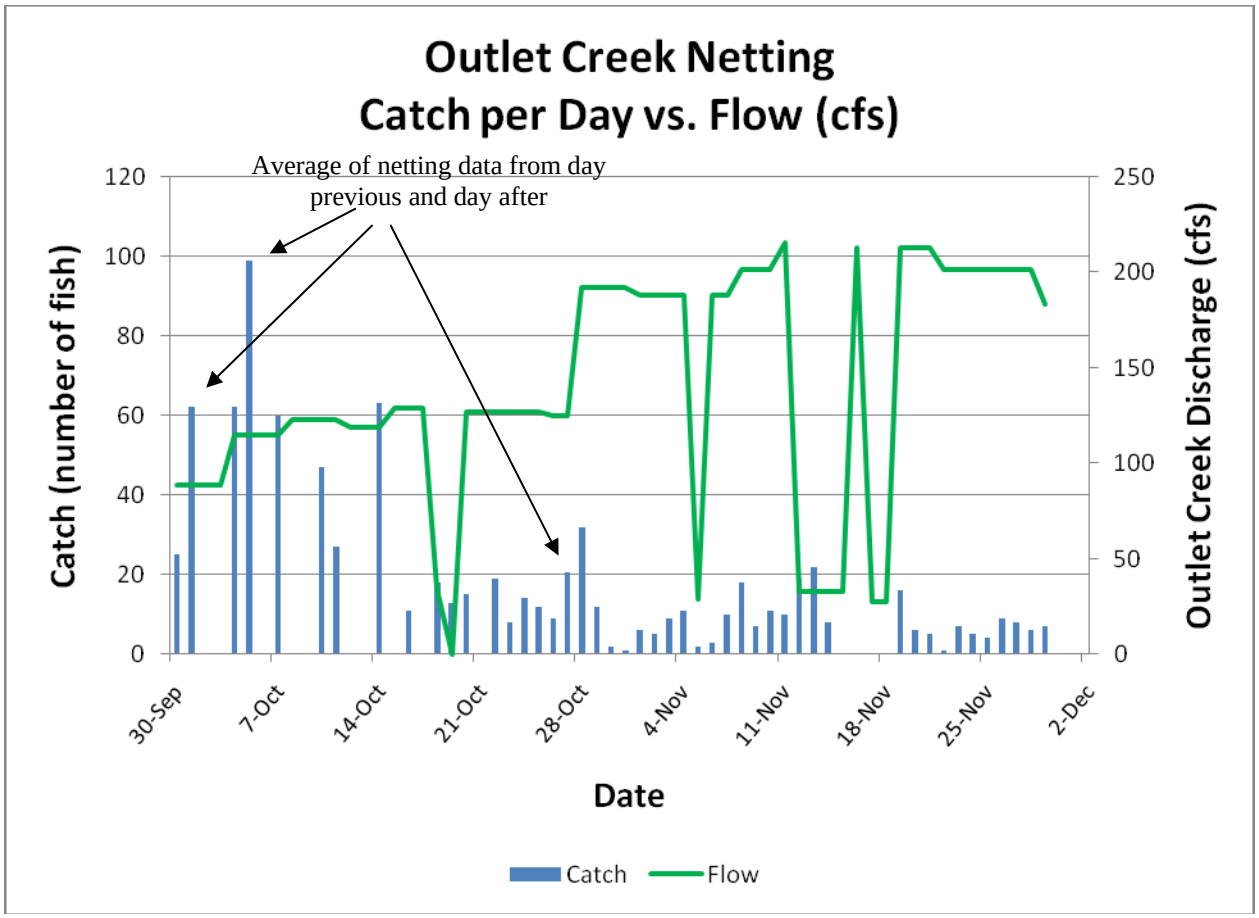


**Figure 3-1. Outlet Creek Catch Data vs. Flow.**
[Note: net and electroshocking catch were combined in catch records; electroshocking numbers were estimated and removed from the total numbers on the days when electroshocking occurred. Approximately 100 – 150 kokanee observed between November 16 -20 and are not represented in the graph].

## 4.0 DISCUSSION

A majority (76%) of the red-sided shiners captured during the nine-week netting period in Outlet Creek were captured during the first week of the survey. It is likely that many of the shiners captured were present in Outlet Creek above the net prior to its deployment. During the Outlet Creek Instream Flow Study conducted by WDFW, WDOE and the District in July, flows of up to 250 cfs or more were released from the lake, likely entraining many of these fish prior to the study beginning. Limited electrofishing in the area upstream of the net took place prior to net deployment and a large number of red-sided shiners were captured and moved downstream. Significantly more were identified and not moved simply due to the large numbers of the species, specifically near the concrete apron of the dam in groups of large boulders.

Prior to the net being removed on November 30, this District electrofished above the net to document any fish that were entrained but not captured in the net. Observations by WDFW personnel on November 16 and EESC personnel on November 18 described 100 plus kokanee present between the dam apron and the net in Outlet Creek. Personal communication with the the District biologist confirmed that an electrofishing survey took place on November 30, prior to the net being removed and that approximately 100 kokanee were captured. Approximately another 40 were not collected and likely moved downstream after the net was removed (pers. comm., Scott Jungblom). Since the net had collapsed during the study, the origin of those fish milling between the dam and traps is unknown; fish could have been swept through the gates and entrained below the dam, or could have migrated upstream from below the traps when the traps were inoperable and not able to return downstream.

As a result the total numbers of fish captured during the netting survey in Outlet Creek is an underestimate of the total number of fish entrained. The flow that was to be provided per the study plan had to be modified due to the limitations of the initially installed nets.

# APPLICATION FOR SURRENDER OF LICENSE
# SULLIVAN CREEK PROJECT
# FERC NO. 2225

## APPENDIX E.4-6
### 2009 SULLIVAN CREEK INSTREAM FLOW STUDY

*WORKING DRAFT*

# SULLIVAN CREEK HYDROELECTRIC PROJECT
# FERC No. 2225

## Sullivan Creek Trout Rearing and Spawning
## Weighted Usable Area Results

**Prepared for:**

**Public Utility District No.1 of Pend Oreille County**
**Newport, Washington**

**Prepared by:**

**EES Consulting, Inc.**

**July 6, 2009**

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# 1.0 INTRODUCTION

As part of the surrender of the Sullivan Creek Hydroelectric Project license (FERC No. 2225), various lake management options are being considered by the Mediation Team (Team). A concern expressed by the Team has been the potential effects of large volume releases from Sullivan Lake as a result of lake management on fish and fish habitat downstream in Sullivan and Outlet creeks. No site-specific fisheries investigations have been conducted to evaluate flows in Outlet Creek; these studies are scheduled for July 15 with WDFW. An instream flow study, however, had been conducted on Sullivan Creek by the Pend Oreille Public Utility District (District) in 1994 (CES 1994).

The Team requested that the District re-run the instream flow model with updated Habitat Suitability Index curves (HSI – formerly called fish preference curves). The results of this new analysis are presented in this report.

# 2.0 METHODS

The following information, including data sources, was used to run the models on Sullivan Creek:

- 17 calibrated and approved transects (in two study sites) representing the habitat from Mill Pond downstream to the confluence of Sullivan Creek with the Pend Oreille River (CES 1994)
- Approved transect weighting for the two study sites and 17 transects (CES 1994)
- Approved hydrology (i.e., inflow from Mill Pond downstream to the confluence of Sullivan Creek with the Pend Oreille River) (CES 1994)
- Target species of interest in Sullivan Creek (Mediation Team 2009)
- HSI curves presented to the Mediation Team (EES Consulting 2009) *[Note: Brown trout curves modified per Dr. Hal Beecher, WDFW (June 18, 2009)]*

# 3.0 RESULTS

## 3.1 Transects and Study Sites

Table 1 includes transects and study sites for the Sullivan Creek IFIM study. Transects, calibration methods and hydraulic models were approved by WDFW and WDOE in 1994 (CES 1994).

## 3.2 Transect Weighting.

Table 2 shows transect weighting used for the instream flow study site. Study Site 1 (from the confluence of the North Fork Sullivan Creek downstream to the Pend Oreille River) constituted 43.8% of the study area, while Study Site 2 (Sullivan Creek from Mill Pond Dam downstream to the confluence of the North Fork of Sullivan Creek) represented 56.2% of the habitat.

### 3.3 Hydrologic Input

Joanne Greenburg, P.E, and hydrologist, calculated inflow to the study sites based upon synthesized flows provided by HDR for the period 1960 - 1968. The yearly flow regime was broken into two periods (March 1 – September 30; and October 1 – March 1), based upon lake management. Currently, the head gate on the dam is opened on October 1, and the lake level is drawn down. In the spring, the head gate is closed and the lake is allowed to fill.

Appendix J of the instream flow report (CES 1994) provides the details, analysis and apportionment of flows used in this analysis.

### 3.4 Target Species

Species and life stages modeled in this analysis are shown in Table 3 (EES Consulting 2009).

### 3.5 HSI Curves

The HSI curve was distributed to the fisheries subgroup of the Team. Modifications to the brown trout curves were suggested by Dr. Hal Beecher on June 18, 2009, and incorporated (EES Consulting 2009).

### 3.6 Weighted Usable Area

Results of the modeling are shown in Tables 4 and 5, and Figures 1 – 4. These tables are broken out by season (March 1 – September 30 and October 1 – March 1) while graphs are stratified by season and life history stage (rearing and spawning). Weighted Usable Area (WUA) is given in feet$^2$/1,000 linear feet of stream

## 4.0 LITERATURE CITED

Cascades Environmental Services (CES). 1994. Draft fisheries study report. Sullivan Lake Hydroelectric Project FERC No. 2225. Prepared for the Public Utility District No. 1 of Pend Oreille County and HDR Engineering. April 1994.

EES Consulting. 2009. Working draft habitat suitability indices for species and life history stage proposed for the instream flow study. Prepared for the Sullivan Lake Project Mediation Team and the Public Utility District No. 1 of Pend Oreille County. May 28, 2009.

**Table 1. Transects and descriptors, Sullivan Creek Instream Flow Study.**

| Study Site | Transect | Description |
|---|---|---|
| 1 | 1 | Deep pool with bedrock walls and control |
| | 2 | Wide, bedrock-walled glide |
| | 3 | Chute |
| | 4 | Pool tailout/fast glide |
| | 5 | Pool/chute |
| | 6 | Narrow low gradient cascades |
| | 7 | Boulder cascade/run |
| | 8 | Wide, low-gradient cascades |
| 2 | 1 | Wide, shallow glide |
| | 2 | Wide boulder/bedrock low gradient cascades |
| | 3 | Chute |
| | 4 | wide boulder riffle |
| | 5 | Plunge pool/chute |
| | 6 | Plunge pool |
| | 7 | Boulder garden/run |
| | 8 | Narrow low gradient cascades |
| | 9 | Narrow deep glide |

**Table 2. Relative transect weighting, Sullivan Creek below Mill Pond Dam.**

| Study Site | Transect | Reach | Total |
|---|---|---|---|
| 1 | 1 | 8.4% | 3.7% |
| | 2 | 2.8% | 1.2% |
| | 3 | 29.4% | 12.9% |
| | 4 | 7.0% | 3.1% |
| | 5 | 19.5% | 8.5% |
| | 6 | 7.7% | 3.4% |
| | 7 | 2.8% | 1.2% |
| | 8 | 22.4% | 9.8% |
| 2 | 1 | 6.2% | 3.5% |
| | 2 | 15.0% | 8.4% |
| | 3 | 6.0% | 3.4% |
| | 4 | 18.4% | 10.3% |
| | 5 | 5.3% | 2.9% |
| | 6 | 7.5% | 4.2% |
| | 7 | 23.6% | 13.3% |
| | 8 | 4.5% | 2.5% |
| | 9 | 13.5% | 7.6% |

**Table 3. Species and life history stages modeled in IFIM analysis.**

| Species | Life History Stage |
|---|---|
| Brook Trout | Juvenile/Adult Rearing |
| Brown Trout | Juvenile Rearing |
| | Adult Rearing |
| | Spawning |
| Bull Trout | Juvenile/Adult Rearing |
| | Spawning |
| Cutthroat Trout | Juvenile/Adult Rearing |
| | Spawning |
| Rainbow Trout | Juvenile/Adult Rearing |
| | Spawning |

**Table 4. Sullivan Creek Weighted Usable Area (ft2/1,000 linear ft of stream), October 1 – March 1.**

| | | | | Brook Trout | Brown Trout | | | Bull Trout | | Cutthroat Trout | | Rainbow Trout | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mill Pond Flow (cfs) | SS2 | SS1 | Total | Juv/Ad | Adult | Juvenile | Spawning | Rearing | Spawning | Spawning | J/A Rearing | J/A Rearing | Spawning |
| 13 | 13 | 14 | 33,228 | 4,781 | 4,480 | 7,029 | 357 | 5,540 | 4,664 | 127 | 2,142 | 2,084 | 83 |
| 14 | 14 | 15 | 33,618 | 4,887 | 4,543 | 7,105 | 391 | 5,719 | 4,683 | 130 | 2,216 | 2,136 | 84 |
| 15 | 15 | 16 | 34,024 | 5,171 | 4,824 | 7,576 | 432 | 6,243 | 4,902 | 141 | 2,420 | 2,335 | 96 |
| 16 | 16 | 17 | 34,313 | 5,364 | 4,997 | 7,816 | 469 | 6,605 | 4,980 | 149 | 2,552 | 2,443 | 104 |
| 17 | 17 | 18 | 34,598 | 5,549 | 5,163 | 8,060 | 497 | 6,951 | 5,057 | 158 | 2,684 | 2,551 | 112 |
| 18 | 18 | 19 | 34,877 | 5,723 | 5,326 | 8,298 | 525 | 7,285 | 5,126 | 166 | 2,824 | 2,659 | 120 |
| 19 | 19 | 20 | 35,143 | 5,892 | 5,489 | 8,539 | 549 | 7,609 | 5,187 | 175 | 2,964 | 2,766 | 129 |
| 20 | 20 | 21 | 35,426 | 6,063 | 5,650 | 8,766 | 568 | 7,930 | 5,242 | 183 | 3,105 | 2,873 | 137 |
| 21 | 21 | 23 | 35,676 | 6,312 | 5,837 | 8,984 | 603 | 8,350 | 5,273 | 193 | 3,304 | 3,004 | 148 |
| 22 | 22 | 24 | 35,874 | 6,497 | 5,976 | 9,144 | 621 | 8,691 | 5,304 | 202 | 3,420 | 3,094 | 155 |
| 23 | 23 | 25 | 36,074 | 6,670 | 6,113 | 9,305 | 636 | 9,044 | 5,344 | 211 | 3,543 | 3,183 | 162 |
| 24 | 24 | 26 | 36,274 | 6,838 | 6,245 | 9,479 | 652 | 9,397 | 5,383 | 220 | 3,659 | 3,270 | 170 |
| 25 | 25 | 27 | 36,471 | 7,012 | 6,374 | 9,636 | 667 | 9,749 | 5,421 | 229 | 3,769 | 3,353 | 179 |
| 30 | 30 | 32 | 37,321 | 7,812 | 6,938 | 10,221 | 743 | 11,526 | 5,572 | 275 | 4,119 | 3,720 | 226 |
| 32 | 32 | 35 | 37,448 | 7,869 | 6,948 | 10,245 | 605 | 11,764 | 5,474 | 272 | 4,128 | 3,728 | 214 |
| 35 | 35 | 38 | 38,206 | 8,562 | 7,426 | 10,644 | 737 | 13,137 | 5,630 | 295 | 4,358 | 4,042 | 262 |
| 40 | 40 | 43 | 39,088 | 9,310 | 7,859 | 10,979 | 848 | 14,488 | 5,689 | 311 | 4,567 | 4,350 | 317 |
| 45 | 45 | 48 | 39,554 | 9,932 | 8,154 | 11,152 | 900 | 15,585 | 5,667 | 311 | 4,717 | 4,596 | 360 |
| 50 | 50 | 53 | 40,457 | 10,492 | 8,357 | 11,253 | 945 | 16,509 | 5,642 | 304 | 4,818 | 4,797 | 402 |
| 55 | 55 | 58 | 41,076 | 10,888 | 8,499 | 11,334 | 980 | 17,215 | 5,589 | 299 | 4,897 | 4,994 | 439 |
| 60 | 60 | 63 | 41,623 | 11,247 | 8,597 | 11,316 | 1,008 | 17,782 | 5,543 | 293 | 4,936 | 5,205 | 470 |
| 65 | 65 | 68 | 42,072 | 11,616 | 8,663 | 11,272 | 1,034 | 18,237 | 5,498 | 292 | 4,914 | 5,403 | 496 |
| 70 | 70 | 73 | 42,414 | 11,887 | 8,706 | 11,216 | 1,055 | 18,614 | 5,476 | 298 | 4,883 | 5,572 | 511 |
| 75 | 75 | 79 | 42,711 | 12,048 | 8,729 | 11,131 | 1,074 | 18,880 | 5,448 | 315 | 4,846 | 5,710 | 522 |
| 80 | 80 | 84 | 42,895 | 12,167 | 8,746 | 11,095 | 1,094 | 19,105 | 5,434 | 357 | 4,836 | 5,818 | 533 |
| 90 | 90 | 94 | 43,229 | 12,377 | 8,750 | 10,923 | 1,137 | 19,202 | 5,447 | 408 | 4,848 | 5,993 | 560 |
| 100 | 100 | 106 | 43,948 | 12,533 | 8,800 | 10,858 | 1,132 | 19,309 | 5,470 | 442 | 4,910 | 6,152 | 591 |
| 125 | 125 | 131 | 46,656 | 12,930 | 8,425 | 10,168 | 1,256 | 19,788 | 5,375 | 473 | 5,221 | 6,475 | 601 |

**Table 4. Sullivan Creek Weighted Usable Area (ft2/1,000 linear ft of stream), October 1 – March 1.**

| | | | | Brook Trout | Brown Trout | | | Bull Trout | | Cutthroat Trout | | Rainbow Trout | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mill Pond Flow (cfs) | SS2 | SS1 | Total | Juv/Ad | Adult | Juvenile | Spawning | Rearing | Spawning | Spawning | J/A Rearing | J/A Rearing | Spawning |
| 150 | 150 | 156 | 48,583 | 12,880 | 8,293 | 9,814 | 1,357 | 19,218 | 5,412 | 444 | 5,343 | 6,525 | 644 |
| 175 | 175 | 180 | 49,937 | 12,618 | 8,152 | 9,515 | 1,403 | 18,704 | 5,487 | 401 | 5,460 | 6,477 | 644 |
| 200 | 200 | 205 | 50,712 | 12,373 | 8,014 | 9,269 | 1,432 | 18,198 | 5,651 | 320 | 5,507 | 6,362 | 653 |
| 225 | 225 | 229 | 51,416 | 12,061 | 7,848 | 9,099 | 1,440 | 17,568 | 5,680 | 279 | 5,540 | 6,255 | 745 |
| 250 | 250 | 253 | 52,011 | 11,748 | 7,694 | 8,959 | 1,444 | 17,049 | 5,618 | 255 | 5,579 | 6,185 | 731 |
| 275 | 275 | 278 | 52,485 | 11,526 | 7,566 | 8,817 | 1,438 | 16,667 | 5,520 | 273 | 5,605 | 6,133 | 614 |
| 295 | 295 | 298 | 52,852 | 11,430 | 7,527 | 8,780 | 1,435 | 16,519 | 5,491 | 284 | 5,601 | 6,103 | 601 |
| 300 | 300 | 303 | 53,076 | 11,294 | 7,488 | 8,704 | 1,436 | 16,314 | 5,414 | 342 | 5,616 | 6,064 | 522 |
| 325 | 325 | 328 | 53,610 | 11,013 | 7,428 | 8,601 | 1,448 | 16,033 | 5,350 | 386 | 5,668 | 6,042 | 481 |
| 350 | 350 | 353 | 54,254 | 10,802 | 7,371 | 8,546 | 1,476 | 15,699 | 5,238 | 402 | 5,687 | 6,025 | 467 |
| 375 | 375 | 380 | 54,704 | 10,629 | 7,318 | 8,469 | 1,524 | 15,469 | 5,126 | 389 | 5,685 | 5,993 | 448 |
| 400 | 400 | 404 | 55,031 | 10,547 | 7,284 | 8,415 | 1,576 | 15,357 | 5,006 | 383 | 5,663 | 5,938 | 425 |
| 425 | 425 | 429 | 55,368 | 10,445 | 7,264 | 8,385 | 1,618 | 15,218 | 4,909 | 378 | 5,668 | 5,909 | 413 |
| 450 | 450 | 454 | 55,623 | 10,303 | 7,256 | 8,316 | 1,652 | 15,052 | 4,892 | 390 | 5,671 | 5,914 | 423 |
| 475 | 475 | 481 | 56,088 | 10,193 | 7,272 | 8,257 | 1,687 | 14,961 | 4,907 | 390 | 5,640 | 5,929 | 434 |
| 500 | 500 | 506 | 56,284 | 10,149 | 7,270 | 8,209 | 1,720 | 14,859 | 4,844 | 387 | 5,603 | 5,932 | 448 |

**Table 5. Sullivan Creek Weighted Usable Area (ft2/1,000 linear ft of stream), March 1 – September 30.**

| | | | | Brook Trout | Brown Trout | | | Bull Trout | | Cutthroat Trout | | Rainbow Trout | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mill Pond Flow (cfs) | SS2 | SS1 | Total | Juv/Ad | Adult | Juvenile | Spawning | Rearing | Spawning | Spawning | J/A Rearing | J/A Rearing | Spawning |
| 13 | 13 | 13.3 | 33,080 | 4,709 | 4,433 | 6,974 | 334 | 5,443 | 4,646 | 126 | 2,098 | 2,045 | 83 |
| 14 | 14 | 14.3 | 33,544 | 4,813 | 4,499 | 7,053 | 368 | 5,616 | 4,670 | 128 | 2,172 | 2,100 | 83 |
| 15 | 15 | 15.3 | 33,939 | 5,104 | 4,783 | 7,516 | 408 | 6,143 | 4,889 | 139 | 2,377 | 2,303 | 95 |
| 16 | 16 | 16.3 | 34,252 | 5,300 | 4,956 | 7,771 | 445 | 6,510 | 4,963 | 148 | 2,506 | 2,414 | 102 |
| 17 | 17 | 17.3 | 34,540 | 5,490 | 5,127 | 8,013 | 480 | 6,867 | 5,041 | 157 | 2,638 | 2,522 | 110 |
| 18 | 18 | 18.3 | 34,823 | 5,672 | 5,292 | 8,255 | 508 | 7,209 | 5,116 | 165 | 2,772 | 2,631 | 118 |
| 19 | 19 | 19.3 | 35,098 | 5,844 | 5,455 | 8,494 | 535 | 7,540 | 5,182 | 174 | 2,912 | 2,739 | 126 |
| 20 | 20 | 20.3 | 35,369 | 6,014 | 5,617 | 8,730 | 557 | 7,863 | 5,241 | 182 | 3,053 | 2,846 | 135 |
| 21 | 21 | 21.3 | 35,597 | 6,199 | 5,760 | 8,902 | 578 | 8,200 | 5,275 | 192 | 3,185 | 2,939 | 143 |
| 22 | 22 | 22.3 | 35,802 | 6,383 | 5,902 | 9,073 | 599 | 8,532 | 5,308 | 201 | 3,314 | 3,033 | 150 |
| 23 | 23 | 23.3 | 36,001 | 6,565 | 6,042 | 9,234 | 618 | 8,864 | 5,340 | 210 | 3,439 | 3,124 | 158 |
| 24 | 24 | 24.3 | 36,200 | 6,746 | 6,181 | 9,394 | 636 | 9,208 | 5,373 | 219 | 3,557 | 3,214 | 165 |
| 25 | 25 | 25.3 | 36,400 | 6,918 | 6,316 | 9,560 | 651 | 9,562 | 5,413 | 228 | 3,677 | 3,302 | 172 |
| 30 | 30 | 30.3 | 37,234 | 7,739 | 6,895 | 10,168 | 730 | 11,348 | 5,584 | 275 | 4,088 | 3,681 | 219 |
| 32 | 32.2 | 33.5 | 38,270 | 7,892 | 6,974 | 10,262 | 753 | 11,720 | 5,562 | 276 | 4,151 | 3,754 | 233 |
| 35 | 35.2 | 36.5 | 37,990 | 8,477 | 7,373 | 10,601 | 689 | 12,982 | 5,613 | 293 | 4,323 | 3,992 | 251 |
| 40 | 40.2 | 42.5 | 39,079 | 9,288 | 7,852 | 10,978 | 846 | 14,456 | 5,691 | 311 | 4,564 | 4,341 | 315 |
| 45 | 45.2 | 49.5 | 39,625 | 9,980 | 8,165 | 11,148 | 906 | 15,664 | 5,652 | 309 | 4,722 | 4,617 | 365 |
| 50 | 50.2 | 53.5 | 40,483 | 10,505 | 8,357 | 11,251 | 946 | 16,528 | 5,637 | 304 | 4,812 | 4,803 | 403 |
| 55 | 55.2 | 59.5 | 41,215 | 10,897 | 8,496 | 11,323 | 982 | 17,261 | 5,578 | 298 | 4,904 | 5,015 | 444 |
| 60 | 60.2 | 64.5 | 41,688 | 11,271 | 8,592 | 11,300 | 1,011 | 17,818 | 5,534 | 292 | 4,933 | 5,231 | 474 |
| 65 | 65.5 | 69.9 | 42,160 | 11,641 | 8,654 | 11,257 | 1,034 | 18,275 | 5,488 | 292 | 4,896 | 5,430 | 500 |
| 70 | 70.5 | 74.9 | 42,471 | 11,901 | 8,693 | 11,196 | 1,054 | 18,641 | 5,466 | 297 | 4,865 | 5,592 | 515 |
| 75 | 75.5 | 80.9 | 42,754 | 12,038 | 8,715 | 11,114 | 1,073 | 18,888 | 5,444 | 314 | 4,826 | 5,725 | 524 |
| 80 | 80.5 | 85.9 | 42,926 | 12,167 | 8,732 | 11,073 | 1,090 | 19,108 | 5,433 | 358 | 4,820 | 5,828 | 536 |
| 90 | 90.5 | 95.9 | 43,272 | 12,379 | 8,738 | 10,898 | 1,133 | 19,182 | 5,452 | 407 | 4,833 | 6,006 | 561 |
| 100 | 100.7 | 107.4 | 44,052 | 12,546 | 8,809 | 10,863 | 1,125 | 19,329 | 5,475 | 444 | 4,924 | 6,164 | 589 |

**Table 5. Sullivan Creek Weighted Usable Area (ft2/1,000 linear ft of stream), March 1 – September 30.**

| | | | | Brook Trout | Brown Trout | | | Bull Trout | | Cutthroat Trout | | Rainbow Trout | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mill Pond Flow (cfs) | SS2 | SS1 | Total | Juv/Ad | Adult | Juvenile | Spawning | Rearing | Spawning | Spawning | J/A Rearing | J/A Rearing | Spawning |
| 125 | 125.9 | 135.9 | 46,824 | 12,907 | 8,415 | 10,141 | 1,257 | 19,713 | 5,367 | 479 | 5,229 | 6,466 | 599 |
| 150 | 151.2 | 164.3 | 48,770 | 12,830 | 8,269 | 9,766 | 1,361 | 19,177 | 5,412 | 434 | 5,333 | 6,513 | 648 |
| 175 | 176.2 | 190.3 | 50,015 | 12,582 | 8,123 | 9,470 | 1,390 | 18,649 | 5,469 | 370 | 5,452 | 6,451 | 645 |
| 200 | 201.6 | 221.3 | 50,839 | 12,249 | 7,951 | 9,204 | 1,415 | 18,039 | 5,656 | 319 | 5,508 | 6,312 | 658 |
| 225 | 226.9 | 248.7 | 51,708 | 12,008 | 7,791 | 9,033 | 1,425 | 17,422 | 5,657 | 293 | 5,534 | 6,218 | 736 |
| 250 | 251.9 | 273.7 | 52,233 | 11,713 | 7,650 | 8,907 | 1,436 | 16,839 | 5,591 | 270 | 5,632 | 6,169 | 721 |
| 275 | 276.9 | 299.7 | 52,882 | 11,423 | 7,524 | 8,777 | 1,435 | 16,508 | 5,489 | 285 | 5,601 | 6,101 | 600 |
| 295 | 297.3 | 324.7 | 53,285 | 11,215 | 7,455 | 8,677 | 1,437 | 16,219 | 5,408 | 330 | 5,611 | 6,068 | 523 |
| 300 | 302.8 | 334.6 | 53,514 | 11,176 | 7,436 | 8,660 | 1,440 | 16,122 | 5,398 | 333 | 5,608 | 6,058 | 514 |
| 325 | 327.5 | 356.1 | 54,122 | 10,944 | 7,387 | 8,564 | 1,454 | 15,872 | 5,352 | 378 | 5,651 | 6,026 | 473 |
| 350 | 352.7 | 381.1 | 54,603 | 10,731 | 7,339 | 8,530 | 1,482 | 15,576 | 5,266 | 397 | 5,657 | 6,005 | 457 |
| 375 | 377.9 | 408.6 | 54,943 | 10,562 | 7,302 | 8,475 | 1,527 | 15,413 | 5,152 | 386 | 5,651 | 5,965 | 432 |
| 400 | 403.1 | 434.6 | 55,296 | 10,485 | 7,292 | 8,441 | 1,572 | 15,312 | 5,054 | 378 | 5,580 | 5,941 | 413 |
| 425 | 428.3 | 466.5 | 55,738 | 10,380 | 7,282 | 8,413 | 1,613 | 15,232 | 5,064 | 370 | 5,627 | 5,935 | 406 |
| 450 | 453.5 | 494 | 56,057 | 10,305 | 7,293 | 8,380 | 1,651 | 15,132 | 5,004 | 383 | 5,630 | 5,934 | 428 |
| 475 | 478.7 | 521.4 | 56,177 | 10,210 | 7,291 | 8,288 | 1,686 | 14,988 | 4,918 | 387 | 5,733 | 5,933 | 392 |
| 500 | 503.8 | 547.9 | 56,303 | 10,149 | 7,272 | 8,213 | 1,719 | 14,847 | 4,845 | 387 | 5,611 | 5,932 | 574 |

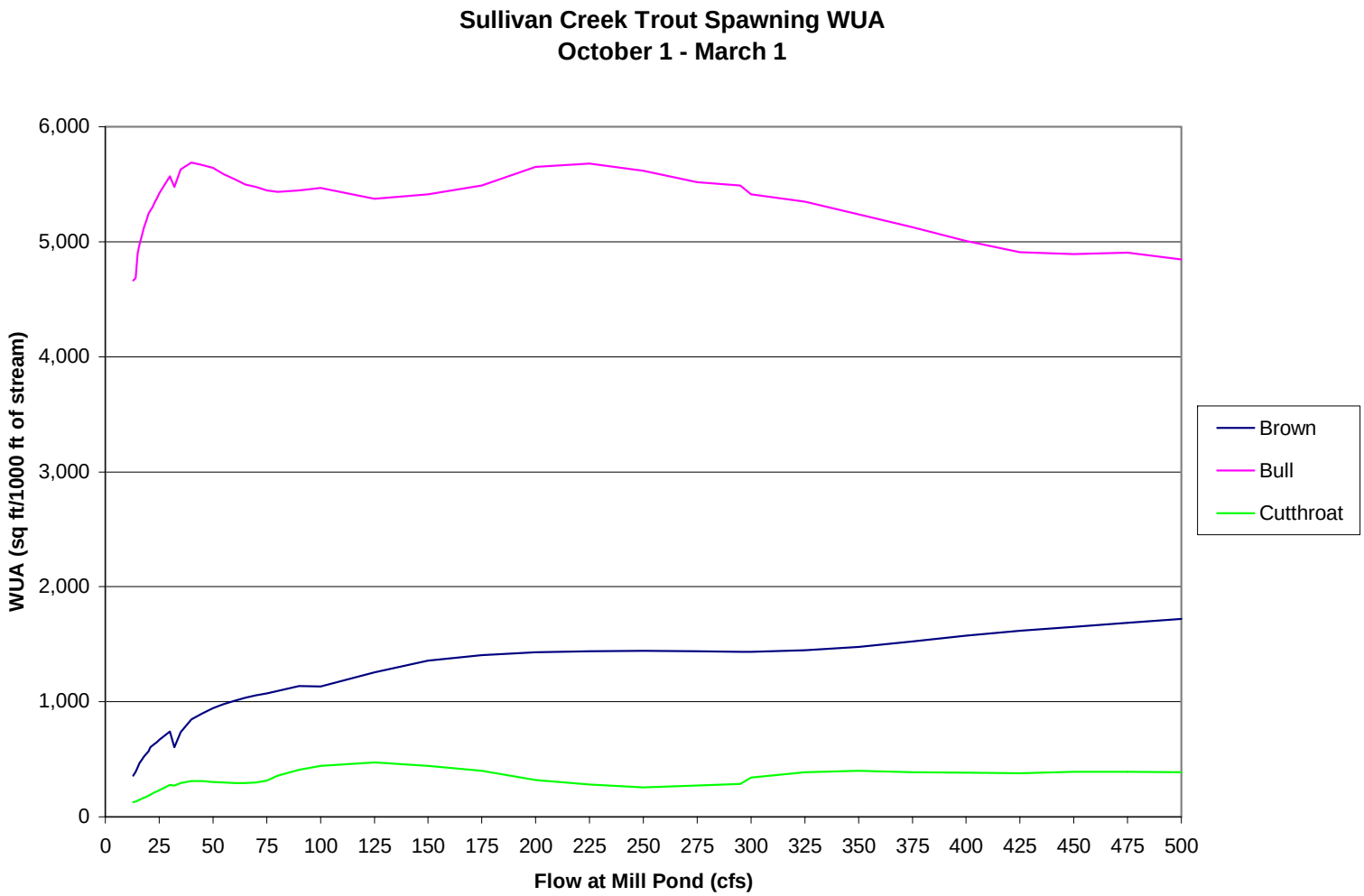


**Figure 1. Sullivan Creek trout spawning WUA, October 1 – March 1.**

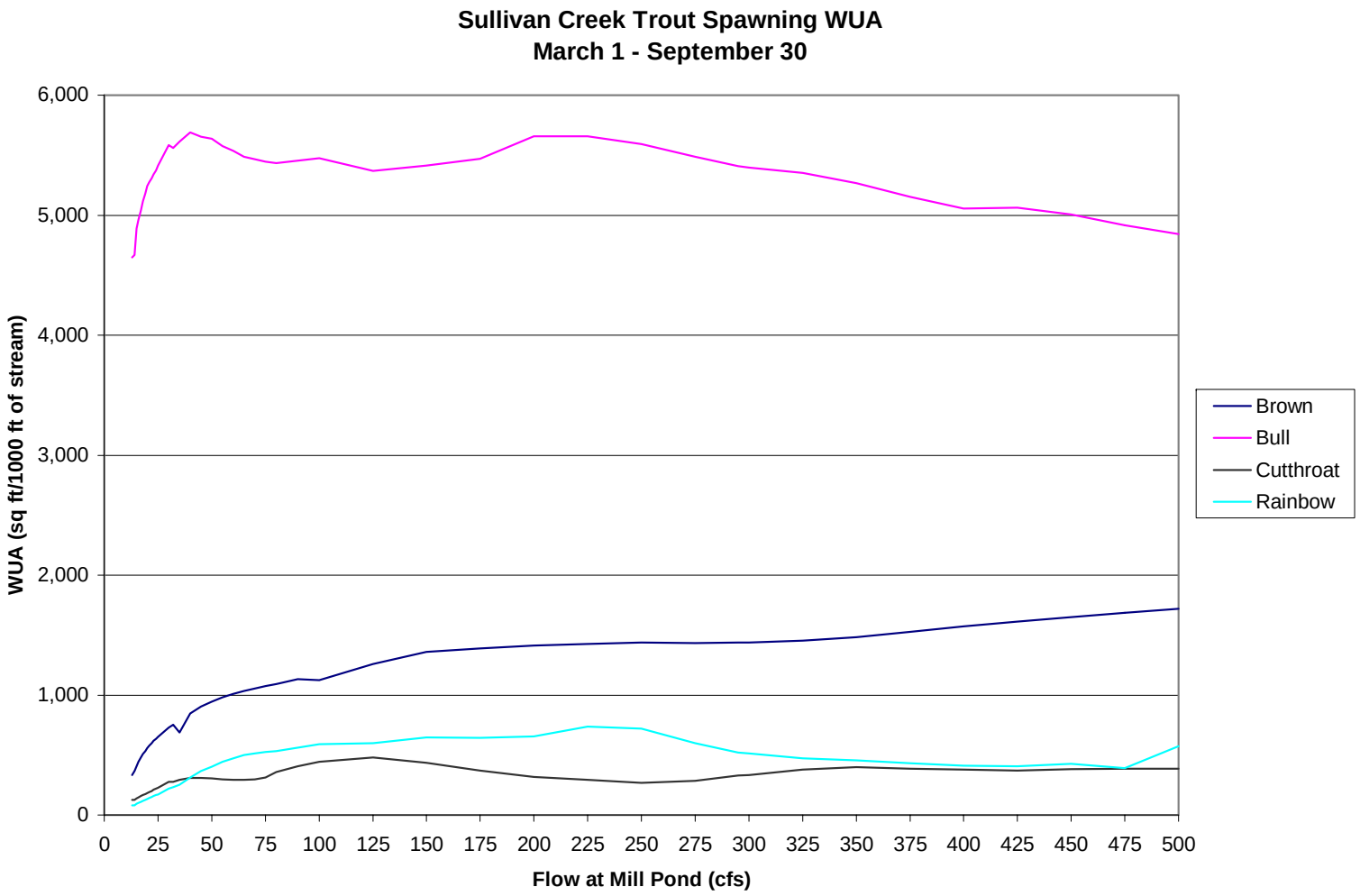


**Figure 2. Sullivan Creek trout spawning WUA, March 1 – September 30.**

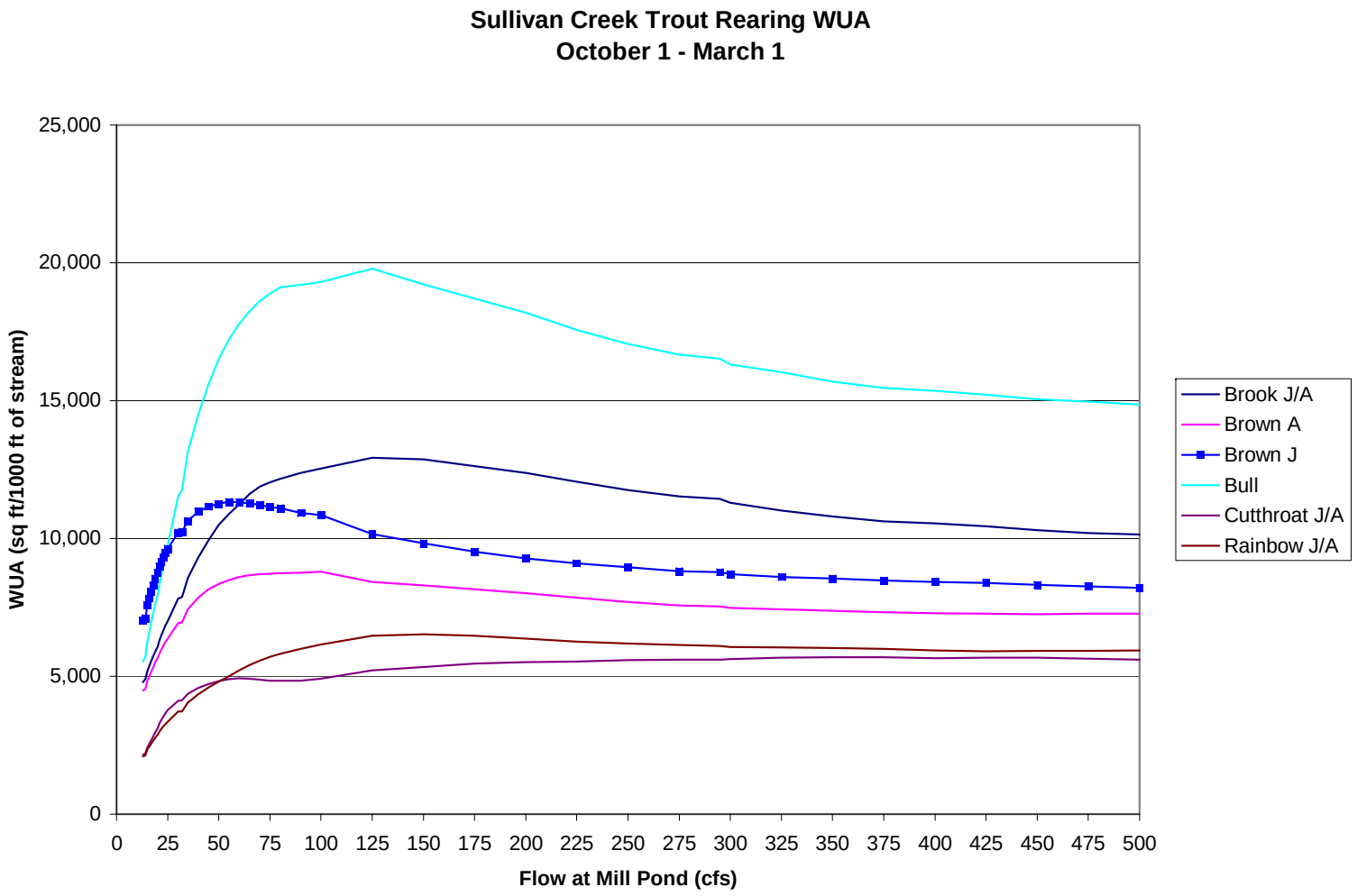


**Figure 3. Sullivan Creek trout juvenile and adult rearing WUA, October 1 - March 1.**

*WORKING DRAFT*

# DRAFT STUDY PLAN

# HABITAT SUITABILITY INDICES FOR SPECIES AND LIFE HISTORY STAGE PROPOSED FOR THE SULLIVAN CREEK INSTREAM FLOW STUDY

***Prepared for:***

**Sullivan Lake Hydroelectric Project Mediation Team**

And

**Public Utility District No. 1 of Pend Oreille County**
**Newport, WA**

***Prepared by:***

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***May 28, 2009***

# HABITAT SUITABILITY INDICES FOR SPECIES AND LIFE HISTORY STAGES PROPOSED FOR THE SULLIVAN CREEK INSTREAM FLOW STUDY

## 1.0 INTRODUCTION

The Public Utility District No. 1 of Pend Oreille County (PUD) has proposed to surrender the license for the Sullivan Lake Hydroelectric Project (FERC No. 2225). Under current operations, Sullivan Lake is drawn down approximately 20 feet each fall from its full pool elevation, beginning October 1.

The Sullivan Work Group is examining a proposal that would draw the lake down 2.4 feet during the summer period, with the fall drawdown commencing in either September or October. In the process of developing this scenario for the management of Sullivan Lake, several information needs were identified regarding the impacts of releases from Sullivan Lake into lower Sullivan Creek (below Mill Pond). These included, but were not limited to:

1. What would be the effects to fish and fish habitat of increased flows from Sullivan Lake on the fish populations downstream in Outlet Creek and Sullivan Creek?
    a. Flows to be released ranging from 100 – 300 cfs from Sullivan Lake
    b. Flows in Sullivan Creek attributable to Sullivan Creek only ranging from 100 – 250 cfs
2. What mean column velocities would be present in lower Sullivan Creek with the combined natural Sullivan Creek and the releases from Sullivan Lake?

The PUD has suggested that the instream flow study conducted on Sullivan Creek for the license amendment effort in 1994 be updated to evaluate the effects of increased flows on fish habitat in lower Sullivan Creek. The major components of this study are:

- The hydraulic model, consisting of 2 study sites and 17 transects (includes study site and transect weighting)
- Hydrology (differences of inflow to the Study Site 1 – the lower site – below the confluence of the North Fork Sullivan Creek
- Habitat Suitability Indices (HSI - previously referred to as preference curves)

The PUD has recommended that the calibrated hydraulic model and hydrology, which had previously been reviewed and approved by WDFW and WDOE, be retained from the earlier modeling effort. During the initial efforts, only brown trout and rainbow trout curves were run with the hydraulic model. Since then, rainbow curves have been updated, and curves for bull trout, cutthroat trout and possibly brook trout, have been requested.

The balance of this report presents the updated HSI curves that are proposed for use in the model.

## 2.0 SPECIES AND LIFE HISTORY STAGE CURVES PROPOSED FOR SULLIVAN CREEK

Habitat suitability data have been compiled for use in the model. Table 2-1 identifies the species, life history stage, and source for each HSI curve proposed for use in the model.

**Table 2-1. Proposed Habitat Suitability Curves**

| Species | Life stage | Source | Year |
|---|---|---|---|
| Rainbow Trout | Juvenile/Adult – Rearing | Washington Department of Fish and Wildlife | Updated 2008 |
| | Spawning | Washington Department of Fish and Wildlife | Updated 2008 |
| Brook Trout | Juvenile/Adult – Rearing | Washington Department of Fish and Wildlife | Updated 2008 |
| Brown Trout | Juvenile – Rearing | US Fish and Wildlife Service | Updated 1986 |
| | Adult – Rearing | US Fish and Wildlife Service | Updated 1986 |
| | Spawning | US Fish and Wildlife Service | Updated 1986 |
| Cutthroat Trout | Juvenile/Adult – Rearing | Washington Department of Fish and Wildlife | Updated 2008 |
| | Spawning | Washington Department of Fish and Wildlife | Updated 2008 |
| Bull Trout | Juvenile/Adult – Rearing | Washington Department of Fish and Wildlife | Updated 2008 |
| | Spawning | Washington Department of Fish and Wildlife | Updated 2008 |

The model uses three habitat suitability curves for each species and life history stage to model weighted usable area: a velocity curve, a depth curve, and a substrate/cover curve. Development of HSI curves is based on observations of fish in natural habitat. Fish are observed in certain locations, and habitat variables are measured at their location; namely, depth, velocity and substrate/cover. The depth and velocity measurements are sorted into uniform ranges (ex: depth ranges of 0.00 – 0.09, 0.10 – 0.19, 0.20 – 0.29, etc.). The frequency of fish observed in a particular range is compared with the frequency that the same range occurs in the natural habitat. From this comparison, species and life stage suitability's are developed. Suitability values are normalized to 1, resulting in a 0 – 1 scale; 0 being the lowest and 1 being the highest. Suitability values for each depth and velocity, ranging from 0 – 99.9, ft and ft/sec respectively, are designated in the model. The model then uses these numbers to compute WUA from the values assigned and the modeled depths and velocities corresponding to different discharges.

Substrate or cover HSI curves are developed in a similar manner but must be input with a numerical code representing the substrate or cover preferred by the species and life stage in question. The numerical code follows an XY.Z format. The X number represents the dominant substrate (composes 50% or more of the streambed), the Y number represents the subdominant substrate (composes 50% or less of the streambed), and the Z number indicates the percent of the streambed made up of the dominant substrate. The substrate codes in Table 2-2 are used to characterize the substrate in the XY.Z format for HSI curve development and IFIM model inputs.

**Table 2-2. IFIM Substrate Codes**
Source: WDFW 2008

| Code Number | Description | Diameter | |
|---|---|---|---|
| | | mm | in |
| 1 | Silt, clay, organics | <2 | <0.1 |
| 2 | Sand | <2 | <0.1 |
| 3 | Small gravel | 2 – 12 | 0.1 – 0.5 |
| 4 | Medium gravel | 12 – 38 | 0.5 – 1.5 |
| 5 | Large gravel | 38 – 76 | 1.5 – 3.0 |
| 6 | Small cobble | 76 – 152 | 3.0 – 6.0 |
| 7 | Large cobble | 152 – 305 | 6.0 – 12.0 |
| 8 | Boulder | >305 | >12 |
| 9 | Bedrock | | |

Cover codes follow the same XY.Z format with the exception that the X and Y values are always 0. The Z number in a cover code represents the type of cover present; cover codes are listed in Table 2-3. Only one substrate or cover code can be input in an IFIM model, professional judgment should be used to determine which code should be input in the model. Generally, the code with the highest habitat value should be used, but both codes should be noted in the field (WDFW, 2008). Limiting the X and Y numbers of cover codes to 0 allows for the development of a combined substrate/cover HSI curve to be used in a model.

**Table 2-3. IFIM Cover Codes**
Source: WDFW 2008

| Code | Description |
|---|---|
| 00.1 | Undercut bank |
| 00.2 | Overhanging vegetation[1] |
| 00.3 | Rootwad (including partly undercut) |
| 00.4 | Log jam/submerged brush pile |
| 00.5 | Log(s) parallel to bank/Rip-rap |
| 00.6 | Aquatic vegetation |
| 00.7 | Short (< 1 ft) terrestrial grass |
| 00.8 | Tall (> 3 ft) dense grass[2] |
| 00.9 | Vegetation beyond the bank-full waters edge |

[1]This includes low tree branches (< 3 vertical ft) and bushes overhanging the bank-full waters edge.
[2]This category refers to stout, almost bushy type grasses such as reed canary grass up to the bank-full waters edge.

## 3.0 HSI CURVE DATA FOR PROPOSED SPECIES AND LIFE HISTORY STAGES

HSI curves for each species and life history stage are presented in the tables below, based on the sources listed in Table2-1.

**Table 3-1. Rainbow Trout Juvenile/Adult Rearing Velocity Suitability Curve**
Source: WDFW

| Velocity (ft/s) | Suitability (0-1) |
|---|---|
| 0.00 | 0.25 |
| 0.85 | 1.00 |
| 1.75 | 0.45 |
| 2.65 | 0.40 |
| 3.70 | 0.10 |
| 5.25 | 0.00 |
| 99.99 | 0.00 |

**Table 3-2. Rainbow Trout Juvenile/Adult Rearing Depth Suitability Curve**
Source: WDFW

| Depth (ft) | Suitability (0-1) |
|---|---|
| 0.00 | 0.00 |
| 0.55 | 0.00 |
| 1.55 | 0.45 |
| 2.25 | 0.50 |
| 2.60 | 0.65 |
| 2.75 | 1.00 |
| 3.40 | 1.00 |
| 4.75 | 0.66 |
| 99.99 | 0.66 |

**Table 3-3. Rainbow Trout Spawning Velocity Suitability Curve**
Source: WDFW

| Velocity (ft/s) | Suitability (0-1) |
|---|---|
| 0.00 | 0.06 |
| 0.60 | 0.10 |
| 1.65 | 0.91 |
| 2.10 | 1.00 |
| 2.45 | 1.00 |
| 3.30 | 0.00 |
| 99.99 | 0.00 |

**Table 3-4. Rainbow Trout Spawning Depth Suitability Curve**
Source: WDFW

| Depth (ft) | Suitability (0-1) |
|---|---|
| 0.00 | 0.00 |
| 0.25 | 0.00 |
| 0.45 | 0.58 |
| 0.85 | 1.00 |
| 1.15 | 1.00 |
| 1.30 | 0.45 |
| 1.95 | 0.40 |
| 2.50 | 0.40 |
| 99.99 | 0.40 |

**Table 3-5. Brook Trout Juvenile/Adult Rearing Velocity Suitability Curve**
Source: WDFW

| Velocity (ft/s) | Suitability (0-1) |
|---|---|
| 0.00 | 0.66 |
| 0.50 | 0.75 |
| 1.05 | 1.00 |
| 1.35 | 1.00 |
| 1.45 | 0.83 |
| 2.15 | 0.75 |
| 2.25 | 0.50 |
| 3.80 | 0.00 |
| 99.99 | 0.00 |

**Table 3-6. Brook Trout Juvenile/Adult Rearing Depth Suitability Curve**
Source: WDFW

| Depth (ft) | Suitability (0-1) |
|---|---|
| 0.00 | 0.00 |
| 0.85 | 0.07 |
| 1.00 | 0.45 |
| 1.60 | 1.00 |
| 2.00 | 1.00 |
| 2.20 | 0.86 |
| 99.99 | 0.86 |

**Table 3-7. Brown Trout Juvenile Rearing Velocity Suitability Curve**
Source: USFWS

| Velocity (ft/s) | Suitability (0-1) |
|---|---|
| 0.00 | 0.58 |
| 0.10 | 0.88 |
| 0.50 | 1.00 |
| 1.00 | 0.92 |
| 1.50 | 0.70 |
| 2.00 | 0.26 |
| 3.50 | 0.05 |
| 4.30 | 0.00 |
| 99.99 | 0.00 |

**Table 3-8. Brown Trout Juvenile Rearing Depth Suitability Curve**
Source: USFWS

| Depth (ft) | Suitability (0-1) |
|---|---|
| 0.00 | 0.00 |
| 0.50 | 0.12 |
| 1.00 | 0.61 |
| 2.00 | 0.84 |
| 3.00 | 1.00 |
| 4.00 | 0.27 |
| 7.00 | 0.24 |
| 8.00 | 0.08 |
| 99.99 | 0.08 |

**Table 3-9. Brown Trout Adult Rearing Velocity Suitability Curve**
Source: USFWS

| Velocity (ft/s) | Suitability (0-1) |
|---|---|
| 0.00 | 0.21 |
| 0.10 | 0.70 |
| 0.50 | 1.00 |
| 1.00 | 0.69 |
| 1.50 | 0.50 |
| 2.40 | 0.20 |
| 3.10 | 0.03 |
| 5.00 | 0.03 |
| 6.00 | 0.00 |
| 99.99 | 0.00 |

**Table 3-10. Brown Trout Adult Rearing Depth Suitability Curve**
Source: USFWS

| Depth (ft) | Suitability (0-1) |
|---|---|
| 0.00 | 0.00 |
| 1.60 | 0.87 |
| 2.00 | 0.95 |
| 2.60 | 1.00 |
| 3.60 | 0.84 |
| 4.00 | 0.45 |
| 5.00 | 0.30 |
| 7.00 | 0.21 |
| 99.99 | 0.21 |

**Table 3-11. Brown Trout Spawning Velocity Suitability Curve**
Source: USFWS

| Velocity (ft/s) | Suitability (0-1) |
|---|---|
| 0.00 | 0.00 |
| 0.30 | 0.00 |
| 0.70 | 1.00 |
| 1.70 | 1.00 |
| 3.90 | 0.00 |
| 99.99 | 0.00 |

**Table 3-12. Brown Trout Spawning Depth Suitability Curve**
Source: USFWS

| Depth (ft) | Suitability (0-1) |
|---|---|
| 0.00 | 0.00 |
| 0.20 | 0.00 |
| 0.80 | 1.00 |
| 99.99 | 1.00 |

**Table 3-13. Cutthroat Trout Juvenile/Adult Rearing Velocity Suitability Curve**
Source: WDFW

| Velocity (ft/s) | Suitability (0-1) |
|---|---|
| 0.00 | 0.13 |
| 0.15 | 0.20 |
| 0.35 | 0.80 |
| 0.65 | 1.00 |
| 0.75 | 1.00 |
| 1.05 | 0.82 |
| 1.35 | 0.50 |
| 1.85 | 0.50 |
| 2.70 | 0.15 |
| 3.25 | 0.15 |
| 4.00 | 0.00 |
| 99.99 | 0.00 |

**Table 3-14. Cutthroat Trout Juvenile/Adult Rearing Depth Suitability Curve**
Source: WDFW

| Depth (ft) | Suitability (0-1) |
|---|---|
| 0.00 | 0.00 |
| 0.65 | 0.00 |
| 1.80 | 0.50 |
| 1.95 | 0.90 |
| 2.05 | 1.00 |
| 2.25 | 1.00 |
| 2.65 | 0.80 |
| 2.80 | 0.60 |
| 99.99 | 0.60 |

**Table 3-15. Cutthroat Trout Spawning Velocity Suitability Curve**
Source: WDFW

| Velocity (ft/s) | Suitability (0-1) |
|---|---|
| 0.00 | 0.00 |
| 0.15 | 0.00 |
| 0.40 | 0.30 |
| 0.55 | 0.90 |
| 0.95 | 1.00 |
| 1.15 | 1.00 |
| 1.50 | 0.80 |
| 2.00 | 0.26 |
| 3.00 | 0.00 |
| 99.99 | 0.00 |

**Table 3-16. Cutthroat Trout Spawning Depth Suitability Curve**
Source: WDFW

| Depth (ft) | Suitability (0-1) |
|---|---|
| 0.00 | 0.00 |
| 0.15 | 0.04 |
| 0.35 | 0.90 |
| 0.45 | 1.00 |
| 0.75 | 1.00 |
| 0.95 | 0.10 |
| 1.30 | 0.07 |
| 5.00 | 0.00 |
| 99.99 | 0.00 |

**Table 3-17. Bull Trout Juvenile/Adult Rearing Velocity Suitability Curve**
Source: WDFW

| Velocity (ft/s) | Suitability (0-1) |
|---|---|
| 0.00 | 0.22 |
| 0.60 | 0.88 |
| 1.30 | 1.00 |
| 2.25 | 1.00 |
| 2.80 | 0.80 |
| 3.45 | 0.00 |
| 99.99 | 0.00 |

**Table 3-18. Bull Trout Juvenile/Adult Rearing Depth Suitability Curve**
Source: WDFW

| Depth (ft) | Suitability (0-1) |
|---|---|
| 0.00 | 0.00 |
| 0.55 | 0.01 |
| 0.85 | 0.27 |
| 1.00 | 1.00 |
| 99.99 | 1.00 |

**Table 3-19. Bull Trout Spawning Velocity Suitability Curve**
Source: WDFW

| Velocity (ft/s) | Suitability (0-1) |
|---|---|
| 0.00 | 0.72 |
| 0.25 | 0.72 |
| 0.55 | 1.00 |
| 1.25 | 0.88 |
| 2.00 | 0.46 |
| 4.00 | 0.38 |
| 5.00 | 0.00 |
| 99.99 | 0.00 |

**Table 3-20. Bull Trout Spawning Depth Suitability Curve**
Source: WDFW

| Depth (ft) | Suitability (0-1) |
|---|---|
| 0.00 | 0.00 |
| 0.35 | 0.38 |
| 0.45 | 1.00 |
| 0.65 | 1.00 |
| 0.95 | 0.88 |
| 1.85 | 0.84 |
| 2.95 | 0.34 |
| 99.99 | 0.34 |

**Table 3-21. Rearing Substrate/Cover Suitability Curves**
Source: WDFW

| Rainbow Trout | | Brook Trout | | Cutthroat Trout | | Bull Trout | |
|---|---|---|---|---|---|---|---|
| **Substrate/ Cover Code** | **Juv/Adult Suitability[1] (0-1)** | **Substrate/ Cover Code** | **Juv/Adult Suitability[1] (0-1)** | **Substrate/ Cover Code** | **Juv/Adult Suitability (0-1)** | **Substrate/ Cover Code** | **Juv/Adult Suitability[1] (0-1)** |
| 00.1 | 1.00 | 00.1 | 1.00 | 00.1 | 1.00 | 00.1 | 1.00 |
| 00.2 | 1.00 | 00.2 | 1.00 | 00.2 | 1.00 | 00.2 | 1.00 |
| 00.3 | 1.00 | 00.3 | 1.00 | 00.3 | 1.00 | 00.3 | 1.00 |
| 00.4 | 1.00 | 00.4 | 1.00 | 00.4 | 1.00 | 00.4 | 1.00 |
| 00.5 | 0.80 | 00.5 | 0.80 | 00.5 | 0.80 | 00.5 | 0.80 |
| 00.6 | 0.80 | 00.6 | 0.80 | 00.6 | 0.80 | 00.6 | 0.80 |
| 00.7 | 0.10 | 00.7 | 0.10 | 00.7 | 0.10 | 00.7 | 0.10 |
| 00.8 | 0.70 | 00.8 | 0.70 | 00.8 | 0.70 | 00.8 | 0.70 |
| 00.9 | 0.20 | 00.9 | 0.20 | 00.9 | 0.20 | 00.9 | 0.20 |
| 11.9 | 0.10 | 11.9 | 0.10 | 11.9 | 0.10 | 11.9 | 0.10 |
| 13.9 | 0.10 | 13.9 | 0.10 | 13.9 | 0.10 | 13.9 | 0.10 |
| 14.5 | 0.20 | 14.5 | 0.20 | 14.5 | 0.20 | 14.5 | 0.20 |
| 14.9 | 0.12 | 14.9 | 0.12 | 14.9 | 0.12 | 14.9 | 0.12 |
| 15.5 | 0.20 | 15.5 | 0.20 | 15.5 | 0.20 | 15.5 | 0.20 |
| 15.9 | 0.12 | 15.9 | 0.12 | 15.9 | 0.12 | 15.9 | 0.12 |
| 16.5 | 0.30 | 16.5 | 0.30 | 16.5 | 0.30 | 16.5 | 0.30 |
| 16.9 | 0.14 | 16.9 | 0.14 | 16.9 | 0.14 | 16.9 | 0.14 |
| 17.5 | 0.40 | 17.5 | 0.40 | 17.5 | 0.40 | 17.5 | 0.40 |
| 17.9 | 0.16 | 17.9 | 0.16 | 17.9 | 0.16 | 17.9 | 0.16 |
| 18.5 | 1.00 | 18.5 | 1.00 | 18.5 | 1.00 | 18.5 | 1.00 |
| 18.9 | 1.00 | 18.9 | 1.00 | 18.9 | 1.00 | 18.9 | 1.00 |
| 19.5 | 0.20 | 19.5 | 0.20 | 19.5 | 0.20 | 19.5 | 0.20 |
| 19.9 | 0.12 | 19.9 | 0.12 | 19.9 | 0.12 | 19.9 | 0.12 |
| 21.5 | 0.10 | 21.5 | 0.10 | 21.5 | 0.10 | 21.5 | 0.10 |
| 23.9 | 0.10 | 23.9 | 0.10 | 23.9 | 0.10 | 23.9 | 0.10 |
| 24.5 | 0.20 | 24.5 | 0.20 | 24.5 | 0.20 | 24.5 | 0.20 |
| 24.9 | 0.12 | 24.9 | 0.12 | 24.9 | 0.12 | 24.9 | 0.12 |
| 25.5 | 0.20 | 25.5 | 0.20 | 25.5 | 0.20 | 25.5 | 0.20 |
| 25.9 | 0.12 | 25.9 | 0.12 | 25.9 | 0.12 | 25.9 | 0.12 |
| 26.5 | 0.30 | 26.5 | 0.30 | 26.5 | 0.30 | 26.5 | 0.30 |
| 26.9 | 0.14 | 26.9 | 0.14 | 26.9 | 0.14 | 26.9 | 0.14 |
| 27.5 | 0.40 | 27.5 | 0.40 | 27.5 | 0.40 | 27.5 | 0.40 |
| 27.9 | 0.16 | 27.9 | 0.16 | 27.9 | 0.16 | 27.9 | 0.16 |
| 28.5 | 1.00 | 28.5 | 1.00 | 28.5 | 1.00 | 28.5 | 1.00 |
| 28.9 | 1.00 | 28.9 | 1.00 | 28.9 | 1.00 | 28.9 | 1.00 |
| 29.5 | 0.20 | 29.5 | 0.20 | 29.5 | 0.20 | 29.5 | 0.20 |
| 29.9 | 0.12 | 29.9 | 0.12 | 29.9 | 0.12 | 29.9 | 0.12 |
| 31.5 | 0.10 | 31.5 | 0.10 | 31.5 | 0.10 | 31.5 | 0.10 |
| 33.9 | 0.10 | 33.9 | 0.10 | 33.9 | 0.10 | 33.9 | 0.10 |
| 34.5 | 0.20 | 34.5 | 0.20 | 34.5 | 0.20 | 34.5 | 0.20 |
| 34.9 | 0.12 | 34.9 | 0.12 | 34.9 | 0.12 | 34.9 | 0.12 |
| 35.5 | 0.20 | 35.5 | 0.20 | 35.5 | 0.20 | 35.5 | 0.20 |

**Table 3-21. Rearing Substrate/Cover Suitability Curves**
Source: WDFW

| Rainbow Trout | | Brook Trout | | Cutthroat Trout | | Bull Trout | |
|---|---|---|---|---|---|---|---|
| **Substrate/ Cover Code** | **Juv/Adult Suitability[1] (0-1)** | **Substrate/ Cover Code** | **Juv/Adult Suitability[1] (0-1)** | **Substrate/ Cover Code** | **Juv/Adult Suitability (0-1)** | **Substrate/ Cover Code** | **Juv/Adult Suitability[1] (0-1)** |
| 35.9 | 0.12 | 35.9 | 0.12 | 35.9 | 0.12 | 35.9 | 0.12 |
| 36.5 | 0.30 | 36.5 | 0.30 | 36.5 | 0.30 | 36.5 | 0.30 |
| 36.9 | 0.14 | 36.9 | 0.14 | 36.9 | 0.14 | 36.9 | 0.14 |
| 37.5 | 0.40 | 37.5 | 0.40 | 37.5 | 0.40 | 37.5 | 0.40 |
| 37.9 | 0.16 | 37.9 | 0.16 | 37.9 | 0.16 | 37.9 | 0.16 |
| 38.5 | 1.00 | 38.5 | 1.00 | 38.5 | 1.00 | 38.5 | 1.00 |
| 38.9 | 1.00 | 38.9 | 1.00 | 38.9 | 1.00 | 38.9 | 1.00 |
| 39.5 | 0.20 | 39.5 | 0.20 | 39.5 | 0.20 | 39.5 | 0.20 |
| 39.9 | 0.12 | 39.9 | 0.12 | 39.9 | 0.12 | 39.9 | 0.12 |
| 41.5 | 0.20 | 41.5 | 0.20 | 41.5 | 0.20 | 41.5 | 0.20 |
| 41.9 | 0.28 | 41.9 | 0.28 | 41.9 | 0.28 | 41.9 | 0.28 |
| 42.5 | 0.20 | 42.5 | 0.20 | 42.5 | 0.20 | 42.5 | 0.20 |
| 42.9 | 0.28 | 42.9 | 0.28 | 42.9 | 0.28 | 42.9 | 0.28 |
| 43.5 | 0.20 | 43.5 | 0.20 | 43.5 | 0.20 | 43.5 | 0.20 |
| 43.9 | 0.28 | 43.9 | 0.28 | 43.9 | 0.28 | 43.9 | 0.28 |
| 44.9 | 0.30 | 44.9 | 0.30 | 44.9 | 0.30 | 44.9 | 0.30 |
| 45.9 | 0.30 | 45.9 | 0.30 | 45.9 | 0.30 | 45.9 | 0.30 |
| 46.5 | 0.40 | 46.5 | 0.40 | 46.5 | 0.40 | 46.5 | 0.40 |
| 46.9 | 0.32 | 46.9 | 0.32 | 46.9 | 0.32 | 46.9 | 0.32 |
| 47.5 | 0.50 | 47.5 | 0.50 | 47.5 | 0.50 | 47.5 | 0.50 |
| 47.9 | 0.34 | 47.9 | 0.34 | 47.9 | 0.34 | 47.9 | 0.34 |
| 48.5 | 1.00 | 48.5 | 1.00 | 48.5 | 1.00 | 48.5 | 1.00 |
| 48.9 | 1.00 | 48.9 | 1.00 | 48.9 | 1.00 | 48.9 | 1.00 |
| 49.5 | 0.30 | 49.5 | 0.30 | 49.5 | 0.30 | 49.5 | 0.30 |
| 49.9 | 0.30 | 49.9 | 0.30 | 49.9 | 0.30 | 49.9 | 0.30 |
| 51.5 | 0.20 | 51.5 | 0.20 | 51.5 | 0.20 | 51.5 | 0.20 |
| 51.9 | 0.28 | 51.9 | 0.28 | 51.9 | 0.28 | 51.9 | 0.28 |
| 52.5 | 0.20 | 52.5 | 0.20 | 52.5 | 0.20 | 52.5 | 0.20 |
| 52.9 | 0.28 | 52.9 | 0.28 | 52.9 | 0.28 | 52.9 | 0.28 |
| 53.5 | 0.20 | 53.5 | 0.20 | 53.5 | 0.20 | 53.5 | 0.20 |
| 53.9 | 0.28 | 53.9 | 0.28 | 53.9 | 0.28 | 53.9 | 0.28 |
| 54.5 | 0.30 | 54.5 | 0.30 | 54.5 | 0.30 | 54.5 | 0.30 |
| 55.9 | 0.30 | 55.9 | 0.30 | 55.9 | 0.30 | 55.9 | 0.30 |
| 56.5 | 0.40 | 56.5 | 0.40 | 56.5 | 0.40 | 56.5 | 0.40 |
| 56.9 | 0.32 | 56.9 | 0.32 | 56.9 | 0.32 | 56.9 | 0.32 |
| 57.5 | 0.50 | 57.5 | 0.50 | 57.5 | 0.50 | 57.5 | 0.50 |
| 57.9 | 0.34 | 57.9 | 0.34 | 57.9 | 0.34 | 57.9 | 0.34 |
| 58.5 | 1.00 | 58.5 | 1.00 | 58.5 | 1.00 | 58.5 | 1.00 |
| 58.9 | 1.00 | 58.9 | 1.00 | 58.9 | 1.00 | 58.9 | 1.00 |
| 59.5 | 0.30 | 59.5 | 0.30 | 59.5 | 0.30 | 59.5 | 0.30 |
| 59.9 | 0.30 | 59.9 | 0.30 | 59.9 | 0.30 | 59.9 | 0.30 |
| 61.5 | 0.30 | 61.5 | 0.30 | 61.5 | 0.30 | 61.5 | 0.30 |

**Table 3-21. Rearing Substrate/Cover Suitability Curves**
Source: WDFW

| Rainbow Trout | | Brook Trout | | Cutthroat Trout | | Bull Trout | |
|---|---|---|---|---|---|---|---|
| **Substrate/ Cover Code** | **Juv/Adult Suitability[1] (0-1)** | **Substrate/ Cover Code** | **Juv/Adult Suitability[1] (0-1)** | **Substrate/ Cover Code** | **Juv/Adult Suitability (0-1)** | **Substrate/ Cover Code** | **Juv/Adult Suitability[1] (0-1)** |
| 61.9 | 0.46 | 61.9 | 0.46 | 61.9 | 0.46 | 61.9 | 0.46 |
| 62.5 | 0.30 | 62.5 | 0.30 | 62.5 | 0.30 | 62.5 | 0.30 |
| 62.9 | 0.46 | 62.9 | 0.46 | 62.9 | 0.46 | 62.9 | 0.46 |
| 63.5 | 0.30 | 63.5 | 0.30 | 63.5 | 0.30 | 63.5 | 0.30 |
| 63.9 | 0.46 | 63.9 | 0.46 | 63.9 | 0.46 | 63.9 | 0.46 |
| 64.5 | 0.40 | 64.5 | 0.40 | 64.5 | 0.40 | 64.5 | 0.40 |
| 64.9 | 0.48 | 64.9 | 0.48 | 64.9 | 0.48 | 64.9 | 0.48 |
| 65.5 | 0.40 | 65.5 | 0.40 | 65.5 | 0.40 | 65.5 | 0.40 |
| 65.9 | 0.48 | 65.9 | 0.48 | 65.9 | 0.48 | 65.9 | 0.48 |
| 66.9 | 0.50 | 66.9 | 0.50 | 66.9 | 0.50 | 66.9 | 0.50 |
| 67.5 | 0.60 | 67.5 | 0.60 | 67.5 | 0.60 | 67.5 | 0.60 |
| 67.9 | 0.52 | 67.9 | 0.52 | 67.9 | 0.52 | 67.9 | 0.52 |
| 68.5 | 1.00 | 68.5 | 1.00 | 68.5 | 1.00 | 68.5 | 1.00 |
| 68.9 | 1.00 | 68.9 | 1.00 | 68.9 | 1.00 | 68.9 | 1.00 |
| 69.5 | 0.40 | 69.5 | 0.40 | 69.5 | 0.40 | 69.5 | 0.40 |
| 69.9 | 0.48 | 69.9 | 0.48 | 69.9 | 0.48 | 69.9 | 0.48 |
| 71.5 | 0.40 | 71.5 | 0.40 | 71.5 | 0.40 | 71.5 | 0.40 |
| 71.9 | 0.64 | 71.9 | 0.64 | 71.9 | 0.64 | 71.9 | 0.64 |
| 72.5 | 0.40 | 72.5 | 0.40 | 72.5 | 0.40 | 72.5 | 0.40 |
| 72.9 | 0.64 | 72.9 | 0.64 | 72.9 | 0.64 | 72.9 | 0.64 |
| 73.5 | 0.40 | 73.5 | 0.40 | 73.5 | 0.40 | 73.5 | 0.40 |
| 73.9 | 0.64 | 73.9 | 0.64 | 73.9 | 0.64 | 73.9 | 0.64 |
| 74.5 | 0.50 | 74.5 | 0.50 | 74.5 | 0.50 | 74.5 | 0.50 |
| 74.9 | 0.66 | 74.9 | 0.66 | 74.9 | 0.66 | 74.9 | 0.66 |
| 75.5 | 0.50 | 75.5 | 0.50 | 75.5 | 0.50 | 75.5 | 0.50 |
| 75.9 | 0.66 | 75.9 | 0.66 | 75.9 | 0.66 | 75.9 | 0.66 |
| 76.5 | 0.60 | 76.5 | 0.60 | 76.5 | 0.60 | 76.5 | 0.60 |
| 76.9 | 0.68 | 76.9 | 0.68 | 76.9 | 0.68 | 76.9 | 0.68 |
| 77.9 | 0.70 | 77.9 | 0.70 | 77.9 | 0.70 | 77.9 | 0.70 |
| 78.5 | 1.00 | 78.5 | 1.00 | 78.5 | 1.00 | 78.5 | 1.00 |
| 78.9 | 1.00 | 78.9 | 1.00 | 78.9 | 1.00 | 78.9 | 1.00 |
| 79.5 | 0.50 | 79.5 | 0.50 | 79.5 | 0.50 | 79.5 | 0.50 |
| 79.9 | 0.66 | 79.9 | 0.66 | 79.9 | 0.66 | 79.9 | 0.66 |
| 81.5 | 1.00 | 81.5 | 1.00 | 81.5 | 1.00 | 81.5 | 1.00 |
| 89.9 | 1.00 | 89.9 | 1.00 | 89.9 | 1.00 | 89.9 | 1.00 |
| 91.5 | 0.20 | 91.5 | 0.20 | 91.5 | 0.20 | 91.5 | 0.20 |
| 91.9 | 0.28 | 91.9 | 0.28 | 91.9 | 0.28 | 91.9 | 0.28 |
| 92.5 | 0.20 | 92.5 | 0.20 | 92.5 | 0.20 | 92.5 | 0.20 |
| 92.9 | 0.28 | 92.9 | 0.28 | 92.9 | 0.28 | 92.9 | 0.28 |
| 93.5 | 0.20 | 93.5 | 0.20 | 93.5 | 0.20 | 93.5 | 0.20 |
| 93.9 | 0.28 | 93.9 | 0.28 | 93.9 | 0.28 | 93.9 | 0.28 |
| 94.5 | 0.30 | 94.5 | 0.30 | 94.5 | 0.30 | 94.5 | 0.30 |

**Table 3-21. Rearing Substrate/Cover Suitability Curves**
Source: WDFW

| Rainbow Trout | | Brook Trout | | Cutthroat Trout | | Bull Trout | |
|---|---|---|---|---|---|---|---|
| **Substrate/ Cover Code** | **Juv/Adult Suitability[1] (0-1)** | **Substrate/ Cover Code** | **Juv/Adult Suitability[1] (0-1)** | **Substrate/ Cover Code** | **Juv/Adult Suitability (0-1)** | **Substrate/ Cover Code** | **Juv/Adult Suitability[1] (0-1)** |
| 95.9 | 0.30 | 95.9 | 0.30 | 95.9 | 0.30 | 95.9 | 0.30 |
| 96.5 | 0.40 | 96.5 | 0.40 | 96.5 | 0.40 | 96.5 | 0.40 |
| 96.9 | 0.32 | 96.9 | 0.32 | 96.9 | 0.32 | 96.9 | 0.32 |
| 97.5 | 0.50 | 97.5 | 0.50 | 97.5 | 0.50 | 97.5 | 0.50 |
| 97.9 | 0.34 | 97.9 | 0.34 | 97.9 | 0.34 | 97.9 | 0.34 |
| 98.5 | 1.00 | 98.5 | 1.00 | 98.5 | 1.00 | 98.5 | 1.00 |
| 98.9 | 1.00 | 98.9 | 1.00 | 98.9 | 1.00 | 98.9 | 1.00 |
| 99.9 | 0.30 | 99.9 | 0.30 | 99.9 | 0.30 | 99.9 | 0.30 |

[1]Species specific curves not available, curves given as generic trout rearing HSI curve from WDFW.

**Table 3-22. Brown Trout Rearing Substrate/Cover Suitability Curves**
Source: USFWS

| **Substrate/ Cover Code[2,3]** | **Juvenile Suitability (0-1)** | **Substrate/ Cover Code[2,3]** | **Adult Suitability (0-1)** |
|---|---|---|---|
| 11.5 | 0.66 | 11.5 | 1.00 |
| 29.9 | 0.66 | 29.9 | 1.00 |
| 31.5 | 1.00 | 31.5 | 0.54 |
| 59.9 | 1.00 | 59.9 | 0.54 |
| 61.5 | 0.97 | 61.5 | 0.86 |
| 79.9 | 0.97 | 79.9 | 0.86 |
| 81.5 | 0.12 | 81.5 | 0.12 |
| 99.9 | 0.12 | 99.9 | 0.12 |

[2]USFWS substrate codes do not match WDFW substrate/cover codes and were adjusted to match WDFW substrate codes as closely as possible.
[3]USFWS did not include cover codes in the development of their substrate suitability curves.

**Table 3-23. Spawning Substrate/Cover Suitability Curves**
Source: WDFW

| Rainbow Trout[1] | | Cutthroat Trout[1] | | Bull Trout | |
|---|---|---|---|---|---|
| **Substrate/ Cover Code** | **Spawning Suitability (0-1)** | **Substrate/ Cover Code** | **Spawning Suitability (0-1)** | **Substrate/ Cover Code** | **Spawning Suitability (0-1)** |
| 11.9 | 0.00 | 11.9 | 0.00 | 11.9 | 0.00 |
| 13.9 | 0.00 | 13.9 | 0.00 | 31.7 | 0.00 |
| 16.9 | 0.00 | 16.9 | 0.00 | 31.8 | 0.80 |
| 17.5 | 0.00 | 17.5 | 0.00 | 31.9 | 0.90 |
| 21.5 | 0.00 | 21.5 | 0.00 | 32.5 | 0.00 |
| 23.9 | 0.00 | 23.9 | 0.00 | 32.7 | 0.00 |
| 26.9 | 0.00 | 26.9 | 0.00 | 32.8 | 0.80 |
| 27.5 | 0.00 | 27.5 | 0.00 | 32.9 | 0.90 |
| 29.9 | 0.00 | 29.9 | 0.00 | 33.9 | 1.00 |
| 31.5 | 0.00 | 31.5 | 0.00 | 35.9 | 1.00 |
| 31.7 | 0.00 | 31.7 | 0.00 | 36.5 | 0.85 |
| 31.8 | 0.64 | 31.8 | 0.64 | 36.9 | 0.97 |
| 31.9 | 0.72 | 31.9 | 0.72 | 37.5 | 0.85 |
| 32.5 | 0.00 | 32.5 | 0.00 | 37.9 | 0.97 |
| 32.7 | 0.00 | 32.7 | 0.00 | 38.5 | 0.50 |
| 32.8 | 0.64 | 32.8 | 0.64 | 38.9 | 0.90 |
| 32.9 | 0.72 | 32.9 | 0.72 | 39.5 | 0.00 |
| 33.9 | 0.80 | 33.9 | 0.80 | 41.7 | 0.00 |
| 34.5 | 0.90 | 34.5 | 0.90 | 41.8 | 0.80 |
| 34.9 | 0.82 | 34.9 | 0.82 | 41.9 | 0.90 |
| 35.5 | 0.80 | 35.5 | 0.80 | 42.5 | 0.00 |
| 35.9 | 0.80 | 35.9 | 0.80 | 42.7 | 0.00 |
| 36.5 | 0.65 | 36.5 | 0.65 | 42.8 | 0.80 |
| 36.9 | 0.77 | 36.9 | 0.77 | 42.9 | 0.90 |
| 37.5 | 0.40 | 37.5 | 0.40 | 43.5 | 1.00 |
| 37.9 | 0.72 | 37.9 | 0.72 | 45.9 | 1.00 |
| 38.5 | 0.40 | 38.5 | 0.40 | 46.5 | 0.85 |
| 38.9 | 0.72 | 38.9 | 0.72 | 46.9 | 0.97 |
| 39.5 | 0.00 | 39.5 | 0.00 | 47.5 | 0.85 |
| 41.7 | 0.00 | 41.7 | 0.00 | 47.9 | 0.97 |
| 41.8 | 0.80 | 41.8 | 0.80 | 48.5 | 0.50 |
| 41.9 | 0.90 | 41.9 | 0.90 | 48.9 | 0.90 |
| 42.5 | 0.00 | 42.5 | 0.00 | 49.5 | 0.00 |
| 42.7 | 0.00 | 42.7 | 0.00 | 51.7 | 0.00 |
| 42.8 | 0.80 | 42.8 | 0.80 | 51.8 | 0.80 |
| 42.9 | 0.90 | 42.9 | 0.90 | 51.9 | 0.90 |
| 43.5 | 0.90 | 43.5 | 0.90 | 52.5 | 0.00 |
| 43.9 | 0.98 | 43.9 | 0.98 | 52.7 | 0.00 |
| 44.9 | 1.00 | 44.9 | 1.00 | 52.8 | 0.80 |
| 45.5 | 0.90 | 45.5 | 0.90 | 52.9 | 0.90 |
| 45.9 | 0.98 | 45.9 | 0.98 | 53.5 | 1.00 |

**Table 3-23. Spawning Substrate/Cover Suitability Curves**
Source: WDFW

| Rainbow Trout[1] | | Cutthroat Trout[1] | | Bull Trout | |
|---|---|---|---|---|---|
| **Substrate/ Cover Code** | **Spawning Suitability (0-1)** | **Substrate/ Cover Code** | **Spawning Suitability (0-1)** | **Substrate/ Cover Code** | **Spawning Suitability (0-1)** |
| 46.5 | 0.75 | 46.5 | 0.75 | 55.9 | 1.00 |
| 46.9 | 0.95 | 46.9 | 0.95 | 56.5 | 0.85 |
| 47.5 | 0.50 | 47.5 | 0.50 | 56.9 | 0.97 |
| 47.9 | 0.90 | 47.9 | 0.90 | 57.5 | 0.85 |
| 48.5 | 0.50 | 48.5 | 0.50 | 57.9 | 0.97 |
| 48.9 | 0.90 | 48.9 | 0.90 | 58.5 | 0.85 |
| 49.5 | 0.00 | 49.5 | 0.00 | 58.9 | 0.97 |
| 51.7 | 0.00 | 51.7 | 0.00 | 59.5 | 0.00 |
| 51.8 | 0.64 | 51.8 | 0.64 | 61.7 | 0.00 |
| 51.9 | 0.72 | 51.9 | 0.72 | 61.8 | 0.56 |
| 52.5 | 0.00 | 52.5 | 0.00 | 61.9 | 0.63 |
| 52.7 | 0.00 | 52.7 | 0.00 | 62.5 | 0.00 |
| 52.8 | 0.64 | 52.8 | 0.64 | 62.7 | 0.00 |
| 52.9 | 0.72 | 52.9 | 0.72 | 62.8 | 0.56 |
| 53.5 | 0.80 | 53.5 | 0.80 | 62.9 | 0.63 |
| 53.9 | 0.80 | 53.9 | 0.80 | 63.5 | 0.85 |
| 54.5 | 0.90 | 54.5 | 0.90 | 63.9 | 0.73 |
| 54.9 | 0.82 | 54.9 | 0.82 | 64.5 | 0.85 |
| 55.9 | 0.80 | 55.9 | 0.80 | 64.9 | 0.73 |
| 56.5 | 0.65 | 56.5 | 0.65 | 65.5 | 0.85 |
| 56.9 | 0.77 | 56.9 | 0.77 | 65.9 | 0.73 |
| 57.5 | 0.40 | 57.5 | 0.40 | 66.9 | 0.70 |
| 57.9 | 0.72 | 57.9 | 0.72 | 67.9 | 0.70 |
| 58.5 | 0.40 | 58.5 | 0.40 | 68.5 | 0.35 |
| 58.9 | 0.72 | 58.9 | 0.72 | 68.9 | 0.63 |
| 59.5 | 0.00 | 59.5 | 0.00 | 69.5 | 0.00 |
| 61.7 | 0.00 | 61.7 | 0.00 | 71.7 | 0.00 |
| 61.8 | 0.40 | 61.8 | 0.40 | 71.8 | 0.56 |
| 61.9 | 0.45 | 61.9 | 0.45 | 71.9 | 0.63 |
| 62.5 | 0.00 | 62.5 | 0.00 | 72.5 | 0.00 |
| 62.7 | 0.00 | 62.7 | 0.00 | 72.7 | 0.00 |
| 62.8 | 0.40 | 62.8 | 0.40 | 72.8 | 0.56 |
| 62.9 | 0.45 | 62.9 | 0.45 | 72.9 | 0.63 |
| 63.5 | 0.65 | 63.5 | 0.65 | 73.5 | 0.85 |
| 63.9 | 0.53 | 63.9 | 0.53 | 73.9 | 0.73 |
| 64.5 | 0.75 | 64.5 | 0.75 | 74.5 | 0.85 |
| 64.9 | 0.55 | 64.9 | 0.55 | 74.9 | 0.73 |
| 65.5 | 0.65 | 65.5 | 0.65 | 75.5 | 0.85 |
| 65.9 | 0.53 | 65.9 | 0.53 | 75.9 | 0.73 |
| 66.9 | 0.50 | 66.9 | 0.50 | 76.5 | 0.70 |
| 67.5 | 0.25 | 67.5 | 0.25 | 76.9 | 0.70 |
| 67.9 | 0.45 | 67.9 | 0.45 | 77.9 | 0.70 |

**Table 3-23. Spawning Substrate/Cover Suitability Curves**
Source: WDFW

| Rainbow Trout[1] | | Cutthroat Trout[1] | | Bull Trout | |
|---|---|---|---|---|---|
| **Substrate/ Cover Code** | **Spawning Suitability (0-1)** | **Substrate/ Cover Code** | **Spawning Suitability (0-1)** | **Substrate/ Cover Code** | **Spawning Suitability (0-1)** |
| 68.5 | 0.25 | 68.5 | 0.25 | 78.5 | 0.35 |
| 68.9 | 0.45 | 68.9 | 0.45 | 78.9 | 0.63 |
| 69.5 | 0.00 | 69.5 | 0.00 | 79.5 | 0.00 |
| 69.9 | 0.00 | 69.9 | 0.00 | 82.9 | 0.00 |
| 71.5 | 0.00 | 71.5 | 0.00 | 83.5 | 0.50 |
| 72.9 | 0.00 | 72.9 | 0.00 | 83.9 | 0.10 |
| 73.5 | 0.00 | 73.5 | 0.00 | 84.5 | 0.50 |
| 76.9 | 0.00 | 76.9 | 0.00 | 84.9 | 0.10 |
| 77.9 | 0.00 | 77.9 | 0.00 | 85.5 | 0.50 |
| 82.9 | 0.00 | 82.9 | 0.00 | 85.9 | 0.10 |
| 83.5 | 0.00 | 83.5 | 0.00 | 86.5 | 0.35 |
| 86.9 | 0.00 | 86.9 | 0.00 | 86.9 | 0.07 |
| 87.5 | 0.00 | 87.5 | 0.00 | 87.5 | 0.35 |
| 92.9 | 0.00 | 92.9 | 0.00 | 87.9 | 0.07 |
| 93.5 | 0.00 | 93.5 | 0.00 | 88.9 | 0.00 |
| 96.9 | 0.00 | 96.9 | 0.00 | 93.5 | 0.00 |
| 97.5 | 0.00 | 97.5 | 0.00 | 97.9 | 0.00 |
| 99.9 | 0.00 | 99.9 | 0.00 | 99.9 | 0.00 |

[1]Species specific curves not available, curves given as generic trout spawning HSI curve from WDFW.

**Table 3-24. Brown Trout Spawning Substrate Suitability Curve**
Source: USFWS

| Substrate Code[4] | Suitability (0-1) |
|---|---|
| 11.50 | 0.00 |
| 29.90 | 0.00 |
| 31.50 | 1.00 |
| 59.90 | 1.00 |
| 61.50 | 0.00 |
| 99.90 | 0.00 |

[4]The USFWS suitability curve was developed using diameter of substrate size instead of a substrate code. Substrate diameter was changed to a substrate code to define the suitability curve.

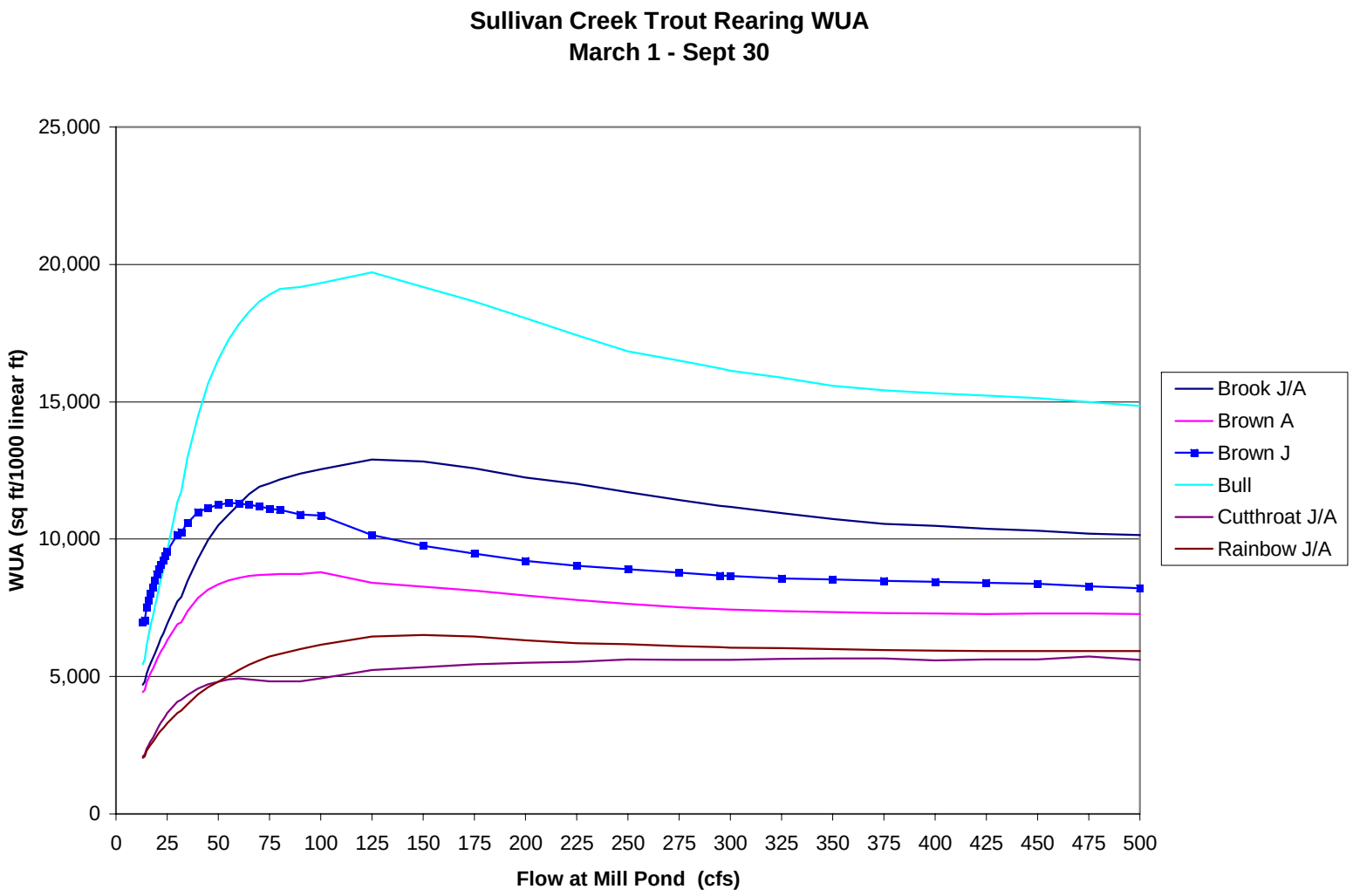


**Figure 4. Sullivan Creek trout juvenile and adult rearing WUA, March 1 – September 30.**

# APPLICATION FOR SURRENDER OF LICENSE
# SULLIVAN CREEK PROJECT
# FERC NO. 2225

## APPENDIX E.4-7
### REVIEW OF LAKE FERTILIZATION

# Sockeye salmon (*Oncorhynchus nerka*) nursery lake fertilization: Review and summary of results

**K.D. Hyatt, D.J. McQueen, K.S. Shortreed, and D.P. Rankin**

**Abstract**: We reviewed 24 sockeye salmon (*Oncorhynchus nerka*) nursery lake experiments that involved whole-lake fertilization with appropriate treatment and control years. We found that: 21 of 21 studies showed that fertilization was associated with increased chlorophyll *a* concentrations, 16 of 16 showed increased zooplankton biomasses, 16 of 16 demonstrated increased average smolt weights, and 11 of 13 showed increased smolt biomasses. Studies involving assessments of egg-to-smolt survival were rare, but all (4 of 4) showed increased survival rates. Studies involving increased smolt-to-adult survival (i.e., marine survival) were even rarer, but all (3 of 3) showed that lake fertilization and increased smolt size were associated with increased marine survival. Several fertilization studies reported problems, and some offered solutions. For instance, when whole-lake fertilization stimulated the growth of blue-green algae, fertilizer with higher nitrogen to phosphorus ratios was used to control the problem. Conversely, when high nitrogen to phosphorus ratios were associated with blooms of ungrazable diatoms, notably *Rhizosolenia eriensis*, reduced nitrate concentrations were recommended. To date, solutions designed to constrain the growth of both blue-green algae and *Rhizosolenia* blooms remain elusive. Some studies showed that when both mysids (large invertebrate planktivores) and juvenile sockeye inhabit the same lake, sockeye suffer from a competitive disadvantage and mysids consume 80–90% of the available zooplanktonic food production. Similarly, a small number of studies demonstrated that competition from sticklebacks (*Gasterosteus aculeatus*) adversely affected sockeye growth rates, and although the problem remains unresolved, ongoing work in lakes containing kokanee (*O. nerka*), suggests that stocked cutthroat trout (*Salmo clarki*) may be capable of controlling stickleback densities through predation. Despite all of these difficulties, in almost all cases, when lakes were fertilized with various mixtures of inorganic nitrogen and phosphorus, pelagic food web bottom-up control was strong enough and predictable enough to ensure that sockeye smolt biomass increased. We conclude that sockeye nursery lake fertilization is a technique that can contribute usefully to both the enhancement and conservation of sockeye salmon populations.

*Key words:* sockeye salmon, lake fertilization, bottom-up, aquatic food web.

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**Résumé** : Les auteurs ont examiné 24 expériences conduites sur la pisciculture du saumon sockeye en lacs, lesquelles impliquent la fertilisation en vrac avec des traitements appropriés et des années témoins. On constate que : 21 des 21 études montrent que la fertilisation est associée avec une augmentation de la teneur en chlorophylle *a*, 16 sur 16 montrent une augmentation des biomasses de zooplancton, 16 sur 16 conduisent à une augmentation des poids moyens des saumoneaux, et 11 sur 13 se traduisent par une augmentation des biomasses en saumoneaux. Les études impliquant des évaluations de la survie, allant de l'œuf au saumoneau, sont rares, mais toutes (4 sur 4) montrent une augmentation des taux de survie. Les études qui portent sur la survie, allant du saumoneau à l'adulte (i. e. survie en mer), sont encore plus rares, mais toutes (3 sur 3) montrent que la fertilisation des lacs et l'augmentation des dimensions des saumoneaux sont associées à une augmentation de la survie marine. Plusieurs études sur la fertilisation font mention de problèmes, et quelques unes proposent des solutions. Par exemple, lorsque la fertilisation en vrac des lacs stimule la croissance d'algues bleues vertes, on utilise des fertilisants ayant des rapports azote/phosphore plus élevés, pour maîtriser le problème. Réciproquement, lorsque des rapports élevés en azote/phosphore sont associés avec une prolifération de diatomées non pâturables, nommément le *Rhizoselenia eriensis*, on recommande de réduire les nitrates. Jusqu'ici, les solutions conçues pour contrôler la croissance des algues bleues vertes aussi bien que la prolifération des *Rhizoselenia*, demeurent élusives. Quelques études montrent que lorsque les mysis (gros planctivores invertébrés) et les jeunes saumons sockeyes habitent le même lac, les saumons souffrent de la compétition, et les mysis consomment 80–90 % de la production en nourriture zooplanctonique. Dans la même veine, un petit nombre d'études démontrent que la compétition par les épinoches (*Gasterosterus aculeatus*) nuisent aux taux de croissance des saumons, et bien que le problème demeure sans solution, les travaux en cours dans des lacs contenant du saumon kokanee (*O. nerka*) suggèrent que la truite fardée introduite (*Salmo clarkii*) pourrait être capable de limiter la densité des épinoches par prédation. En dépit de ces difficultés, dans presque tous les cas, lorsque les lacs sont fertilisés avec divers mélanges d'azote et de phosphore inorganiques, la maîtrise du réseau de nourriture pélagique est suffisamment grande et prévisible pour assurer que la biomasse des saumons sockeyes augmente. Les auteurs concluent que la pisciculture du saumon sockeye en lacs est une technique qui contribue de façon concrète, à la fois à l'augmentation et à la conservation des populations du saumon sockeye.

*Mots clés :* saumon sockeye, fertilisation lacustre, de bas en haut, chaine alimentaire aquatique.

[Traduit par la Rédaction]

## Introduction

More than 70 years ago, Juday et al. (1932) suggested that biogenic nutrient deposition from the carcasses of spawning salmon was responsible for the unusually luxuriant algal and zooplankton communities found in Karluk Lake, on Kodiak Island, Alaska. Five years later, Ricker (1937) also discussed nutrient contributions from carcasses in Cultus Lake, British Columbia, and wrote "The death and decay of adult salmon has for long been considered as resulting in an important accession of nutrient elements by the lake." Nelson and Edmonson (1955) were the first to actually attempt the artificial fertilization of a sockeye nursery lake. They introduced their ground-breaking study by reviewing data from Karluk Lake (37 $km^2$), where sockeye returns had declined from approximately 3 million during the late 1800s to less than 1 million during 1944–1953. They attributed this decline to the combined effects of overfishing and changes in the freshwater environment. They hypothesized that during years of high spawner abundance, nutrients from salmon carcasses stimulated algal production, resulting in more zooplankton, increased food consumption by sockeye fry, larger smolts, and (citing Barnaby 1944) therefore better marine survival. Nelson and Edmonson (1955) then went on to suggest that observed declines might be reversed by adding artificial fertilizers during years when returns were low. This suggestion led to

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a proposed pilot experiment at Bare Lake (0.49 $km^2$, situated near Karluk Lake). During 1950–1953, Bare Lake was fertilized seven times, and both primary production and algal biomasses increased, but there was no change in zooplankton biomass (Nelson and Edmondson 1955). The result was that Karluk Lake was never fertilized, and Alaskan nursery lake fertilizations were not reinitiated until the 1970s (Kyle et al. 1997).

Activity in British Columbia began in 1969 when a group of scientists from the Pacific Biological Station at Nanaimo put theory into practice at Great Central Lake (GCL), Vancouver Island, B.C. This large-scale lake fertilization experiment was based on the assertion (Barraclough and Robinson 1972) that "Decomposing bodies of anadromous fish, such as sockeye salmon (*Oncorhynchus nerka)* contribute to the fertilization of nursery lakes following spawning in the lake. ... removal of maturing sockeye by the commercial fishery may deny lake waters of their essential nutrients and contribute to lowered productivity." The objective of the Great Central Lake experiment was to test the hypothesis that artificial fertilization could replace nutrient losses associated with sockeye carcasses removed by the commercial fishery. In-lake productivity responses (Parsons et al. 1972; LeBrasseur and Kennedy 1972; Barraclough and Robinson 1972) and subsequent increases in adult returns associated with the first year of fertilization (1970) were judged to be very "positive" and a long-term fertilization program was approved for Great Central Lake. During the late 1970s, a large-scale Lake Enrichment Program (LEP) was established. It began with six lakes and grew until the early 1990s to include 17 (Hilborn and Winton 1993). Since then, priorities within the Department of Fisheries and Oceans have changed, and federally funded lake fertilization has been all but abandoned. In Alaska, during 1979, the Division of Fisheries Rehabilitation, Enhancement, and Development (FRED), a section of the Alaska Department of Fish and Game, initiated a nutrient enrichment and fry outplanting program that included 16 lakes (Kyle et al. 1997). During the 1990s, support for FRED declined and most Alaskan lake fertilization projects were halted.

As we move into the early 21st century, priorities for nursery lake fertilization have begun to change. The emphasis is no longer on stock enhancement for the commercial fishery. Rather, the emphasis has shifted to stock conservation. During the last 50 years, continuous over-fishing, freshwater habitat destruction, and climate-induced marine survival failures have decimated many sockeye stocks. Now, a few government agencies, non-governmental organizations, and First Nations are actively using or considering the use of sockeye nursery lake fertilization to conserve stocks that are depressed, threatened, or near extinction. The review that follows may assist with that important work.

## Food web theory

Lake fertilization theory is based on two assumptions. The first is that the size and survival advantages gained by sockeye fry originating from fertilized lakes can be successfully carried into the marine environment, thus ensuring increased returns of adults. The second assumption is that juvenile sockeye biomass in the pelagic zones of lakes is primarily regulated by nutrient availability ("bottom-up" control) and that substantial portions of the nutrient added at the bottom of a food web will successfully make its way from algae, through zooplankton, to fish.

With respect to the first assumption, Ricker (1962) showed that over a broad geographic range there is a positive relationship between sockeye smolt length and marine survival. Similar relationships have also been demonstrated for sockeye from the Karluk River (Barnaby 1944) and Cultus Lake (Foerster 1954). The question is: Do these general patterns apply to sockeye nursery lakes, where artificial fertilization is applied to increase smolt size and production?

With respect to the second assumption, there is general agreement that decomposing bodies of spawning salmon contribute highly variable, but sometimes substantial fractions (0–95%, depending on the lake) of the annual nutrient load to sockeye nursery lakes (Willson and Halupka 1995; Bilby et al. 1996; Larkin and Slaney 1997; Cederholm et al. 1989, 1999; Gresh et al. 2000; Thomas et al. 2002). There is also some consensus that phosphorus and nitrogen availability can be augmented through lake

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fertilization (Stockner and MacIsaac 1996; Kyle et al. 1997). Nelson and Edmondson (1955) were the first to clearly delineate the fertilizer enhancement theory (carcasses → nutrients → phytoplankton → zooplankton → increased food consumption by fry → larger smolts → increased marine survival) that is generally accepted today. The assumption is that bottom-up control is both predictable and strong. Over the past 30 years, the food web literature has verified the general predictability of bottom-up relationships between (1) nutrients and algae (reviewed in Dillon and Rigler (1975) and Stockner and Shortreed (1985)), (2) algae and zooplankton (reviewed in McCauley and Kalff (1981) and Hanson and Peters (1984)), and (3) zooplankton and planktivorous fish (reviewed in Downing et al. (1990) and Koenings and Kyle (1997)).

However, during the last 20 years, the same literature has featured considerable disagreement about the relative strength of these bottom-up relations in comparison with top-down processes, which tend to reduce bottom-up control (reviewed in Shapiro and Wright (1984), McQueen (1998), McQueen et al. (1986, 1989), Carpenter et al. (1985, 2001), Mehner et al. (2002), and Jeppesen et al. (2003)). Briefly stated, food web theory supports the general assertion that overall trophic level biomass is regulated by nutrient availability, but there are many top-down processes that can influence energy transfer up pelagic food webs (reviewed in McQueen et al. (2001)). Some of the main factors are (1) the effects of algal cell size and species composition on relative grazability of algae by zooplankton (Hyatt et al. 2004), (2) the effects of algal species composition on availability of fatty acids required for enhanced zooplankton growth (Brett et al. 2000), (3) the influence of regional diversity pools on the availability of the large-bodied zooplankton most favored by planktivorous fish (Matveev et al. 1994), (4) the effects of diel migration on the availability of zooplankton as prey for juvenile sockeye (Levy 1990; Cooper et al. 1992), (5) the effects of grazer body size on rates of phosphorus excretion and recycling by zooplankton (Vanni 1996), (6) the rates of nutrient transport and (or) sedimentation caused by predator-induced changes in zooplankton body size and (or) species composition (Taylor and Carter 1997), (7) abundances of invertebrate planktivores that might be expected to reduce grazer abundance and therefore food availability for planktivorous fish (Benndorf 1995), (8) changes in fish-induced transport of phosphorus from the benthos to the pelagic zone (Perez-Fuentetaja et al. 1996), and (9) potential competitive interactions between juvenile sockeye and other pelagic planktivorous fish (Hyatt et al. 2004). Given the potential effects of these and other top-down factors, there remains considerable uncertainty about the proportion of fertilizer-induced energy captured by phytoplankton that can successfully move from algae to fish. The question remains: Can substantial amounts of the photosynthetically fixed energy stimulated by the addition of fertilizers to lakes make its way up the pelagic food web, causing juvenile sockeye to survive better and (or) grow larger?

## Organization of this review

In the pages that follow we have reviewed 24 sockeye nursery lake fertilization experiments. We have divided these studies geographically into those based in Alaska, British Columbia, and the Columbia River, Idaho. In all cases we have summarized relevant lake characteristics, fertilizer quantities, and experimental designs and durations. We have then compared (fertilized vs. unfertilized) averages for epilimnetic nutrient concentrations, phytoplankton biomass and (or) chlorophyll *a* concentrations, zooplankton biomasses, juvenile sockeye growth rates, juvenile sockeye survival, and where available, smolt to adult survival rates. Lake-specific summaries are also provided in Tables 1 to 3. Readers interested in an overview rather than detail may wish to skip these lake-by-lake summaries and move on to the two final sections. The first of these is titled "Cautionary tales" and deals with the problems that have been encountered during various nursery lake fertilizations. The second, titled "Summary of general outcomes", identifies emergent generalizations and explores the relationship between the quantity of nutrients added and lake responses.

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**Table 1.** British Columbia, Lake Enrichment Program (LEP) data, summarized from Stockner and Hyatt (1984) and Shortreed et al. (2001).

| | | Treatment years | | N and P added ($g\ ha^{-1}\ a^{-1}$) | | Mean summer Chl *a* ($\mu g\ L^{-1}$) | | Mean zooplankton biomass ($mg\ m^{-2}$ dw) | |
|---|---|---|---|---|---|---|---|---|---|
| Lake | Area (ha) | NF | F | N | P | NF | F | NF | F |
| Bonilla | 230 | 1979 | 1980 | 18 217 | 2 696 | 1.00 | 5.40 | 280 | 700 |
| Kennedy Clayoquot Arm | 1 700 | 1977 | 1978 | 9 094 | 1 982 | | | 280 | 400 |
| Kennedy MA | 4 700 | 1978 | 1979 | 4 268 | 649 | | | 270 | 400 |
| Curtis | 300 | 1979 | 1980 | 6 067 | 900 | 1.24 | 4.02 | 100 | 150 |
| Long | 2 100 | 1981 | 1982 | 7 143 | 1 048 | 2.24 | 2.48 | 150 | 350 |
| Morice | 9 610 | 1978 | 1980 | 3 479 | 527 | | | 750 | 820 |
| Sproat | 4 100 | | 1985–1986 | 11 139 | 493 | 0.60 | 1.08 | 285 | 590 |
| Nimpkish | 3 700 | | 1982–1987, 1989 | 3 327 | 730 | 0.80 | 1.78 | 73 | 260 |
| Devon | 180 | 1979, 1981 | 1980 | 6 222 | 944 | 1.79 | 4.57 | 77 | 108 |
| Lowe | 370 | | 1979–1982 | 7 980 | 1 169 | 1.22 | 1.34 | 180 | 815 |

**Note:** N, total nitrogen; P, total phosphorus; Chl a, chlorophyll *a*; NF, years when not fertilized; F, years when fertilized.

**Table 2.** British Columbia, Lake Enrichment Program data summarized from Hyatt and Stockner (1985). Calculation of smolt biomass assumes no mortality from fall fry to smolt.

| | | Treatment years | | Loading rates ($g\ ha^{-1}\ a^{-1}$) | | Age 1 smolt weights (g) | | Fall-fry densities ($ha^{-1}$) | | Smolt biomass ($ha^{-1}$) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Lake | Area (ha) | NF | F | N | P | NF | F | NF | F | NF | F |
| Kennedy Clayoquot Arm | 1 700 | 1977 | 1978 | 9 094 | 1 982 | 1.98 | 2.55 | 2 025 | 3 260 | 4 010 | 8 313 |
| Great Central Lake | 5 100 | 1969, 1974–1976 | 1977–1981 | 4 029 | 716 | 2.78 | 4.28 | 2 500 | 2 103 | 6 950 | 9 001 |
| Long | 2 100 | 1980–1981 | 1977–1979 | 9 710 | 1 946 | 2.47 | 2.82 | 4 313 | 7 016 | 10 653 | 19 785 |
| Bonilla | 230 | 1979 | 1980–1981 | 20 891 | 3 196 | 1.62 | 2.25 | 1 222 | 5 473 | 1 980 | 12 314 |
| Devon | 180 | 1979, 1981 | 1980 | 6 222 | 944 | 2.62 | 4.35 | 2 903 | 2 796 | 7 606 | 12 163 |
| Curtis | 300 | 1979 | 1980–1981 | 10 867 | 1 617 | 1.09 | 2.78 | 1 589 | 4 287 | 1 732 | 11 918 |
| Kitlope | 1 260 | 1978 | 1979–1980 | 8 944 | 1 381 | 2.14 | 5.20 | 310 | 208 | 663 | 1 082 |

**Note:** N, total nitrogen; P, total phosphorus; Chl a, chlorophyll *a*; NF, years when not fertilized; F, years when fertilized.

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**Table 3.** Multi-year lake fertilization studies. Summary of some data provided in the text. Calculation of smolt biomass assumes no mortality from fall-fry to smolt. All of the comparisons involve the same lake "before and after" treatment. The exception is the Woss–Vernon experiment where Woss Lake was fertilized and Vernon Lake used as an unfertilized reference.

| | | Treatment years | | Loading ($g\ ha^{-1}\ a^{-1}$) | | TP ($\mu g\ L^{-1}$) | | Chl a ($\mu g\ L^{-1}$) | | Zoop biomass ($mg\ m^{-2}$) | | Smolt weight (g) | | Smolt biomass ($g\ ha^{-1}$) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Area (ha) | NF | F | N | P | NF | F | NF | F | NF | F | NF | F | NF | F |
| Great Central Lake | 5 100 | 1969, 1974–1976 | 1970–1973 | 5 184 | 1 227 | | | 7.00 | 11.00 | 900 | 7 400 | 2.78 | 3.13 | 6 950 | 5 822 |
| Hobiton | 360 | 1984 | 1980–1983 | 5 840 | 861 | 2.1 | 3.2 | 1.30 | 2.20 | | | | | | |
| Kennedy Clayoquot Arm | 1 700 | 1977, 1985 | 1978–1984 | 9 571 | 1 157 | 1.5 | 4.3 | 0.95 | 4.70 | | | | | | |
| Kennedy MA | 4 700 | 1977–1978, 1981–1984 | 1979–1980, 1985 | 5 691 | 613 | 1.6 | 2.2 | 1.14 | 2.30 | | | | | | |
| Yakoun | 810 | 1982, 1986–1998[a] | 1983–1985 | 3 563 | 553 | 1.9 | 4.0 | 1.69 | 3.28 | | | 1.12 | 2.47 | 2 700 | 1 700 |
| Woss–Vernon | 1 300 | 2000–2003 | 2000–2003 | 8 579 | 584 | 2.90 | 3.6 | 0.36 | 0.92 | 510 | 660 | 2.50 | 3.30 | 1 710 | 2 030 |
| Chilko | 18 500 | 1984–1986, 1989, 1994–1995 | 1988, 1990–1993 | 5 480 | 499 | 2.7 | 4.1 | 0.90 | 1.20 | 829 | 1 119 | | | | |
| Adams | 12 900 | 1986 | 1997 | 5 040 | 540 | | | 0.87 | 0.97 | 590 | 743 | 2.64 | 3.68 | | |
| Leisure | 110 | 1982–1984 | 1985–1992 | 31 100 | 3 455 | 5.3 | 9.0 | 0.65 | 3.95 | 70 | 600 | 1.70 | 3.60 | 2 727 | 9 544 |
| Fraser | 1 660 | 1985–1987 | 1988–1992 | 8 940 | 982 | 6.7 | 8.0 | 1.00 | 1.37 | 150 | 300 | 3.60 | 5.10 | | |



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**Table 3.** *Concluded.*

| | | Treatment years | | Loading (g ha$^{-1}$ a$^{-1}$) | | TP ($\mu$g L$^{-1}$) | | Chl a ($\mu$g L$^{-1}$) | | Zoop biomass (mg m$^{-2}$) | | Smolt weight (g) | | Smolt biomass (g ha$^{-1}$) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Area (ha) | NF | F | N | P | NF | F | NF | F | NF | F | NF | F | NF | F |
| Coghill | 1 270 | 1988–1992 | 1993–1996 | 3 161 | 812 | 8.0 | 9.8 | 0.64 | 2.05 | 48 | 92 | 1.46 | 1.48 | 302 | 641 |
| Packers period 1 vs. 2[a] | 210 | 1981–1983 | 1984–1986 | 17 400 | 1 760 | 14.7 | 15.0 | 1.30 | 2.00 | 200 | 349 | 5.20 | 10.40 | 9 523 | 14 285 |
| Redoubt | 1280 | 1980–1983 | 1984–1986 | 15 600 | 1 530 | | | 0.76 | 1.20 | 100 | 150 | 4.00 | 10.00 | | |
| Redfish | 615 | 1992 | 1995–1998 | 5 265 | 281 | | | 0.50 | 1.00 | 348 | 453 | | | | |

**Note:** N, total nitrogen; TP, mean summer total phosphorus; Chl a, mean summer chlorophyll *a*; Zoop biomass, mean summer zooplankton biomass; NF, years when not fertilized; F, years when fertilized.

[a]Yakoun Lake: water chemistry comparison only during 1982–83. Fish comparisons from all other years.

[b]See text for definition of periods 1 and 2.



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## Field studies in Alaska

### Leisure Lake, Alaska

Leisure Lake (latitude 59°35′N, longitude 151°19′W, surface area 1.1 $km^2$) was stocked with about 2 million sockeye salmon fry per year from 1980–1985 and then stocked and heavily fertilized using a mean loading rate of 31 100 g $ha^{-1}$ $a^{-1}$ of N and 3 455 g $ha^{-1}$ $a^{-1}$ of P during 1985–1992 (Kyle 1994; Koenings and Kyle 1997). Nutrients, chlorophyll, and zooplankton were recorded during both the unfertilized (1985–1992) and fertilized (1982–1984) periods. Fertilization produced almost immediate results. Mean epilimnetic total phosphorus (TP) concentrations increased by 70% from 5.3 $\mu g\ L^{-1}$ during the unfertilized period to 9.0 $\mu g\ L^{-1}$ during the fertilized period. Mean chlorophyll *a* concentrations increased by 500% from 0.65 $\mu g\ L^{-1}$ during the unfertilized period to 3.65 $\mu g\ L^{-1}$ during the fertilized period. Zooplankton biomass increased more than 700% from 70 mg $m^{-2}$ dry weight (dw) during the unfertilized period to 600 mg $m^{-2}$ dw during the fertilized period. Smolt weights increased 112% from 1.7 g during the unfertilized period to 3.7 g during the fertilized period. Smolt age decreased, and total stocked fry-to-smolt survival almost doubled from 16% during the unfertilized period to 27% during the fertilized period, although between-year variability was high and the differences were not statistically significant. Finally, marine survival, when averaged over three years, increased from 11.4% during the unfertilized period to 14.2% during the fertilized period, but again, between-year variability was very high (13.8%, 6.8%, 13.7% during the unfertilized period and 24.4%, 9.9%, 8.2% during the fertilized period) and the differences were not significant.

### Fraser Lake, Alaska

Fraser Lake (57°5′N, 154°10′W, surface area 16.6 $km^2$) was first seeded with sockeye eggs in 1951. During 1964–1986, sockeye escapement increased from 14 000 to 257 000 $a^{-1}$ and mean annual smolt lengths and weights decreased from 148 to 89 mm and 29.5 to 5.9 g (Kyle et al. 1988; Kyle 1994; Koenings and Kyle 1997). In an attempt to increase sockeye lengths and weights, Fraser Lake was fertilized during 1988–1992 using a mean loading rate of 8940 g $ha^{-1}$ $a^{-1}$ of N and 982 g $ha^{-1}$ $a^{-1}$ of P. Data for nutrients, chlorophyll, zooplankton, and fish were recorded for the unfertilized (1985–1987) and fertilized (1988–1992) periods. Mean epilimnetic TP concentrations increased by 19% from 6.7 $\mu g\ L^{-1}$ during the unfertilized period to 8.0 $\mu g\ L^{-1}$ during the fertilized period. Mean chlorophyll *a* concentrations increased by 37% from 1.00 $\mu g\ L^{-1}$ during the unfertilized period to 1.37 $\mu g\ L^{-1}$ during the fertilized period. Mean zooplankton biomass doubled from 150 mg $m^{-2}$ dw during the unfertilized period to 300 mg $m^{-2}$ dw during the fertilized period. Smolt weights increased 42% from an average of 3.6 g during the unfertilized period to 5.1 g during the fertilized period. During years when escapement exceeded a "target" derived from the eutrophic olume model (see the section "Euphotic volume model" below), fry size declined. When escapement was below or near the euphotic volume (EV) escapement goal, the average length of fry remained stable at approximately 65 mm, and smolt weights increased. The authors concluded that, within limits, fertilization of Fraser Lake counterbalanced top-down effects of fish on zooplankton, so that fry densities could increase without obvious density-dependent declines in smolt weights.

### Coghill Lake, Alaska

Edmundson et al. (1997) described trophic-level responses to the nutrient treatment of Coghill Lake (61°4′N, 147°54′W, surface area 12.70 $km^2$). During 1980–1990 total returns of sockeye to the Coghill Lake system were the highest in Prince William Sound, but during 1990–1994 run sizes declined, possibly in response to earlier over-grazing of the zooplankton forage base. Coghill Lake was fertilized during 1993–1996 using a mean loading rate of 3161 g $ha^{-1}$ $a^{-1}$ of N and 812 g $ha^{-1}$ $a^{-1}$ of P, and it was stocked with sockeye fry during 1995–1996. Fertilizer additions accounted for 40–60% of the mean annual total phosphorus loading. Sockeye salmon carcasses accounted for about 10%. A comparison of

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seasonal means for unfertilized years (1988–1992) with fertilized years (1993–1996) showed that mean epilimnetic TP concentrations increased from 8.0 $\mu$g $L^{-1}$ during the unfertilized period to 9.8 $\mu$g $L^{-1}$ during the fertilized period. Mean epilimnetic $NO_3$ concentrations decreased from 18.8 $\mu$g $L^{-1}$ during the unfertilized period to 13.4 $\mu$g $L^{-1}$ during the fertilized period. Mean epilimnetic chlorophyll *a* concentrations increased from 0.64 $\mu$g $L^{-1}$ during the unfertilized period to 2.05 $\mu$g $L^{-1}$ during the fertilized period. In response to fertilization, zooplankton biomass (comprising >90% cyclopoids, some bosminids, and little else) roughly doubled from 48.1 mg $m^{-2}$ dw during the unfertilized period to 92.4 mg $m^{-2}$ dw during the fertilized period (Note, this difference was evident only when the authors removed from the comparison the 1988 pre-fertilization data, which may have been influenced by a sampling error). Mean smolt weights remained unchanged at 1.46 g during the unfertilized period and 1.48 g during the fertilized period, but average abundance of smolts doubled from 207 $ha^{-1}$ during the unfertilized period to 433 $ha^{-1}$ during the fertilized period, and average smolt biomass increased from 302 g $ha^{-1}$ to 641g $ha^{-1}$. In two of the fertilization years, increases in smolt densities were attributed to increased spawner abundance or increased spawners plus stocking. However, during 1 year (1995) higher smolt densities resulted from a 600% increase in smolt survival from 25 to 150 smolts per spawner. In summary, the data suggest that although Coghill Lake was relatively unproductive (meromictic and glacially influenced), and although smolt weights did not change, fertilization was associated with a doubling of smolt densities and therefore a doubling of smolt biomass.

**Packers Lake, Alaska**

Packers Lake (60°28′N, 151°55′W, surface area 2.1 $km^{-2}$) is located on Kalgin Island, Cook Inlet, Alaska. Kyle (1994) analyzed the first 12 years of data, and Mazumder and Edmundson (2002) reanalyzed those data and added an additional four years of observations. In an attempt to concisely summarize this complex 16 year data set, we have divided the chronology into four sections: During period 1, comprising years 1 and 2 (1981–1982), baseline data were collected and there was no stocking and no fertilization. During period 2, comprising years 3–6 (1983–1986) the lake was fertilized but not stocked. During period 3, comprising years 7–12 (1987–1992), the lake was both fertilized and stocked. During period 4, comprising years 13–16 (1993–1996), the lake was fertilized and stocked, but N loading and stocking rates were reduced.

Comparisons of time periods 1 and 2: (unfertilized vs. fertilized but not stocked). During period 2, fertilization rates were very high, averaging 17 400 g of N and 1760 g of P $ha^{-1}$ $a^{-1}$, and this was reflected in higher values for TP, chlorophyll *a*, zooplankton, and fish. Epilimnetic, summer TP concentrations averaged 14.7 $\mu$g $L^{-1}$ during the unfertilized period 1 (control) and increased to 15.0 $\mu$g $L^{-1}$ during fertilized, but not stocked, period 2. Chlorophyll *a* concentrations averaged 1.3 $\mu$g $L^{-1}$ during unfertilized period 1 and increased to 2.0 $\mu$g $L^{-1}$ during fertilized period 2. Zooplankton biomasses averaged 200 mg $m^{-2}$ dw during unfertilized period 1 and increased to 349 mg $m^{-2}$ dw during fertilized period 2. These increases were associated with gains in average age 1 smolt weights from 5.2 to 10.4 g and increases in mean smolt biomass from 2000 kg per lake during unfertilized period 1 to 3000 kg per lake during fertilized period 2. Smolt age composition changed from 8% age 1 smolts during unfertilized period 1 to 42% age 1 smolts during fertilized period 2, and marine survival measured as percent smolts returning as adults increased from 9.5% during unfertilized period 1 to 13.6% during the fertilized and not stocked period 2.

Comparisons of time periods 2 and 3: (heavily fertilized vs. reduced fertilization and stocked). During period 3, (1987–1992) fertilization rates were reduced to 619 mg $ha^{-1}$ $a^{-1}$ of P, and this was reflected in declining biomass values for algae, zooplankton, and fish. Summer epilimnetic TP concentrations declined from a mean 15.0 $\mu$g $L^{-1}$ during fertilized but not stocked period 2 to 13.0 $\mu$g $L^{-1}$ during fertilized and stocked period 3. Chlorophyll *a* concentrations remained stable at 2.0 $\mu$g $L^{-1}$. Mean summer zooplankton biomasses declined from 349 mg $m^{-2}$ dw during period 2 to 200 mg $m^{-2}$ during period 3. Age 1 smolt weights declined from an average of 10.4 g during period 2 to 3.4 g during

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period 3. Smolt age composition greatly favored age 1 smolts early in period 3 but declined back to near pre-fertilization levels dominated by older age groups by the end of that period. During period 3, fry stocking rates averaged 3 000 000 fry $a^{-1}$, but because mean smolt size decreased. Mean annual smolt biomass also decreased from 3000 kg per lake during period 2, when the lake was fertilized but not stocked, to 2700 kg per lake during period 3, when the lake was both stocked and fertilized. Marine survival data for period 3 were unavailable.

Comparisons of time periods 3 and 4: (stocked and fertilized vs. stocked and less fertilizer added). During period 4 (1993–1996), fertilization rates were further reduced to 480 mg $ha^{-1}$ $a^{-1}$ of P. Epilimnetic TP concentrations continued to decline from an average of 13.0 $\mu$g $L^{-1}$ during period 3 to 9.0 $\mu$g $L^{-1}$ during period 4. Chlorophyll *a* concentrations remained unchanged at 2.0 $\mu$g $L^{-1}$. Mean summer zooplankton biomasses declined from an average of 200 mg $m^{-2}$ dw during period 3 to 149 mg $m^{-2}$ dw during period 4. Smolt weights and biomass remained about as they were in period 3. Marine survival data were unavailable.

In summary, during period 2, when Packer Lake was fertilized but not stocked, smolt weights and biomasses were the highest recorded. During periods 3 and 4, when the lake was stocked and fertilizer loads were reduced, smolt weights and biomasses fell. The conclusion is that at Packers Lake fertilization alone produced much better overall results than fertilization plus stocking.

### Redoubt Lake, Alaska

Kyle et al. (1997) summarized a portion of the Redoubt Lake (56°53′N, 135°15′W, surface area 12.8 $km^2$) data set for 1980–1983 (unfertilized) and 1984–1986 when it was fertilized with an average of 15 600 g $ha^{-1}$ $a^{-1}$ of N and 1530 g $ha^{-1}$ $a^{-1}$ of P. Fertilization was associated with increased concentrations of chlorophyll *a*, higher zooplankton biomasses, and larger smolts. Mean epilimnetic chlorophyll *a* increased from 0.76 $\mu$g $L^{-1}$ during the unfertilized period to 1.20 $\mu$g $L^{-1}$ during the fertilized period. Mean summer zooplankton biomass increased from 100 mg $m^{-2}$ during the unfertilized period to 150 mg $m^{-2}$ during the fertilized period. Mean weights of age 2 smolts increased from 4 g during the unfertilized period to 10 g during the fertilized period. Data analysis for additional years is in progress.

### Pass Lake and Esther Pass Lake, Alaska

The objective of the Pass and Esther Pass experiment (Koenings and Kyle 1997) was to test the hypothesis that overgrazing by strong sockeye year classes could restructure the zooplankton assemblages of fertilized lakes to such an extent that they were slow or even unable to respond to lake fertilization. Their results clearly demonstrate the effects of overstocking.

The Esther Pass (60°52′N, 147°56′W, surface area 0.2 $km^2$) experiment lasted 4 years and included one un-stocked control year (1985), two years (1988–1989) of stocking averaging approximately 600 000 fry per year, and one year (1990) when stocking was discontinued. The lake was never fertilized, but it has been included here because the authors compare outcomes with those obtained from Pass Lake, which was fertilized. During the stocked years, mean summer zooplankton biomasses declined from 402 mg $m^{-2}$ in the control year to an average of approximately 65 mg $m^{-2}$ during stocking. During the stocked years, mean smolt weights remained about constant at 5.4 and 4.8 g, and mean smolt biomasses also remained similar at 69 and 72 kg per lake. When stocking was halted (1990), zooplankton biomass rebounded to 184 mg $m^{-2}$. The authors concluded that Esther Pass Lake was not stocked beyond the carrying capacity derived from their EV model (see text below), and the post-stocking zooplankton community was able to retain its normal species composition and size frequency characteristics.

The Pass Lake (60°55′N, 148°3′W, surface area 0.5 $km^2$) experiment also lasted 4 years and included an unstocked control year (1985), two years (1988–1989) of stocking averaging approximately 154 000 fry per year, and one year (1990) when stocking was discontinued. Fertilizer additions occurred during the final two years (1989–1990), which included one year of supplemental fry additions (1989)

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and one year without (1990). During the stocked years, mean smolt weights were low, equaling 2.2 and 2.1 g. Mean smolt biomass declined from an average of 158 kg per lake during the control year to 45 kg per lake during the stocked year. Mean summer zooplankton biomasses also declined, averaging 783 mg $m^{-2}$ during the control year (1985) and only 13 mg $m^{-2}$ during the stocked year (1989). When stocking was halted and fertilizers applied (1990), zooplankton biomass remained depressed at 10 mg $m^{-2}$. The authors concluded that Pass Lake had been overstocked and that the zooplankton community was unable to retain its normal species composition and size distribution. The severe degradation of the Pass Lake zooplankton community may have been because Pass Lake TP was lower (2.6 $\mu g\ L^{-1}$) than Esther Pass Lake TP (3.2 $\mu g\ L^{-1}$), and more importantly, during the first year of stocking Pass Lake smolt biomass was higher than Esther Pass Lake smolt biomass. The response was almost complete elimination of all cladocerans from Pass Lake, and the authors concluded that the bottom-up effects of fertilization were unable to counterbalance the top-down, density-dependent effects of overstocking.

### Euphotic volume model

At the International Sockeye Salmon Symposium held at Nanaimo, British Columbia, during the fall of 1985, Koenings and Burkett (1987) reported results of stock density and lake fertilization manipulations in a series of Alaskan lakes. The experiments involved both reduction of food competition through lake fertilization and increased food competition through increased stocking. The objective was to develop an "empirical classification of sockeye salmon smolt production based upon the population characteristics of density, freshwater age and mean size." They used data from 13 Alaskan Lakes (Kyle et al. 1997), and their conclusions were based on a mix of historical data and some of the whole-lake manipulations described above. As noted, the experiment involving fertilization of Leisure Lake produced especially clearcut results. Comparisons of data from pre-fertilized (1981–1983) with fertilized years (1984–1986) showed that the system exhibited strong bottom-up control and that well-fed smolts grew much larger. In general, Koenings and Burkett (1987) reported that "reduced intraspecific competition for food in fertilized lakes resulted in younger and larger smolts, whereas increased intraspecific competition under high stocking regimes resulted in older and smaller ones." In addition, they used their data to derive a simple empirical model (euphotic volume model) based on the volume of a lake capable of photosynthesis. One EV unit was defined to equal 1 000 000 $m^3$ of water receiving sufficient irradiance to support photosynthesis, and this was used to predict lake-specific optima for smolt numbers (23 000 smolts per EV unit), smolt biomasses, and adult escapement (2500 adults per EV unit).

## Field studies in British Columbia

### Great Central Lake, British Columbia, 1969–1976

The Lake Enrichment Program grew out of a series of forward-looking experiments started in 1969 at Great Central Lake (49°22′N, 125°15′W, surface area 51 $km^2$). The early work reported by Parsons et al. (1972), LeBrasseur and Kennedy (1972), and Barraclough and Robinson (1972) suggested that during the first year of fertilization, Great Central Lake algae, zooplankton, and fish all responded positively to fertilizer additions. These early reports were followed by others summarizing data collected during 1969–1976 (LeBrasseur et al. 1978). The lake was fertilized for 4 years (1970–1973) using a mean loading rate of 5184 g $ha^{-1}$ $a^{-1}$ of N and 1227 g $ha^{-1}$ $a^{-1}$ of P. It was not fertilized during 1969 and 1974–1976. Comparisons between the fertilized and unfertilized periods revealed that fertilization was associated with higher mean summer epilimnetic primary production of C averaging 5 $g^{-2}$ $a^{-1}$ during the unfertilized period and 11 $g^{-2}$ $a^{-1}$ during the fertilized period, mean epilimnetic chlorophyll *a* averaging 7 mg $m^{-2}$ during the unfertilized period and 11 mg $m^{-2}$ during the fertilized period, and mean growing season zooplankton biomass averaging 0.9 $g^{-2}$ during the unfertilized period and 7.4 $g^{-2}$ during the fertilized period. Age 1 smolt weights were slightly (but not significantly) higher, averaging 2.78 g during the unfertilized period and 3.13 g during the fertilized period. Age 1 smolt fork lengths

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were also only slightly higher, averaging 68 mm during the unfertilized years and 70 mm during the fertilized years. Average age 2 smolt weights were significantly higher, averaging 4.3 g during the unfertilized period and 9.9 g during the fertilized period, but age 2 smolts comprised only an average of 3.5% of the population during the fertilized years. There was also some uncertainty about smolt aging, so that some of the age 2 smolts could have been age 3. In-lake survival (i.e., percent egg-to-fry survival) was almost twice as high, averaging 5.2% during the unfertilized period and 10.3% during the fertilized one. However, average acoustic estimates of juvenile sockeye numbers were higher during the unfertilized period (2500 juveniles $ha^{-1}$) than during the fertilized period (1860 juveniles $ha^{-1}$). LeBrasseur et al. (1978) stated that marine survival increased from approximately 58 000 adult returns per year produced during the unfertilized years, to approximately 218 000 per year originating from fertilized years. However, because the fry were less than 5% larger during fertilization, it is difficult to explain how increased marine survival could have resulted from fertilizer-induced increases in smolt weights. In addition, the authors noted that during the 1970s returns to nearby Sproat Lake also increased. This observation was confirmed by Hyatt and Steer (1987), who showed that commencing in 1973 the entire Barkley Sound sockeye stock aggregate increased approximately five-fold and that the pattern observed for the Sproat Lake stock closely followed the pattern seen for Great Central Lake. Although juvenile sockeye survival increases at Great Central Lake were readily attributable to lake fertilization, increased marine survivals were not, since nearby Sproat Lake was not fertilized, yet still exhibited coincident increases in returns. Hyatt and Steer (1987) concluded that "there are many unanswered questions concerning the role of lake fertilization in promoting the increased returns of sockeye to GCL and in the intervening years many alternate hypotheses have been suggested as explanations for the increase."

### Combined results from other British Columbia Lake Enrichment Program nursery lakes

An expanded Lake Enrichment Program (LEP) began in 1977, lasted for more than 10 years, and involved various levels of fertilization of 17 sockeye nursery lakes (summarized in Stockner and Hyatt (1984), Stockner and Shortreed (1985, 1988, 1994), Hyatt and Stockner (1985), Hyatt and Steer (1987), Hardy et al. (1986), Stockner (1987), Stockner and MacIsaac (1996)). Summary reports (Stockner and Hyatt 1984; Shortreed et al. 2001) compared the results of short-term pre- and post-fertilization limnological conditions in several of these sockeye nursery lakes (summarized in Table 1). Stockner and Hyatt (1984) also anecdotally noted the following. (1) Kennedy-Clayoquot developed blue-green algal blooms that were reduced by increasing the N:P ratio of the fertilizer (i.e., more nitrogen). (2) Nimpkish Lake developed blooms of *Rhizosolenia*, a large diatom that acted as a nutrient sink, and Stockner and Hyatt (1984) predicted these blooms could be corrected by reducing fertilizer N:P ratios. (3) Great Central Lake was prone to the development of hypolimnetic blue-green algal plates, and they predicted that this problem could be corrected by increasing fertilizer N:P ratios. (4) During 3 years of fertilization, Long Lake developed such large populations of sticklebacks that juvenile sockeye growth rates no longer responded positively to fertilization.

Additional LEP data on limnological responses to lake fertilization were reported in a series of papers published during the 1980s. Stockner and Shortreed (1985) analyzed 1980–1983 phosphorus, nitrogen, chlorophyll, and primary production data from 17 fertilized coastal nursery lakes and verified highly significant bottom-up relationships (Dillon and Rigler 1975) between phosphorus concentrations and various measures of algal biomass and production. Stockner (1987) noted that coastal food chains (picoplankton → protozoans → microzooplankton → zooplankton → sockeye) tended to be longer and therefore perhaps less efficient than food chains found in more eutrophic interior British Columbia nursery lakes. Also focusing on lower trophic levels, Stockner and Shortreed (1988) provided a detailed analysis of water chemistry and algal data from Kennedy Lake. The Clayoquot Arm of Kennedy Lake was fertilized from 1978 to 1984. During 1978 fertilizer with a 10:1 molar N:P ratio was used, and in 1979–1981 the ratio was increased to 15:1. In 1981–1982 a fall bloom of *Anabaena circinalis* was

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observed. *Anabaena circinalis* was undesirable (i.e., relatively inedible by zooplankton) and known to be a nitrogen fixer, so it was assumed that *A. circinalis* blooms reflected a nitrogen shortage limiting other more desirable algae. Therefore, during 1982 the molar N:P ratio of the fertilizer was increased to 26:1 and during 1983–1984 increased again to 35:1. The result was that during 1983–1984 *Anabaena* disappeared almost entirely but was replaced by large blooms of *Rhizosolenia* sp., a non-grazable diatom. This bloom disappeared in 1985 when fertilization was suspended. Finally, at Sproat Lake, Shortreed and Stockner (1990) reported that *Rhizosolenia eriensis* was the dominant species in the epilimnion during the spring, but during the summer was restricted to a deep chlorophyll maximum (DCM) at the bottom of the epilimnion (20–25 m), and consequently was not influenced by fertilization during 1985 when fertilizers were added slowly over 18 weeks. However, during 1986, when the entire fertilizer load was applied over 8 weeks, epilimnetic algal densities (*R. eriensis* plus other edible species) increased to such an extent that the light penetration into the upper hypolimnion was reduced and production at the DCM declined, resulting in a net loss of algal biomass available to grazers. The authors concluded that fertilization at Sproat Lake may have decreased rather than enhanced food availability for sockeye.

Sockeye data from the LEP experiments were summarized in Hyatt and Stockner (1985). Combined results from 38 lake-years showed significant correlations between age 1 smolt weight and mean summer zooplankton biomass ($r^2 = 0.22$, $n = 38$, $p < 0.003$) and between age 1 smolt weight and mean summer zooplankton biomass per juvenile sockeye ($r^2 = 0.44$, $n = 38$, $p < 0.001$). Hyatt and Stockner (1985) also reported a negative relationship between age 1 smolt weight and summer–fall juvenile density ($r^2 = 0.52$, $n = 38$, $p < 0.001$), and they found that average smolt sizes in unfertilized lakes were smaller than in fertilized lakes having similar juvenile densities (summarized in Table 2). Taken together, these relationships all strongly suggest that no matter what problems may have occurred with algae, lake fertilization was almost always associated with the production of larger age-1 smolts. Although the authors gave several examples from lakes such as Owikeno and Babine, demonstrating a positive relationship between sockeye smolt size and increased marine survival, comparable data were not available from any of the fertilized or unfertilized LEP lakes.

## Hobiton Lake, British Columbia

Hobiton Lake (48°45′N, 124°49′W, surface area 3.6 km$^2$) is located on the west coast of Vancouver Island. This lake was fertilized using a mean loading rate of 5840 g ha$^{-1}$ a$^{-1}$ of N and 861 g ha$^{-1}$ a$^{-1}$ of P during 1980–1983, and it was not fertilized in 1984–1986 (Hardy et al. 1986). In general, fertilization was associated with higher TP and chlorophyll concentrations but no significant differences in zooplankton and sockeye densities. Mean epilimnetic TP concentration was 2.1 $\mu$g L$^{-1}$ during the unfertilized year and 3.2 $\mu$g L$^{-1}$ during the fertilized years. Mean summer chlorophyll *a* concentration was 1.3 $\mu$g L$^{-1}$ during the unfertilized year and 2.2 $\mu$g L$^{-1}$ during the fertilized years. The authors note that during the fertilized years summer TN:TP (weight) averaged 50:1 and picoplankton was abundant. When fertilization was discontinued in 1984, TN:TP increased to 129:1 (weight) and there was a large post-fertilization bloom of *Rhizosolenia* sp. Because both picoplankton and *Rhizosolenia* are resistant to zooplankton grazing, it was not surprising that zooplankton abundances changed little, averaging 4300 and 3700 m$^{-3}$ during unfertilized and fertilized years, respectively. Juvenile sockeye density also remained relatively unchanged, averaging 1576 ha$^{-1}$ during the unfertilized year and 1623 ha$^{-1}$ during the fertilized years. As with the original Great Central Lake experiment, mean smolt size in fertilized years increased by only about 25% by weight, but egg-to-fry survivals in fertilized years were approximately double those in unfertilized years.[2]

[2] K.D. Hyatt and D.P. Rankin. Unpublished observations.

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**Yakoun Lake, British Columbia**

Yakoun Lake (53°19′N, 132°17′W, surface area 8.1 $km^2$), located on the Queen Charlotte Islands, was fertilized during 1983–1985 at an average loading rate of 3563 g $ha^{-1}$ $a^{-1}$ of N and 533 g $ha^{-1}$ $a^{-1}$ of P. Water chemistry (Stockner and Shortreed 1985) was reported for one control year (1982) and for the first year of fertilization (1983). Sockeye data (Hyatt and Rankin 1996; Rankin and Hyatt 2002) were reported for several years between 1982 and 1998. Fertilization was associated with increased concentrations of nutrients and chlorophyll *a*. The summer epilimnetic TP average was 1.9 $\mu$g $L^{-1}$ during the unfertilized year and 4.0 $\mu$g $L^{-1}$ during the fertilized year. The summer epilimnetic TN average was 187 $\mu$g $L^{-1}$ during the unfertilized year and 288 $\mu$g $L^{-1}$ during the fertilized year. The epilimnetic chlorophyll *a* concentration average was 1.69 $\mu$g $L^{-1}$ during the unfertilized year and 3.28 $\mu$g $L^{-1}$ during the fertilized year. The general conclusion was that all the limnological variables increased significantly because of fertilization.

The fish data were more difficult to interpret. The first complication was that average brood-year escapement was 13 300 adults during fertilized years and only 7 800 adults during unfertilized years. Therefore, average potential egg deposition was 16.6 million during fertilized years and 9.9 million during unfertilized years. Also, during 1982–1986 Yakoun Lake had exceptionally large populations of sticklebacks. During this period stickleback densities averaged 1846 $ha^{-1}$, and juvenile sockeye densities averaged only 922 $ha^{-1}$. The expected effect of both increased sockeye fry recruitment and high stickleback densities was increased competition for food leading to potentially lower growth rates for both during the fertilized period. This prediction proved to be true. When total fish density (sockeye fry plus stickleback) exceeded 1800 fish $ha^{-1}$, sockeye growth rates declined (Hyatt and Rankin 1996). Therefore, to make meaningful comparisons for juvenile sockeye responses to fertilized (1983–1986) and unfertilized periods (1982, 1986–1999), we restricted our unfertilized data set to years when total fish densities were greater then 1500 $ha^{-1}$. Comparisons between the fertilized data set (1983–1986) and the selected unfertilized data set (including 1981, 1986–1989, 1995) indicated total fish density (sockeye + stickleback) averaged 2775 $ha^{-1}$ during the fertilized years and 2214 $ha^{-1}$ during the unfertilized years. The density of sockeye alone was 709 $ha^{-1}$ during the fertilized years and 1528 $ha^{-1}$ during the unfertilized years, and the density of stickleback alone was 2066 $ha^{-1}$ during the fertilized years and 686 $ha^{-1}$ during the unfertilized years. Sockeye fall fry weights averaged 2.47 g during the fertilized years compared with only 1.12 g during the unfertilized years, but egg-to-fry survival during the fertilized years averaged only 6.7% compared with 11.2% during the unfertilized years. The overall result was that juvenile sockeye production averaged only 1.7 kg $ha^{-1}$ during the fertilized period compared with 2.7 kg $ha^{-1}$ during the unfertilized period. Note that average fish production (sockeye plus stickleback) was higher at 4.2 kg $ha^{-1}$ during fertilized years compared with only 3.7 kg $ha^{-1}$ during unfertilized years. Although fertilization was associated with increased overall total fish production and with larger sockeye fall-fry, the differences were not statistically significant. Also, during fertilized years sockeye densities and sockeye production were lower than during the unfertilized years.

**Chilko Lake, British Columbia**

Chilko Lake (51°16′N, 124°04′W, surface area 18.5 $km^2$) situated in the interior of British Columbia, was fertilized for 5 years (1988, 1990–1993) using a mean loading rate of 5480 g $ha^{-1}$ $a^{-1}$ of N and 499 g $ha^{-1}$ $a^{-1}$ of P. Results from the fertilized years, were compared with measurements from 6 unfertilized years (1984–1986, 1989, 1994–1995) (Bradford et al. 2000). There was a significant increase in mean epilimnetic TP concentration from 2.7 $\mu$g $L^{-1}$ during the unfertilized period to 4.1 $\mu$ g $L^{-1}$ during the fertilized period. Average summer epilimnetic primary production increased from 102 mg C $m^{-2}$ $d^{-1}$ during the unfertilized period to 175 mg C $m^{-2}$ $d^{-1}$ during the fertilized period. Mean summer chlorophyll *a* increased from 0.9 $\mu$g $L^{-1}$ during the unfertilized period to 1.2 $\mu$ g $L^{-1}$ during the fertilized period. Mean summer zooplankton biomass increased from 829 mg $m^{-2}$ dw during the unfertilized period to 1119 mg $m^{-2}$ dw during the fertilized period, but variability was high and

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the difference was not statistically significant. During the fertilized years, the mean weight of age 1 smolts increased by 34% and the mean weight of age 2 smolts increased by 58%. The average number of recruits per spawner was 73% higher during fertilized versus unfertilized years, but the confidence interval was large (−2% to 174%). Finally, marine survival was positively associated with smolt size.

### Adams Lake, British Columbia

Adams Lake (51°15′N, 119°30′W, surface area 12.9 $km^2$) located in south-central British Columbia, was fertilized for 1 year (1997) using a loading rate of 5040 g $ha^{-1}$ $a^{-1}$ of N and 540 g $ha^{-1}$ $a^{-1}$ of P (Hume et al. 2003). Water chemistry data were reported for a control year (1986) and for the fertilized year (1997). Mean summer epilimnetic particulate P averaged 1.2 $\mu g$ $L^{-1}$ during the unfertilized year and 2.7 $\mu g$ $L^1$ during the fertilized year. Mean summer epilimnetic $NO_3$ averaged 77.1 $\mu g$ $L^{-1}$ during the unfertilized year and 61.6 $\mu g$ $L^{-1}$ during the fertilized year. The average of summer chlorophyll *a* was 0.87 $\mu g$ $L^{-1}$ during the unfertilized year and 0.97 $\mu g$ $L^{-1}$ during the fertilized year. During fertilization there was an increase in all of the major zooplankton species (*Daphnia thorata*, *Eubosmina longispina*, *Diacyclops bicuspidatus thomasi*, and *Leptodiaptomus ashlandi*), and mean summer zooplankton biomass was higher, averaging 590 mg $m^{-2}$ dw during the unfertilized year and 743 mg $m^{-2}$ dw in the fertilized year. During the fertilized year sockeye diets comprised > 80% *Daphnia* plus 10% other cladocerans. Copepods were seldom consumed. Comparisons of age 1 smolt weights from an unfertilized brood year (1992) with age 1 smolt weights from the fertilized brood year (1996), suggested that mean smolt weight increased from 2.64 to 3.58 g.

### Muriel Lake, British Columbia

Muriel Lake (49°08′N, 125°36′W, surface area 1.5 $km^2$), is located on the west coat of Vancouver Island. The lake was fertilized during 1984 using slow release pellets maintained in floating cassettes at the lake surface. Loading rate records have been lost, but were calculated to maintain summer N and P values similar to those observed in other fertilized British Columbia lakes.[3]

The objective of the Muriel Lake experiment (Hyatt et al. 2005) was to investigate potential competitive interactions among juvenile sockeye, threespine stickleback, and *Neomysis mercedis*. Smolt samples taken during 1982–1989 suggested that age 1 and age 2 smolt weights and lengths did not increase during fertilization. Also, bioenergetic assessments of the 1985–1986 data sets suggested that *N. mercedis* could consume 7% to 8% of the zooplankton standing stock per day, while sockeye younger then 1 year old (0+) and sockeye younger than 2 years old (1+) could consume only 0.8% $d^{-1}$. Threespine stickleback could consume less than 0.2% $d^{-1}$. Although *N. mercedis* was the main consumer of zooplankton, they were themselves consumed by fish. During the second summer of the study (1986) an increase in the relative numbers of 1+ sockeye was associated with substantial declines in *Neomysis* biomass. Although this came too late in the season to benefit 1986 Muriel Lake sockeye fry, it did serve to highlight the importance of pelagic food web "trophic triangles" (Hyatt et al. 2005). The authors suggested that during years when exogenous recruitment events result in high sockeye biomasses, *Neomysis* populations could be held in check by 0+ and especially 1+ sockeye. During years when sockeye biomasses were low, zooplankton consumption rates by *Neomysis* would be so high that sockeye could gain little benefit from fertilizer-induced enhancement of their zooplankton food base. The authors concluded that *Neomysis* lakes should only be fertilized when sockeye densities are high enough to reduce *Neomysis* densities and mitigate the effects of competition from *Neomysis*.

[3] K. Stephens. Personal communication.

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**Woss Lake, British Columbia**

Woss Lake (50°07′N, 126°37′W, surface area 13.6 $km^2$) is located on the north-east side of Vancouver Island. Woss Lake was fertilized during 2000–2003, using an average loading rate of 8579 g $ha^{-1}$ $a^{-1}$ of N and 584 g $ha^{-1}$ $a^{-1}$ of P. Nearby Vernon Lake (surface area 8.4 $km^2$) was maintained as an unfertilized reference lake. The experimental protocol (Hyatt et al. 2004) was to quantify species compositions, densities, and biomasses for phytoplankton, zooplankton, and sockeye and then to use these data to estimate the proportion of species-specific zooplankton production and standing stock consumed by sockeye. In the fertilized lake (Woss), epilimnetic TP averaged 3.6 $\mu$g $L^{-1}$, and in the unfertilized control (Vernon), epilimnetic TP averaged only 2.9 $\mu$g $L^{-1}$. In the fertilized lake, average chlorophyll *a* was 0.92 $\mu$g $L^{-1}$ and in the unfertilized lake, 0.36 $\mu$g $L^{-1}$. Similarly, average edible algal biovolume (algae 2–30 $\mu$m diameter) was 300 $mm^3$ $m^{-3}$ in the fertilized lake but only 100 $mm^3$ $m^{-3}$ in the unfertilized control. Average biomass of edible zooplankton (zooplankton found in stomach content samples) was dw of 22 $\mu$g $L^{-1}$ in the fertilized lake compared with 17 $\mu$g $L^{-1}$ in the unfertilized control. In December, average weight and total biomass of juvenile sockeye was 3.3 g and 2.03 kg $ha^{-1}$, respectively, in the fertilized lake compared with 2.5 g and 1.71 kg $ha^{-1}$ in the unfertilized control.

The authors note that these "treatment" vs. "control" comparisons should be viewed with caution! During the first year of the experiment (2000), both Woss (fertilized) and Vernon (unfertilized) had about equal volumes of edible algae and zooplankton; and fish densities and growth rates in both lakes were almost the same. During the next three years (2001–2003) edible algal biomass in the unfertilized control lake remained about the same, but zooplankton biomasses declined and 0+ sockeye growth rates also declined. Given available 0+ sockeye weights and densities, bioenergetics-based consumption estimates suggested that the 0+ sockeye could not have caused the observed declines in Vernon Lake (unfertilized) zooplankton biomasses. Because the algal biomass did not change, the only other logical explanation was that some of the targets assessed during the Vernon Lake acoustic surveys must have been fish that were larger than 0+ sockeye. In fact, larger fish (kokanee) were found in the Vernon Lake trawl nets during 2001–2003, and bioenergetic simulations suggested that during all of those years they competed significantly with 0+ sockeye and were, in part, responsible for the reduced sockeye growth rates observed in Vernon Lake. Kokanee catches in Woss Lake remained very low throughout the experiment (Hyatt et al. 2004).

The authors concluded that because Woss Lake (fertilized) fish densities were low (mean 646 $ha^{-1}$), juvenile sockeye consumed only a portion of the available zooplankton production and had no long-term density dependent effects on zooplankton biomass. Also, because Woss Lake was subject to blooms of *Rhizosolenia*, an algae that is large and therefore resistant to zooplankton grazing, an average of less than 20% of the algal production was available to zooplankton. For both these reasons, less than 0.1% of the fertilizer added to Woss Lake was incorporated into fish biomass. On the other hand, even this small amount of fertilizer stimulated an additional 3–19% increase (depending on the year) in sockeye production. These increases translated into 69 kg of additional 0+ sockeye production in 2000, 114 kg in 2001, 399 kg in 2002, and 206 kg in 2003. Given the unused zooplankton production capacity that was generated by Woss Lake fertilization, the authors suggested that 0+ sockeye production could have been 2–3 times greater had the sockeye fry densities been greater.

**Photosynthetic rate model**

Development of the photosynthetic rate (PR) model (Hume et al. 1996; Shortreed et al. 2000, 2001) to determine production potential of juvenile sockeye in both fertilized and unfertilized lakes served to underscore the importance of bottom-up biological control mechanisms over juvenile sockeye production in British Columbia lakes. The PR model is a modification of the EV model (Koenings and Burkett 1987), which was developed for Alaskan lakes where abiotic factors such as glacial silt and organic stain varied widely but nutrient loading varied relatively little. Consequently, euphotic zone depths were positively and strongly ($r = 0.9$) correlated with areal primary production rates, and

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euphotic zone depth could be used as an index of primary production in Alaskan lakes (Koenings and Burkett 1987). In British Columbia sockeye lakes there was a greater range in nutrient loading, so biotic factors (phytoplankton biomass and productivity) played a greater role in determining euphotic zone depth. Hume et al. (1996) demonstrated that in British Columbia lakes there was a negative correlation between euphotic zone depth (EZD) and areal primary production rates such that EZD does not readily index productive capacity of a lake for planktivorous fish. However, the PR model of Hume et al. (1996) demonstrates direct linkages between measured primary production rates and nursery lake capacity to support juvenile sockeye salmon production. Practical applications of the PR Model are found in Shortreed et al. (2000, 2001) and Cox-Rogers et al. (2004).

## Field studies in Idaho

### Redfish Lake, Columbia River system

(Gross et al. 1998, Budy et al. 1998, Luecke et al. 1996, Griswold et al. 2003). Declining returns of sockeye to the Snake and Salmon Rivers (headwaters of the Columbia River) have been largely attributed to the construction of eight dams in the Columbia corridor. Only 16 spawners returned between 1989 and 1994. In 1991, Snake River sockeye were listed under the U.S. Endangered Species Act (ESA). The ESA listing prompted several preliminary studies of the potential for lake fertilization to contribute to sockeye stock recovery at Redfish Lake (44°N, 115°W, surface area 6.15 $km^2$).

Gross et al. (1998) constructed a nutrient loading model for Redfish Lake and then predicted the likely long-term consequences of lake fertilization. The model suggested that under pre-dam conditions the annual return to Redfish Lake would have been 3800 sockeye and that this would have contributed about 3% of the annual nutrient load received by the lake. The model also suggested that 3 years of lake fertilization would stimulate sockeye production but that the effects would almost disappear after 8 post-fertilization years. They concluded that permanent effects could be achieved only by solving migration problems in the Columbia River to increase smolt-to-adult survival.

Budy et al. (1998) reported results from Redfish Lake enclosures (350 $m^3$) treated with fish (juvenile kokanee) and nutrients (added to the metalimnion). The objectives were to assess the potential impacts of fertilization on water clarity (Redfish is a highly valued recreation area) and to assess the potential to increase juvenile sockeye growth rates. They found that fertilization substantially increased chlorophyll (150%), primary production (250%), zooplankton biomass (200%), and that water clarity was reduced by 2–4 m (Secchi disk). However, fish growth increased very little (15%), and even then it was likely that increased growth rates were because the enclosures were fertilized (and zooplankton biomasses increased) for several weeks before fish were added. The authors concluded that fertilization in conjunction with removals of kokanee could benefit anadromous sockeye.

Luecke et al. (1996) used a food web model to assess various management strategies for Redfish Lake and also concluded that fertilization in conjunction with removals of kokanee could benefit anadromous sockeye. They knew from earlier cage studies that kokanee densities in Redfish Lake were near carrying capacity, and the model suggested that if the kokanee were left unchecked, more than 98% of the extra nerkid (juvenile sockeye and kokanee) production stimulated by fertilizer addition would accrue to kokanee. They recommended that if the lake was fertilized at a rate of 715 kg $a^{-1}$ of P, a reduction of 50–70% of the 0+ kokanee would be required to ensure that increased fertilizer-induced zooplankton biomass would benefit stocked anadromous sockeye fry.

In conjunction with the above studies, Redfish Lake was fertilized during 1995–1998 (Griswold et al. 2003). The data comprised three pre-fertilization years (1992–1994) and four fertilized years (1995–1998) and included both an experimental lake (Redfish) and an unfertilized control lake (Stanley). The nerkid population in both lakes was a mix of kokanee and stocked anadromous juvenile sockeye. Fertilizer was added at an average rate of 5265 g $ha^{-1}$ $a^{-1}$ of N and 281 g $ha^{-1}$ $a^{-1}$ of P. Comparisons of pre- and post-fertilization years showed that during fertilization Secchi depth declined and chlorophyll *a* increased from a mean of 0.5 $\mu g\,L^{-1}$ during the pre-fertilization period to 1.0 $\mu g\,L^{-1}$ during the fertilized

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period. During fertilization mean summer zooplankton biomass increased from 7.9 to 10.3 $\mu$g $L^{-1}$ dw, and *Daphnia* biomass increased from 0.8 to 2.6 $\mu$g $L^{-1}$ dw. Owing to sockeye stocking, fish density increased from 240 $ha^{-1}$ during pre-fertilization to 301 $ha^{-1}$ during fertilization. The authors noted that post-manipulation nerkid survival improved from 6.7% during pre-fertilization to 19.7% during the fertilization period, but they also stated that these changes could have been due to changes at the hatchery that produced higher quality fish during the fertilization period. Changes in juvenile lengths and weights were not assessed.

Stanley Lake was monitored as a control, and during the pre- and post-manipulation time periods Stanley Lake chlorophyll increased slightly, *Daphnia* biomasses declined slightly, total zooplankton biomass did not change, and fish density (kokanee plus a few stocked sockeye) increased from about 100 to 400 $ha^{-1}$. Changes in juvenile lengths and weights were not assessed. The authors stated that climatic changes influencing snow pack and discharge rates coincided with the pre- and post-fertilization periods and confounded experimental outcomes. They also noted that it was possible that the kokanee in Redfish Lake may have disproportionately benefitted from lake fertilization (see Luecke et al. (1996)) and the planned 1999 fertilization was suspended for that reason. Also, because of concerns for esthetic values (clear water), the amount of fertilizer added (200 kg $a^{-1}$ of P) was less than recommended (see Luecke et al. (1996)), and this may have weakened the anticipated bottom-up response by sockeye salmon.

## Cautionary tales

Although virtually all the studies summarized above suggest that lake fertilization is likely to yield positive gains in smolt biomass and may even contribute to increased marine survival, they also suggest that problems are possible — even likely. This is not surprising. Freshwater food webs are relatively complex, and when entire lakes are fertilized to enhance the production and survival of anadromous sockeye, it is almost certain that unexpected results will emerge. Based on the preceding literature review, seven potential "issues" have been identified. The first two deal with some of the myths and realities of phosphorus loading. The last five with technical problems, some resolved, others not.

(1) The very first lake fertilization at Great Central Lake (1969) was prompted by the suggestion that declines in sockeye might be partially explained by the "smaller amounts of phosphorus introduced into a lake in the carcasses of fewer sockeye spawners" (Foerster 1968). Recently, stable isotope studies (reviewed in Cederholm et al. (1999)) have shown that marine-derived N and C is found in lake, stream, and terrestrial biota and that watersheds with higher escapements have more marine-derived N in some terrestrial species (Reimchen et al. 2003). These data, combined with escapement and mass-balance analyses, leave little doubt that sockeye salmon carcasses contribute to the nutrient regimes of *rivers and streams* of watersheds containing sockeye (reviewed in Naiman et al. (2002)). For sockeye nursery *lakes*, there is also evidence suggesting that carcasses can make significant contributions to nutrient budgets, but conclusions seem to be very lake-dependent. The evidence that is generally cited (Kyle et al. 1997; Naiman et al. 2002) to support the case for the importance of carcasses to nursery lakes is primarily based on data from two lakes. Krokhin (1967) used a 24-year (1937–1960) data set to estimate phosphorus inputs and losses from Lake Dalnee, Kamchatka, Russia, and he concluded that low sockeye returns during 1948–1960 were associated with negative phosphorus balances (inputs – losses) to the lake. Even more intensive data are available from Karluk Lake, Kodiak Island, Alaska. Juday et al. (1932) were among the first to suggest that primary and secondary production at Karluk Lake was strongly influenced by sockeye salmon carcasses. This early work was followed by an overview of the Karluk Lake data up to 1953 (Nelson and Edmondson 1955) and by a recent analysis by Schmidt et al. (1998), who concluded that carcasses could account for 40% or more of the phosphorus in Karluk Lake. They also found that there was a clear relationship (although

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confounded by fertilizer additions during the mid-1980s) between July–August TP concentrations and fertilizer derived from carcasses deposited during the pervious year.

Ricker (1937) acknowledged the Karluk Lake data (Juday et al. 1932), but stated that at Cultus Lake "even the largest runs would not be sufficient to add greatly, on decomposition, to the dissolved supply [of nutrients] already available." He pointed out that this was because run density (per cubic metre of lake water) was 10 times higher in Karluk Lake than in Cultus Lake and that the Cultus Lake water turnover rate is high, resulting in the loss of at least one half of the nutrient load each year. Gross et al.(1998) used the Redfish Lake simulation model (see above) to estimate that carcasses accounted for only about 3% of the annual historical total nutrient load to the lake, even before the advent of hydroelectric dams, and Edmundson et al. (1997) estimated that Coghill Lake carcasses contributed only 10% of the annual load. From these data, it may be wise to conclude that the contribution of carcasses varies considerably from lake to lake. Factors such as spawner numbers, redd locations, lake volumes, watershed areas, turnover times, the timing of flushing events, and the effectiveness of a variety of nutrient retention and recycling processes influence historical and current contributions made by carcasses. Additional mass-balance studies for sockeye nursery lakes are much needed. In the meantime, it should be noted that in all the case-studies reviewed here artificial fertilizer was added during the spring and summer, when it was most needed, and that fertilizer-loading rates often exceeded carcass-loading rates by an order of magnitude or more.

(2) One of the stated objectives of this review was to determine whether substantial amounts of fertilizer-induced primary production could make its way up a nursery lake food web, to increase juvenile sockeye growth and survival. Even the most basic calculations show that if a four-step food chain (TP → algae → zooplankton → sockeye) and an average ecological efficiency of 20% are assumed, less than 1% of the nutrients added to a lake are expected to end up in sockeye. To our knowledge only one study (Hyatt et al. 2004) has addressed this question in detail. In Woss Lake during 2000–2003, the amount of fertilizer-P incorporated into new sockeye tissue varied from 0.04 to 0.14% of the fertilizer-P added to the lake. Conversely, 99.9% of the fertilizer-P added to the lake was *not* incorporated into sockeye tissue. Given these estimates, one must ask how fertilization could have contributed significantly to increased juvenile sockeye biomass? The answer is that fish contain relatively small amounts of phosphorus. In Woss Lake during 2000–2003, a very small portion (average 0.14%) of the phosphorus added as fertilizer contributed to an additional 200 kg (150 g $ha^{-1}$) of juvenile sockeye production per year. This translated to a cost of approximately CAN$200 per kg of enhanced smolt production. It should be noted that during 2000–2003 Woss Lake fry abundance (average 645 sockeye $ha^{-1}$) was low, and edible zooplankton were always underused. Fertilization coincident with higher sockeye densities observed during the 1980's (1500–3000 sockeye $ha^{-1}$) would have substantially reduced smolt production costs per koligram, but still the cost would be high.

Five additional cautionary issues involve technical problems that have been encountered and often solved. The first three deal with nutrients and algae.

(1) In Great Central Lake, Stockner and Hyatt (1984) reported the development of hypolimnetic blue-green algal plates, and they suggested that this problem could be corrected by increasing the N:P ratio of added fertilizer.

(2) Also, Stockner and Hyatt (1984) and Stockner and Shortreed (1988) reported that when fertilizer with low N:P ratios (low N) was added to Kennedy-Clayoquot, an *Anabaena* bloom developed. When the fertilizer having a higher N:P ratio (increased N) was applied, the blue green bloom disappeared.

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(3) Finally, Stockner and Hyatt (1984) and Stockner and Shortreed (1988) reported that when higher N:P ratio fertilizer was added to Kennedy-Clayoquot, a *Rhizosolenia* bloom developed. Stockner and Hyatt (1984) also reported that during 1982, when fertilizer having an N:P ratio of 15:1 (mass) was added to Nimpkish Lake, *Rhizosolenia* bloomed, but when the mass ratio was reduced to 1:1 (unpublished data), *Rhizosolenia* became far less abundant. *Rhizosolenia eriensis* also appeared at Woss Lake during both 2000 and 2003. *Rhizosolenia eriensis* cells resemble large "glass-like" cylinders, measuring approximately 75 $\mu$m × 6 $\mu$m × 4 $\mu$m with spines at each end. Their shape ensures that they are non-grazable and it also allows individual cells to absorb considerable quantities of nutrients that might otherwise fuel the growth of grazable species. Over the 4-year fertilization period at Woss Lake, only 20% of the available algae were grazable, and during *R. eriensis* blooms, percent grazable algae fell to 2–5% by volume. *Rhizosolenia* was also reported at Mohun Lake (Perrin et al. 1986), where densities increased when fertilizer was added, and also at Hobiton Lake, which was fertilized during 1980–1983 (Hardy et al. 1986). At Hobiton Lake, during fertilization the epilimnetic TN:TP mass ratio was 50:1. When fertilization stopped in 1984, mean summer TN:TP mass ratio increased to 129:1, and this was associated with a large bloom of *Rhizosolenia* sp. Finally, MacIsaac[4] found that in the laboratory *Rhizosolenia* grew better with a high TN:TP ratio. It appears that the potential key to *Rhizosolenia* control is to reduce the N:P ratio in the fertilizer. The obvious problem is that too little N is widely associated with the growth of blue-green algae. However, this also appears to be partially controlled by the fact that blue-green algae like *Anabaena* are most common in lakes with warm, shallow, stable epilimnia and are seldom found in lakes subject to more wind, such as Henderson, Chilko, and Woss lakes, even when TN:TP ratios are low (less nitrogen). Clearly, before additional coastal-lake fertilizations are attempted, lake-specific information pertaining to algal species composition and preferences for physical-chemical conditions is highly recommended. Some of the relevant information pertaining to appropriate nutrient ratios is available in Ashley and Stockner (2003).

The final two cautionary issues deal with fish and zooplankton.

(4) Hyatt and Stockner (1985) reported that after the onset of fertilization Long Lake developed a very large stickleback population that appeared to suppress juvenile sockeye growth responses to fertilization. O'Neill (1986) and O'Neill and Hyatt (1987) used enclosure manipulations to compare food preferences and consumption rates of threespine sticklebacks and juvenile sockeye. They found that both ate roughly the same food types and that consumption rates were about equal. As noted in the preceding case-study review, stickleback also caused competitive problems at Yakoun Lake. During the fertilization years stickleback accounted for more than half of the fish in the lake, and the result was reduced sockeye yields. To date, there is no clear understanding of the factors that cause stickleback "outbreaks". Their appearance tends to be sporadic, lasting a few years, after which they may virtually disappear, sometimes for 10–20 years at a time. Potential solutions to the stickleback–sockeye competition problem require more work. Currently, scientists from the British Columbia Ministry of Water Land and Air Protection are involved in several whole-lake fertilization projects designed to increase kokanee production (Ashley et al. 1999; Pieters et al. 2003). One innovative solution to the stickleback problem comes from the work of Ashley and Rosenau,[5] who addressed a kokanee collapse in Walheach Reservoir (British Columbia), by introducing 25-cm sterilized cutthroat trout, which preyed on resident stickleback, thus reducing the effects of stickleback–kokanee competition for zooplankton.

Kokanee (a sibling species of "landlocked" sockeye salmon) are potential competitors and are common in relatively productive nursery lakes. For that reason, only two sockeye nursery lakes

[4] E.A. MacIsaac. Personal communication.
[5] K.I. Ashley and Rosenau. Personal communication.

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containing kokanee have been fertilized to date. At Redfish Lake, Griswold (2003) suggested that fertilization may have benefitted kokanee more than sockeye. At Vernon Lake (Hyatt et al. 2004), fertilization has just begun (2004), and results are still unavailable, but the expectation is that 0+ sockeye and 0+ kokanee may be able to compete equally, although sockeye may be at a competitive advantage in the early spring because they originate from larger eggs than kokanee. Predictions involving competition among 0+ sockeye and older kokanee (1+ and 2+) are less certain. Lakes having large pelagic invertebrates such as mysids could tip the competitive balance in favor larger and older kokanee. However, in Vernon Lake, zooplankton tend to be small-bodied and relatively unproductive, suggesting that older, larger kokanee may be at a competitive disadvantage. During the next 2 years production, consumption, and fish bioenergetics methods will be used to assess competitive outcomes between sockeye and multiple age classes of kokanee during fertilization of Vernon Lake.

(5) Finally, Cooper (1988), Cooper et al. (1992), Ashley et al. (1999), and Hyatt et al. (2005) have commented on the problems associated with competition between mysids (*Mysis relicta* and *Neomysis mercedis*) and juvenile sockeye. Concern is based on the fact that in Kennedy and Muriel lakes, the mysid population (*N. mercedis*) has been estimated to consume 5–10 times as much zooplankton as the juvenile sockeye population (Hyatt et al. 2005). No solutions have been offered, but Hyatt et al. note that sockeye (especially 1+ juveniles) consume substantial quantities of *Neomysis*, and they recommend that lakes containing mysids should be fertilized only when sockeye densities are relatively high or *Neomysis* densities are low. The expected outcome is that sockeye could benefit directly by consuming these large invertebrate planktivores and indirectly by reduced competition for food.

In general, the problems associated with algae (blue-green algae or large diatoms) appear to be manageable. Partially because alterations of fertilizer N:P ratios have been shown to be effective (for blue-green algae at least), and also because even when algal problems have been encountered, increased biomasses of zooplankton have still been associated with the fertilization of coastal lakes (Hyatt and Stockner 1985). Briefly stated, when fertilizers are added to lakes, increased zooplankton biomass and production is almost guaranteed. The more serious problems have occurred at the zooplankton → sockeye link in the food web. Aside from the obvious difficulties associated with temperature effects and competition from mysids and sticklebacks, one must ask why the literature shows so much variation in fertilizer-induced increases in smolt sizes. It seems likely that the answer to this problem must involve the amount of energy that juvenile sockeye are able to derive from available zooplankton species compositions and production levels. Stockner (1987) noted that food chains tend to be long in oligotrophic coastal lakes including substantial fractions of picoplankton, protozoans, and microzooplankton. In addition, coastal nursery lakes tend to have simple macrozooplankton food webs, usually dominated by *Cyclops bicuspidatus thomasi* and *Skistodiaptomus oregonensis*, which are too small and fast to yield optimum food value to sockeye. Coastal food webs also frequently lack the large cladoceran species typically found in the more productive interior nursery lakes. To date, the geographical and bottom-up factors that regulate the zooplankton species compositions of coastal lake food webs have not been clearly identified. Thus, basic zooplankton research is needed here.

Given the structure of the planktonic food webs of coastal lakes dominated by small cladocerans and copepods, it seems likely that sockeye smolt weights and yields will be limited no matter how much fertilizer is added. On the other hand, some interior British Columbia lakes, such as those in the Fraser River system (reviewed in Shortreed et al. (2001)), are known to have *Daphnia*-dominated food webs capable of producing very large smolts, but these systems are also susceptible to strong density dependence. For example, at Quesnel Lake smolt weights averaged 2.7 g at a density of 2590 $ha^{-1}$ and increased to 9.4 g at a density of 201 $ha^{-1}$. Similarly at Chilko Lake, smolt weights averaged 3.3 g at a density of 1990 $ha^{-1}$ and increased to 6.2 g at a density of 279 $ha^{-1}$. Not surprisingly, when Chilko Lake

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(Bradford et al. 2000) was fertilized, the result was increased phytoplankton, increased zooplankton including *Daphnia*, larger smolts, and improved in-lake and marine survival. Again, more work is needed to determine the unique mix of algal species composition and perhaps physical conditions that characterizes these *Daphnia*-dominated "interior lake" food webs. Given observed differences in food web structure, it seems likely that the cost-benefits of "interior lake" fertilization will be substantially greater than for "coastal lake" fertilization.

## Summary of general outcomes

At the outset we noted that the potential success of sockeye nursery lake fertilization is predicated on the assumption that bottom-up trophic transfers between nutrients → algae → zooplankton → fish can be shown to be both predictable enough and strong enough to yield increased smolt survival and size. We also noted that nursery lake fertilization is based on the assumption that the size and survival advantages gained by sockeye fry, originating from fertilized lakes, can be successfully carried into the marine environment, thus ensuring increased total returns.

### Bottom-up processes

The preceding literature review suggests that lake fertilization is associated with increased biomasses and (or) production of phytoplankton, zooplankton, and juvenile sockeye (Tables 1, 2, and 3). At the base of the food web (Fig. 1*a*) 11 of 11 studies showed that when fertilizers were applied, epilimnetic TP increased. For chlorophyll *a* (Fig. 1*b*), 21 of 21 studies showed positive responses to fertilization. This effect was especially clear for the two most heavily loaded lakes (Leisure, 3455 g $ha^{-1}$ $a^{-1}$ of P and Bonilla 2696 g $ha^{-1}$ $a^{-1}$ of P). For zooplankton (Fig. 1*c*), responses to fertilization were generally more muted, but 16 of 16 studies showed a positive increase in zooplankton biomass following fertilization. Two studies showed exceptionally large increases in zooplankton biomass. In the case of Leisure Lake, the loading rates were very high (3455 g $ha^{-1}$ $a^{-1}$ of P), but in the case of Great Central Lake (LeBrasseur et al. 1978) increased zooplankton abundances were probably associated with sockeye densities and biomasses that were lower during the fertilized years than during the unfertilized years.

In 16 of 16 studies, fertilization was associated with increased weight gains by fall fry and (or) smolts (Fig. 2*a*). Although the relationship between phosphorus loading rate and smolt weight is positive, the trend is not significant (RANOVA based on weight differences from fertilized and unfertilized treatments, df = 15, $p = 0.49$). In some cases this poor correlation is due to unexplained outliers. For example, the highest percentage weight gains came from three lakes (Cultis, Kitlope, and Redoubt) that received intermediate loading rates, and the lake with the second highest rate of fertilization (Bonilla) showed one of the lowest weight gains for smolt. None of the original data explain any of these patterns. In other cases, it is clear that there was a density-dependent trade-off between increased average smolt size and increased smolt densities. For example, at Coghill Lake densities increased and average smolt weight remained stable, while at Great Central, Yakoun, and Kitlope lakes densities declined and smolt weights increased.

In 11 of 13 experiments (Fig. 2*b*), fertilization was associated with increased smolt production, and the trend was significant (RANOVA based on average weight differences from fertilized and unfertilized treatments, df = 12, $p = 0.03$). Leisure Lake was again a standout, showing an increase of more than 250%. Great Central Lake recorded a loss due to poor escapement and little increase in smolt weight, and Yakoun recorded a loss due to competition from sticklebacks.

As noted above, smolt biomasses depend on both smolt weight and smolt density. Fertilization can accelerate weight gains, but densities are dependent on both escapement and egg-to-fry survival. Escapement is dependent on many factors that are beyond the control of those adding fertilizer to sockeye nursery lakes, but juvenile survival is likely to be influenced by resource availability. Egg-to-fry survival rates were recorded for four studies. At Leisure Lake, fertilization was associated with an

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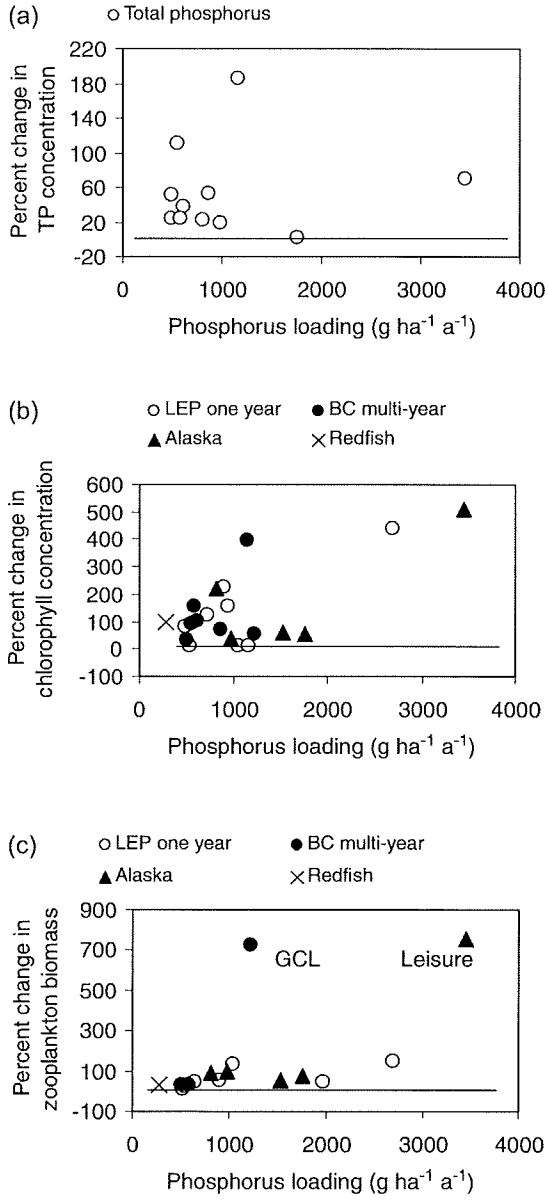
**Fig. 1.** (*a*) Percent change in epilimnetic TP for fertilized vs. unfertilized lake-years; (*b*) percentage change in epilimnetic chlorophyll *a* for fertilized vs. unfertilized lake-years; (*c*) percentage change in zooplankton biomass for fertilized vs. unfertilized lake-years. Horizontal line represents 0% change.




average survival increase of 69%. At Coghill Lake, during 1 year (1995), smolts per spawner increased from 25 to about 150 per female, but during the other two years there was no increase. At Chilko Lake, recruits per female increased by 73% and Great Central Lake egg-to-fry survival increased by almost 100%. On balance, although data are sparse, it seems likely that fertilization is associated with increased egg-to-fry survival.

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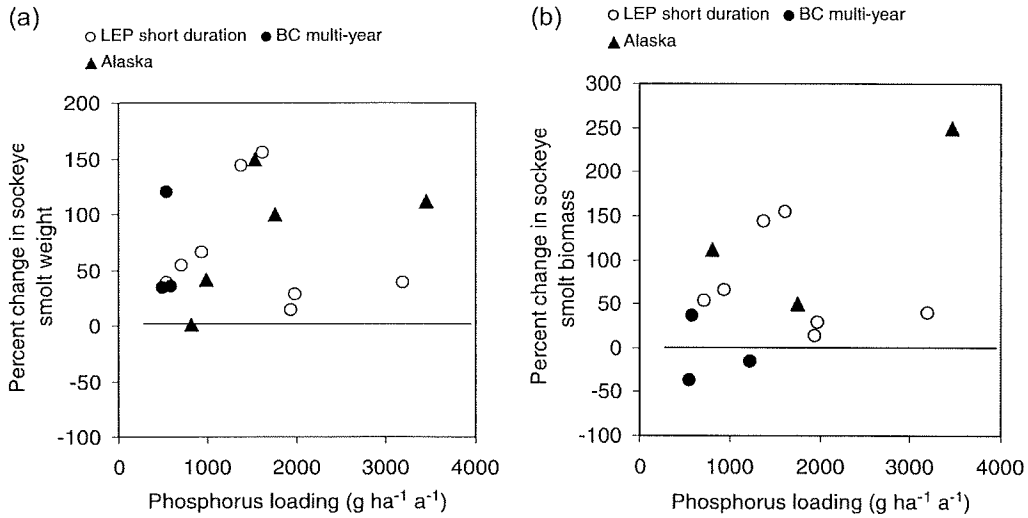
**Fig. 2.** (*a*) Percentage change in smolt weights for fertilized vs. unfertilized lake-years; (*b*) percentage change in smolt biomasses for fertilized vs. unfertilized lake-years. Horizontal line represents 0% change.




## Smolt size and marine survival

We now turn our attention to the second assumption, which is that larger smolts survive better at sea (Koenings et al. 1993). As noted, Ricker (1962) showed that over a broad geographical range there is a positive relationship between sockeye smolt length and marine survival. This pattern has also been observed in between-year data from Owikeno and Babine lakes (Hyatt and Stockner 1985), from the Karluk River (Barnaby 1944), and from Cultus Lake (Foerster 1954). The question is: Do the weight gains that result from fertilization confer survival advantages in the marine environment? At Leisure Lake, smolt weights increased 112% and smolt-to-adult survival increased 25%. At Packers Lake, comparisons of results from the unfertilized period and the 1983–1986 fertilized period (Kyle 1994) show that smolt weights increased by 100% and marine survival increased by 43%. At Chilko Lake, each 1 g increase in smolt weight was associated with a 14% increase in the rate of adult returns. It should be noted that these results depend on rather small numbers of lake-years and that variability in the data is large and statistical significance is weak. On the other hand, there are no studies that show that fertilization is associated with reduced marine survival. On balance, we suggest that it seems likely that lake fertilization is positively associated with increased marine survival of sockeye salmon.

## Fishery and climate induced variations

As noted earlier, Nelson and Edmonson (1955) reviewed historical data from Karluk Lake (37 $km^2$) and attributed an almost continuous decline in lake productivity to a decline in sockeye abundance caused by over fishing. Recently this pattern has been confirmed by Finney et al. (2000, 2002), who used paleolimnological evidence to show that during the 1882–1985 period of rapid development of commercial fishing for sockeye salmon in the eastern Pacific there was a positive correlation between declining sediment concentrations of $\delta^{15}N$ originating from sockeye carcasses and declining pelagic productivity at Karluk Lake. Using these $\delta^{15}N$ data, Finney et al. (2000, 2002) also demonstrated that Karluk Lake sockeye abundances were low during the early 1700s and again during the period 1810–1835, prior to the advent of industrial scale fishing. Thus, it appears that supplies of marine derived nutrients associated with sockeye salmon returns to freshwater may be disrupted not only by large magnitude

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removals associated with commercial fishing but also by naturally occurring variations in sockeye stock productivity associated with poorly understood climate variation and change events. Natural climate variations inducing either increases or decreases in stock productivity may have considerable potential to confound effects of some sockeye lake fertilization experiments. Indeed, simultaneous increases and decreases in sockeye returns are now known to occur over decades of time to both fertilized (Great Central Lake) and unfertilized (Sproat Lake) lakes in the Barkley Sound area of British Columbia (Hyatt et al. 2002). These observations suggest that increased returns exhibited by the Barkley Sound sockeye aggregate in the early 1970s were related, in part, to "climate" events that favored increases to marine survival for several local stocks rather than just lake fertilization that doubled freshwater sockeye fry survival in Great Central Lake.

Climatically induced variations in either freshwater or marine production of sockeye salmon clearly have the potential to confound interpretation of outcomes of some lake fertilization events. However, the north–south geographic and temporal scope of lake fertilization trials reviewed here (Alaska to Idaho and 1950s through 2003) provide sufficient temporal and spatial "control" observations to largely discount a pervasive influence of uncontrolled climate variation on biological outcomes of fertilization experiments in general. Accordingly, known effects of lake fertilization from specific nursery lake assessments serve as a more parsimonious explanation of observed sockeye responses than basin-wide production trends associated with shifting climate "regimes" for North Pacific salmon (Beamish et al. 1999), inverse production trends between northern and southern stocks (Hare et al. 1999), or co-variation in stock abundance for salmon populations that are geographically proximal (Mueter et al. 2002).

### In summary

The available literature dealing with sockeye nursery lake fertilization, suggests that bottom-up, trophic transfers between nutrients → algae → zooplankton → fish are both predictable and strong enough to increase fry survival and smolt size. Larger smolts also appear to survive better at sea, resulting in increased escapement back to the nursery lake of origin, and that within limits, increased phosphorus loading is associated with increased smolt weights and yields. Although it may be argued that the fertilization of sockeye nursery lakes is interventionist and unnatural, it is important to note that human activities, including habitat destruction by industrial or urban development and over-exploitation of sockeye stocks by the commercial fishery, have been strongly implicated in the decline of many Pacific sockeye populations (Slaney et al. 1996). Currently, a number of depressed or threatened sockeye stocks have been identified in both the United States and Canada. These include sockeye originating from Redfish Lake, Ozette Lake (Gustafson et al. 1997), Cultus Lake, and Adams Lake (Schubert et al. 2002; MacKinlay[6]). Given appropriate conditions, nursery lake fertilization may make significant contributions to the recovery of these and other depressed or threatened sockeye salmon populations.

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# APPLICATION FOR SURRENDER OF LICENSE
# SULLIVAN CREEK PROJECT
# FERC NO. 2225

## APPENDIX E.4-8
### DRAFT TEMPERATURE RANGES OF FISH IN SULLIVAN AND OUTLET CREEKS REPORT

*WORKING DRAFT*

# SULLIVAN CREEK HYDROELECTRIC PROJECT
# FERC No. 2225

## Temperature Ranges of Fishes Potentially Found in Sullivan and Outlet Creeks

**Prepared for the Public Utility District No.1 of Pend Oreille County**
**Newport, Washington**

**Prepared by**
**EES Consulting, Inc.**

**July 2, 2009**

# TEMPERATURE RANGES OF FISHES POTENTIALLY FOUND IN SULLIVAN AND OUTLET CREEKS

## 1.0 INTRODUCTION

As part of the surrender of the Sullivan Creek Hydroelectric Project license (FERC No. 2225), various lake management options are being considered by the Mediation Team. A concern expressed by the Team has been the effects of potentially releasing warmer waters from Sullivan Lake into Outlet Creek, and subsequently, into Sullivan Creek. Concern was expressed as to the effects of potential warm water releases on stream-dwelling fishes in the Sullivan Creek system below the lake. As a result, EES Consulting has provided a literature review of temperature thresholds for the potential species of concern.

## 2.0 POTENTIAL SPECIES OF CONCERN

Table 1 presents those species that are either present or could potentially be present in Outlet and Sullivan creeks:

**Table 1. Fish species present or potentially present below Sullivan Lake in Outlet and Sullivan creeks.**

| Species | Scientific Name |
|---|---|
| Bull Trout | *Salvelinus confluentus* |
| Brook Trout | *Salvelinus fontinalis* |
| Brown Trout | *Salmo trutta* |
| Kokanee | *Oncorhynchus nerka* |
| Rainbow Trout | *Oncorhynchus mykiss* |
| Westslope Cutthroat Trout | *Oncorhynchus clarki lewisi* |

## 3.0 METHODS AND DEFINITION OF TERMS

The results tabulated below are from four different sources in the literature. While most are familiar with Milo C. Bell (1991) and his assessments on temperature, other investigations have been conducted since his seminal paper. Not all sources evaluate the same criteria; for this reason, we have included explanations of some of the terms used in Table 2 (below). This language is taken directly from Bear et al (2005):

> *Traditionally, the lethal thermal limits of aquatic ectotherms have been established by means of laboratory studies using two methods, the critical thermal maximum or minimum (CTM) method and the upper or lower incipient lethal temperature (ILT) method. The CTM method entails rapidly heating or cooling water until loss of equilibrium or death occurs, indicating the thermal limit of that fish species. The CTM method is advantageous in that measures of thermal tolerance can be simply and rapidly obtained. However, the unnaturally rapid rates of temperature change inherent in the method are unlikely to be experienced by an aquatic organism in nature (Becker and Genoway 1979) and thus its*

*ecological relevance has been questioned (Becker and Genoway 1979; Selong et al. 2001). The ILT method entails transferring fish from an acclimation temperature directly to a constant test temperature and measuring time to death. The incipient lethal temperature is then defined as the temperature at which 50% of the population survives indefinitely, in most cases, based on a 7-d exposure period (Brett 1956; Jobling 1981). Although inclusion of exposure time in the ILT method is advantageous over the CTM method, the abrupt temperature change experienced by the fish is not analogous to water temperature changes in natural conditions (Becker and Genoway 1979; Selong et al. 2001).*

*The acclimated chronic exposure (ACE) method was developed as a thermal criteria method with enhanced application to conditions fish experience in nature (Zale 1984). The ACE method entails adjusting water temperature 1°C per day to allow for temperature acclimation among test fish until a predetermined test temperature is reached (Selong et al. 2001). Fish are then held at the constant test temperature for 60 days or until death, the length of the test period simulating the duration of seasonal maxima (or minima). Growth and survival are assessed over the 60-d test period to establish an optimum growth temperature and ultimate upper incipient lethal temperature (UUILT).*

*Thermal preference is an additional metric developed to assess thermal requirements of a species. Thermal preference is defined as the temperature individuals will select, given a wide range of equally available temperatures (Johnson and Kelsch 1998). The thermal preference of a species often corresponds to the species' thermal optimum for physiological functioning such as growth and aerobic metabolism (Jobling 1981; Bryan et al. 1984; Sauter et al. 2001), but can be influenced by a host of factors including age (Kwain and McCauley 1978), thermal history (Javaid and Anderson 1967; Konecki at al. 1995), and ration (Brett et al. 1969). For example, fish may select lower than optimal temperatures under conditions of low food availability (Brett et al. 1969; Welch et al. 1998). Mobile organisms typically express temperature preferences that optimize survival and reproduction, thus contributing to their evolutionary fitness (Reynolds 1977). Thermal preference information can help identify habitat suitable for a species in terms of water temperature. It can also help identify possible overlap in suitable thermal habitat by competitors or predators (Edsall and Cleland 2000).*

*Typically, thermal preference has been measured in the laboratory (Javaid and Anderson 1967; Cherry et al. 1975; McCauley et al. 1977; Kwain and McCauley 1978; Peterson et al. 1978; Edsall and Cleland 2000; Myrick et al. 2004) or using field observations relating presence of fish to water temperature (Brett 1971; Roper and Scarnecchia 1994; Bonneau and Scarnecchia 1996; Welch et al. 1998). Field observations of thermal preference are often difficult to interpret due to confounding variables such as food availability, competition and predation, and presence of thermal refugia. Therefore, exact determination of thermal*

*preference is routinely done in the laboratory where preference can be examined under closely controlled conditions.*

*A method commonly used involves determining the acute thermal preference temperature by allowing a fish to acclimate to a certain temperature and then placing this fish in a thermal gradient for a short (2 h or less) time period. Acute preference temperatures typically represent the average temperature from multiple readings of temperatures at which fish are located (Sauter et al. 2001). This process is then repeated for several acclimation temperatures as acute thermal preferences are influenced by acclimation temperature (Sauter et al. 2001). The final preference temperature is derived from the regression of acclimation temperature and acute preferences and is the temperature at which the preferred temperature and acclimation temperature are equal (Fry 1947). The relationship between acclimation and preferred temperature varies among species from direct to inversely proportional (Kelsch and Neill 1990). Generally, the acute thermal preference temperature of salmonids increases with increasing acclimation temperature (Sauter et al. 2001).*

## 4.0 RESULTS

Table 2 summarizes the results of this literature review. Rainbow, brook, and brown trout have the highest temperature tolerances, with UUILT values exceeding 24$^{o}$C, while bull trout and cutthroat trout have much more restricted temperature tolerances, extending only to about 21$^{o}$C. Over 98% of the bull trout survived to 60 days at a temperature of 18$^{o}$C, while 79% survived to 60 days at a temperature of 20$^{o}$C. Mortality at 20$^{o}$C was first observed at 31 days and continued to the end of the study (Selong et al. 2001).

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**Table 2. Temperature Thresholds for Salmonids in Outlet and Sullivan Creeks ($^{o}$C)**

| Species | Lower Lethal | Preferred | Optimum | Avoid | Ult. Upper Incipient Lethal Temp | Upper Lethal | Thermal Limits | Source |
|---|---|---|---|---|---|---|---|---|
| *Rainbow* | 0 | 12.2 - 18.9 | 13.9 | 21.7 | | 29.4 | | 1 |
| | | 6.8-18.2 | 13.1 | | | 24.2 | 1.8, 24.3 | 2 |
| | | 17.2 | | | 25.6 | | | 3 |
| | | | | | 26.2 | | | 3 |
| *Kokanee* | | 10.0 | | | 15.6 | | | 1 |
| | | | | | | 21.7 (Fry) | | 1 |
| *Brook Trout* | 0 | 8.3-11.1 | 9.4 | | | 25.0 | | 1 |
| | | 14.4 - 16 | | | 24.5 | | | 3 |
| *Brown Trout* | 2.2 | 3.3- 21.0 | | | | 23.9 | | 1 |
| | | | | | | 28.9 (fry) | | 1 |
| | | 12.4-17.6 | | | | 25.0 | | 4 |
| | | 13.9 | | | 24.7 | | | 3 |
| *Cutthroat Trout* | 0.6 | 8.3 - 12.8 | | | | 22.8 | | 1 |
| | | | | | 25 | | | 3 |
| *Westslope Cutt Age-1* | | 10.3-17.0 | 13.6 | | 19.7 | 20.0 | 5.5,21.8 | 2 |
| *Bull Trout* | | 10.9-15.4 | 13.2 | | 20.9 | | | 3 |

[1] Bell 1991
[2] Bear et al. 2005
[3] Selong et al. 2001
[4] Bell 2006

# APPLICATION FOR SURRENDER OF LICENSE
# SULLIVAN CREEK PROJECT
# FERC NO. 2225

## APPENDIX E.4-9
### WORKING DRAFT, SULLIVAN CREEK BULL TROUT SPAWNING AND INCUBATION ANALYSIS

*WORKING DRAFT*

# SULLIVAN CREEK BULL TROUT SPAWNING AND INCUBATION ANALYSIS

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***December 4, 2009***

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# SULLIVAN CREEK BULL TROUT SPAWNING AND INCUBATION ANALYSIS

## 1.0 INTRODUCTION

For the surrender of the Sullivan Creek Hydroelectric Project license (FERC No. 2225), various lake management options are being considered by the Settlement Team (Team). One option currently being discussed by the Team is the fall release of water from Sullivan Lake into Outlet Creek. Concerns expressed by the Team have included: 1) the magnitude of releases during the fall period and the potential effects on fall spawners (notably bull trout), and 2) as the lake empties, the potential effects on incubating bull trout eggs as flow levels in Sullivan Creek recede.

EES Consulting (EESC) re-ran the previously calibrated Instream Flow models using the Instream Flow Incremental Methodology (IFIM); this report was submitted to the Team during the Summer, 2009. Further details can be found in EESC (2009a).

An incubation report was submitted to the Team, that outlined the methodologies and analysis that could be performed on the data sets available. After discussion, the Team requested that the following analysis be performed:

- Determine the amount and location of higher quality bull trout spawning habitat (as represented by the transect selected during the IFIM study) over a range of flows
- Analysis should be conducted under:
  - Current conditions (e.g., substrate and habitat as reflected in the IFIM report
  - With enhanced substrate
- Flows for spawning should reflect those examined under the Outlet Creek/Sullivan Creek temperature model (EESC 2009c) and include wet, average, and dry year.
- Determine the effects of reductions in streamflow on incubating bull trout eggs, as determined by the models.

## 2.0 METHODS

The following data, including data sources, were used to run the models on Sullivan Creek:

- EESC selected five calibrated and approved transects (in two study sites) representing spawning habitat from the existing instream flow study (EESC 2009b). This model reflects habitat from Mill Pond downstream to the confluence of Sullivan Creek with the Pend Oreille River (CES 1994)
- Approved transect weighting for the two study sites and five transects (CES 1994)
- Bull trout Habitat Suitability Index Curve (previously called “preference” curves; Mediation Team 2009 – EES Consulting 2009b)
- Bed elevation at each transect
- Stage at given flows (from the HYDSIM sub module of RHABSIM)

EESC used RHABSIM (Riverine Habitat Simulation System) by Thomas R. Payne and Associates (Arcata, CA) to produce Weighted Usable Area (WUA) curves for bull trout spawning. One of the options available in the program is the ability to evaluate WUA on a cell-by-cell basis along each transect at a variety of flows.

WUA for an individual cell is calculated as:

*S* (depth) * *S* (velocity) * *S* (substrate) * the area cell represents,

where *S* = the suitability index for depth, velocity, and substrate, respectively. A value of 1.0 for each suitability index is optimum, while a value of 0.0 indicates no value for that particular variable.

For this analysis, two different scenarios were modeled:

1. Existing substrate as reflected in the hydraulic models.
2. Enhanced substrate.

The Team recognized that the removal of Mill Pond Dam would remove a barrier to sediment transport, and that smaller, spawning-sized sediment would most likely replace the armored sediment that current exists over much of lower Sullivan Creek. In order to provide an optimal condition, EESC assigned a value of 1 to all substrates found on each transect. As a result, the model is driven by the preferences for depth and velocity, since *S* (substrate) now = 1.

## 2.1 Value of Spawning Habitat

For this analysis, the emphasis was on protecting the better quality spawning habitat. As a result, only those cells with a combined suitability value of 0.25 or greater (e.g., *S* (depth) * *S* (velocity) * *S* (substrate)) were used. This methodology was used previously by EESC staff and WDFW and WDOE personnel (Hal Beecher and Brad Caldwell) when examining spawning habitat and protection of incubating eggs. If the suitability value was $\geq$ 0.25, the area of that cell was counted; if the combined suitability value was < 0.25, the area of that cell was given a value of 0.00.

## 2.2 Criteria for Protection of Incubating Eggs

The criteria used in this analysis was that the depth of water over a particular cell that was included as spawning habitat had to be at least 0.1 ft or greater (1.2 inches). The analysis conducted to determine the WUA value included the following:

- The water surface elevation for the transect was calculated (from submodule HYDSIM of RHABSIM) for each modeled flow.
- For each modeled flow, the depth of the water over that cell was calculated by subtracting the bed elevation of the cell from the calculated water surface elevation.
- If the depth of water over the cell was $\geq$ 0.1 ft, the WUA for that cell was used and added to the total.

- If the depth of water over the cell was < 0.1 ft, a value of 0.0 was used.
- Flows were modeled down from the spawning flows in 10 cfs increments.
- Analysis was continued to incubation flows of 10 cfs.

The level of protection afforded incubating eggs was then calculated as the percentage of spawning habitat still covered with at least 0.1 ft of water at a given incubation flow. The following ranges were used to evaluate level of protection.

| Protection (%) of incubating eggs | Range |
|---|---|
| 100% | 100% |
| 90% | 86 – 99% |
| 80% | 76 – 85% |
| 70% | 70- 75% |

## 2.3 Spawning Flows Modeled

A model was recently developed by EESC (2009c) to examine the effects of Outlet Creek flow releases on flow and temperature in lower Sullivan Creek. The model was developed to examine three different operating scenarios for Sullivan Lake:

1. Mean Outlet Creek Sullivan Creek flows. Sullivan Creek flows were based upon 20 years of stream gage data on Sullivan Creek (USGS 12396900) from 1960 - 2002.
2. "Wet year" flows in Outlet and Sullivan creeks. For purposes of this analysis, a "wet year" was considered to be 120% of the mean flow in Sullivan Creek; Outlet Creek flows are as proposed to meet water temperature requirements in Sullivan Creek.
3. "Dry year" flows in Outlet and Sullivan creeks. For purposes of this analysis, a "dry year" was considered to be 80% of the mean flow; Outlet Creek flows are as proposed to meet water temperature requirements in Sullivan Creek.

Since the spawning timing for Sullivan Creek is not known at this time, EESC used the general timing of bull trout in order to be conservative: mid-August through November. EESC initiated spawning during each week block between Week 3 of August through Week 4 of December.

## 2.4 Incubation Flows

Incubation flows were derived from weekly steps within months, as modeled by EESC (2009c). Not knowing the specific emergence timing (which is based upon known spawning timing and temperature), EESC modeled incubation from the time of spawning (starting during Week 3, August) through the end of Week 4 in May. Weekly incubation flows were modeled for the three scenarios of wet, average, and dry years.

# 3.0 RESULTS

## 3.1 Transects and Study Sites

Table 1 includes transects and study sites for the Sullivan Creek IFIM study. Five transects were selected for modeling, based upon their likelihood to provide spawning habitat. Transects, calibration methods and hydraulic models were approved by WDFW and WDOE in 1994 (CES 1994).

## 3.2 Transect Weighting.

Table 2 shows transect weighting used for the instream flow study site. Study Site 1 (from the confluence of the North Fork Sullivan Creek downstream to the Pend Oreille River) constituted 43.8% of the study area, while Study Site 2 (Sullivan Creek from Mill Pond Dam downstream to the confluence of the North Fork of Sullivan Creek) represented 56.2% of the habitat.

## 3.3 Target Species

The target species for this analysis was bull trout in the spawning life history stage.

## 3.4 HSI Curves

The HSI curve was distributed to the fisheries subgroup of the Team in June, 2009 (EES Consulting 2009b).

## 3.5 Spawning and Incubation WUA

The results of the spawning analysis for the five transects have been compiled in spreadsheets. In order to limit the amount of data produced, all transects in each study site were totaled, to give a cumulative amount of quality bull trout spawning habitat at each spawning flow. The sensitivity of each transect to changes in flow, given an initial spawning flow, was also analyzed individually before being aggregated. Figure 1 depicts the bed elevation, cumulative suitability index for bull trout spawning, and water surface elevations ranging from 100 – 500 cfs on Transect 1, Study Site 2.

Table 3 shows the weekly step flows examined in this modeling effort in wet, mean and dry years, respectively. Levels of Protection for incubating eggs, given a particular spawning flow (associated with a month and week) are given in Tables 4 – 6 for wet, average, and dry years by existing and enhanced substrate, respectively.

Tables 2 - 4 show spawning timing and protection of incubating eggs by month, week, type of water year, and existing and enhanced substrate on lower Sullivan Creek.

## 4.0 DISCUSSION

The analysis provided in this working draft is based upon an instream flow study conducted as part of the Sullivan Lake License Amendment in 1994. Spawning habitat was, and continues to be, sparse in Sullivan Creek due to the presence of Mill Pond Dam, which prevents sediment and gravels of appropriate size from being transported downstream of Mill Pond Dam to lower Sullivan Creek. If Mill Pond Dam is removed and the reach of Sullivan Creek at and above the present location of the dam is restored, it is anticipated that gravel will be transported downstream to lower Sullivan Creek and the amount of spawning gravel, and spawning and incubation habitat, will increase.

If this restoration occurs, it would be logical to assume that the distribution of spawning- sized sediment will be much more widespread, both laterally along transects and the habitat types they represent, as well as longitudinally along the stream. The analysis here provides both extremes: habitat as it currently exists, and what it potentially could be, provided channel morphology remains consistent with the current condition. Under nearly all scenarios, over 80% of the spawning habitat is protected while eggs are incubating in the gravel, while the majority of spawning flow regimes examined provided at least 90% protection of incubating eggs.

## 3.0 LITERATURE CITED

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EESC. 2009b. Working draft habitat suitability indices for species and life history stage proposed for the instream flow study. Prepared for the Sullivan Lake Project Mediation Team and the Public Utility District No. 1 of Pend Oreille County. May 28, 2009.

EESC. 2009c. Sullivan Lake temperature model. Revised November 19, 2009.

**Table 1. Transects and descriptors used in the Sullivan Creek incubation analysis.**

| Study Site | Transect | Description |
|---|---|---|
| 1 | 2 | Wide, bedrock-walled glide |
| | 4 | Pool tailout/fast glide |
| 2 | 1 | Wide, shallow glide |
| | 4 | wide boulder riffle |
| | 9 | Narrow deep glide |

**Table 2. Relative transect weighting, Sullivan Creek below Mill Pond Dam.**

| Study Site | Transect | Reach | Total |
|---|---|---|---|
| 1 | 2 | 2.8% | 1.2% |
| | 4 | 7.0% | 3.1% |
| 2 | 1 | 6.2% | 3.5% |
| | 4 | 18.4% | 10.3% |
| | 9 | 13.5% | 7.6% |

**Table 3. Flows used to calculate spawning and incubation protection in lower Sullivan Creek by month, week, and type of water year.**

| | | Wet Year | | | Mean Flows | | | Dry Year | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Month | Week | Outlet Cr. | Sullivan Cr | Total | Outlet Cr. | Sullivan Cr | Total | Outlet Cr. | Sullivan Cr | Total |
| Jan | Week 1 | 42.3 | 42.7 | 85.0 | 42.3 | 35.6 | 77.9 | 42.3 | 28.5 | 70.8 |
| Jan | Week 2 | 39.7 | 39.1 | 78.8 | 39.7 | 32.6 | 72.3 | 39.7 | 26.1 | 65.8 |
| Jan | Week 3 | 44.1 | 37.3 | 81.4 | 44.1 | 31.1 | 75.2 | 44.1 | 24.8 | 68.9 |
| Jan | Week 4 | 36.6 | 37.0 | 73.6 | 36.6 | 30.9 | 67.5 | 36.6 | 24.7 | 61.3 |
| Feb | Week 1 | 34.3 | 38.7 | 73.0 | 34.3 | 32.3 | 66.6 | 34.3 | 25.8 | 60.1 |
| Feb | Week 2 | 26.9 | 40.7 | 67.6 | 26.9 | 33.9 | 60.8 | 26.9 | 27.1 | 54.0 |
| Feb | Week 3 | 26.0 | 41.2 | 67.2 | 26.0 | 34.3 | 60.3 | 26.0 | 27.5 | 53.5 |
| Feb | Week 4 | 25.3 | 42.0 | 67.3 | 25.3 | 35.0 | 60.3 | 25.3 | 28.0 | 53.3 |
| March | Week 1 | 24.3 | 41.4 | 65.7 | 24.3 | 34.5 | 58.8 | 24.3 | 27.6 | 51.9 |
| March | Week 2 | 24.1 | 45.0 | 69.1 | 24.1 | 37.5 | 61.6 | 24.1 | 30.0 | 54.1 |
| March | Week 3 | 28.2 | 54.2 | 82.4 | 28.2 | 45.2 | 73.4 | 28.2 | 36.2 | 64.4 |
| March | Week 4 | 29.4 | 70.2 | 99.6 | 29.4 | 58.5 | 87.9 | 29.4 | 46.8 | 76.2 |
| April | Week 1 | 10.0 | 85.1 | 95.1 | 10.0 | 70.9 | 80.9 | 10.0 | 56.7 | 66.7 |
| April | Week 2 | 10.0 | 128.5 | 138.5 | 10.0 | 107.1 | 117.1 | 10.0 | 85.7 | 95.7 |
| April | Week 3 | 10.0 | 161.6 | 171.6 | 10.0 | 134.7 | 144.7 | 10.0 | 107.7 | 117.7 |
| April | Week 4 | 10.0 | 240.5 | 250.5 | 10.0 | 200.4 | 210.4 | 10.0 | 160.3 | 170.3 |
| May | Week 1 | 10.0 | 343.0 | 353.0 | 10.0 | 285.8 | 295.8 | 10.0 | 228.6 | 238.6 |
| May | Week 2 | 10.0 | 484.7 | 494.7 | 10.0 | 404.0 | 414.0 | 10.0 | 323.2 | 333.2 |
| May | Week 3 | 10.0 | 620.8 | 630.8 | 10.0 | 517.4 | 527.4 | 10.0 | 413.9 | 423.9 |
| May | Week 4 | 10.0 | 771.6 | 781.6 | 10.0 | 643.0 | 653.0 | 10.0 | 514.4 | 524.4 |
| June | Week 1 | 60.0 | 780.0 | 840.0 | 60.0 | 650.0 | 710.0 | 60.0 | 520.0 | 580.0 |
| June | Week 2 | 60.0 | 568.9 | 628.9 | 60.0 | 474.1 | 534.1 | 60.0 | 379.3 | 439.3 |
| June | Week 3 | 60.0 | 463.6 | 523.6 | 60.0 | 386.3 | 446.3 | 60.0 | 309.0 | 369.0 |
| June | Week 4 | 60.0 | 291.3 | 351.3 | 60.0 | 242.8 | 302.8 | 60.0 | 194.2 | 254.2 |
| July | Week 1 | 40.0 | 195.3 | 235.3 | 40.0 | 162.8 | 202.8 | 40.0 | 130.2 | 170.2 |
| July | Week 2 | 35.0 | 144.9 | 179.9 | 35.0 | 120.8 | 155.8 | 35.0 | 96.6 | 131.6 |
| July | Week 3 | 30.0 | 110.3 | 140.3 | 30.0 | 91.9 | 121.9 | 30.0 | 73.6 | 103.6 |
| July | Week 4 | 30.0 | 85.9 | 115.9 | 30.0 | 71.6 | 101.6 | 30.0 | 57.3 | 87.3 |
| Aug | Week 1 | 30.0 | 70.8 | 100.8 | 30.0 | 59.0 | 89.0 | 30.0 | 47.2 | 77.2 |
| Aug | Week 2 | 30.0 | 60.8 | 90.8 | 30.0 | 50.7 | 80.7 | 30.0 | 40.5 | 70.5 |
| Aug | Week 3 | 30.0 | 54.9 | 84.9 | 30.0 | 45.8 | 75.8 | 30.0 | 36.6 | 66.6 |
| Aug | Week 4 | 30.0 | 49.3 | 79.3 | 30.0 | 41.1 | 71.1 | 30.0 | 32.8 | 62.8 |

**Table 3. Flows used to calculate spawning and incubation protection in lower Sullivan Creek by month, week, and type of water year.**

| | | Wet Year | | | Mean Flows | | | Dry Year | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Month | Week | Outlet Cr. | Sullivan Cr | Total | Outlet Cr. | Sullivan Cr | Total | Outlet Cr. | Sullivan Cr | Total |
| Sept | Week 1 | 30.0 | 45.8 | 75.8 | 30.0 | 38.2 | 68.2 | 30.0 | 30.5 | 60.5 |
| Sept | Week 2 | 60.0 | 42.8 | 102.8 | 60.0 | 35.7 | 95.7 | 60.0 | 28.5 | 88.5 |
| Sept | Week 3 | 90.0 | 50.3 | 140.3 | 90.0 | 42.0 | 132.0 | 90.0 | 33.6 | 123.6 |
| Sept | Week 4 | 120.0 | 43.2 | 163.2 | 120.0 | 36.0 | 156.0 | 120.0 | 28.8 | 148.8 |
| Oct | Week 1 | 200.0 | 42.6 | 242.6 | 200.0 | 35.5 | 235.5 | 200.0 | 28.4 | 228.4 |
| Oct | Week 2 | 200.0 | 44.4 | 244.4 | 200.0 | 37.0 | 237.0 | 200.0 | 29.6 | 229.6 |
| Oct | Week 3 | 200.0 | 42.3 | 242.3 | 200.0 | 35.3 | 235.3 | 200.0 | 28.2 | 228.2 |
| Oct | Week 4 | 200.0 | 43.0 | 243.0 | 200.0 | 35.9 | 235.9 | 200.0 | 28.7 | 228.7 |
| Nov | Week 1 | 150.0 | 44.7 | 194.7 | 200.0 | 37.2 | 237.2 | 150.0 | 29.8 | 179.8 |
| Nov | Week 2 | 100.0 | 50.2 | 150.2 | 180.0 | 41.8 | 221.8 | 100.0 | 33.5 | 133.5 |
| Nov | Week 3 | 80.0 | 52.7 | 132.7 | 90.0 | 43.9 | 133.9 | 80.0 | 35.2 | 115.2 |
| Nov | Week 4 | 60.0 | 50.8 | 110.8 | 70.0 | 42.3 | 112.3 | 60.0 | 33.9 | 93.9 |
| Dec | Week 1 | 112.1 | 49.4 | 161.5 | 112.1 | 41.2 | 153.3 | 112.1 | 32.9 | 145.0 |
| Dec | Week 2 | 78.4 | 43.4 | 121.8 | 78.4 | 36.2 | 114.6 | 78.4 | 29.0 | 107.4 |
| Dec | Week 3 | 63.4 | 46.0 | 109.4 | 63.4 | 38.3 | 101.7 | 63.4 | 30.6 | 94.0 |
| Dec | Week 4 | 52.6 | 39.0 | 91.6 | 52.6 | 32.5 | 85.1 | 52.6 | 26.0 | 78.6 |

**Table 4. Approximate flows at which certain percentages of spawning and incubation habitat are protected, given an initial spawning flow (in cfs) for a "wet" year.**

| | Existing Substrate | | | | Enhanced Substrate | | | |
|---|---|---|---|---|---|---|---|---|
| Spawning Flow | 100% | 90% | 80% | 70% | 100% | 90% | 80% | 70% |
| 65.73 | 50 | 30 | 22 | 15 | 50 | 28 | 20 | <10 |
| 67.20 | 50 | 30 | 20 | 15 | 50 | 35 | 18 | <10 |
| 67.33 | 50 | 30 | 20 | 15 | 40 | 27 | 18 | <10 |
| 67.61 | 58 | 45 | 28 | 19 | 50 | 29 | 21 | <10 |
| 69.13 | 60 | 48 | 40 | 25 | 110 | 45 | 26 | 16.00 |
| 73.01 | 110 | 52 | 43 | 27 | 110 | 55 | 30 | 20.00 |
| 73.63 | 190 | 115 | 60 | 46 | 180 | 120 | 70 | 38.00 |
| 75.81 | 190 | 115 | 60 | 46 | 180 | 120 | 70 | 38.00 |
| 78.80 | 190 | 115 | 60 | 46 | 180 | 120 | 70 | 38.00 |
| 79.27 | 190 | 115 | 60 | 46 | 180 | 120 | 70 | 38.00 |
| 81.36 | 110 | 95 | 53 | 42 | 140 | 90 | 50 | 36.00 |
| 82.43 | 110 | 50 | 42 | 26 | 110 | 48 | 36 | 16.00 |
| 84.90 | 100 | 58 | 45 | 30 | 100 | 46 | 28 | 15.00 |
| 84.98 | 58 | 45 | 29 | 20 | 60 | 38 | 26 | 10.00 |
| 91.59 | 110 | 52 | 43 | 27 | 110 | 55 | 30 | 20.00 |
| 95.11 | 60 | 38 | 32 | 23 | 70 | 38 | 26 | 10.00 |
| 99.63 | 58 | 45 | 29 | 20 | 60 | 38 | 26 | 10.00 |
| 102.79 | 50 | 40 | 25 | 15 | 50 | 28 | 20 | <10 |

**Table 5. Approximate flows at which certain percentages of spawning and incubation habitat are protected, given an initial spawning flow (in cfs) for an average year.**

| | Existing Substrate | | | | Enhanced Substrate | | | |
|---|---|---|---|---|---|---|---|---|
| Mean Spawning | 100% | 90% | 80% | 70% | 100% | 90% | 80% | 70% |
| 75.75 | 50 | 28 | 20 | 15 | 40 | 26 | 17 | <10 |
| 71.06 | 40 | 25 | 18 | 12 | 40 | 26 | 17 | <10 |
| 68.18 | 40 | 24 | 18 | 12 | 40 | 25 | 17 | <10 |
| 95.66 | 60 | 41 | 26 | 16 | 60 | 28 | 20 | <10 |
| 131.95 | 60 | 47 | 38 | 26 | 80 | 40 | 25 | 12 |
| 155.98 | 110 | 50 | 42 | 27 | 110 | 50 | 28 | 17 |
| 235.49 | 140 | 98 | 58 | 45 | 170 | 100 | 50 | 28 |
| 237.01 | 140 | 98 | 58 | 45 | 170 | 100 | 50 | 28 |
| 235.26 | 140 | 98 | 58 | 45 | 170 | 100 | 50 | 28 |
| 235.86 | 140 | 98 | 58 | 45 | 170 | 100 | 50 | 28 |
| 237.21 | 140 | 98 | 58 | 45 | 170 | 100 | 50 | 28 |
| 221.84 | 140 | 98 | 58 | 45 | 160 | 95 | 50 | 28 |
| 133.94 | 60 | 47 | 38 | 26 | 80 | 40 | 25 | 12 |
| 112.34 | 60 | 46 | 28 | 20 | 70 | 32 | 22 | 10 |
| 153.26 | 110 | 50 | 42 | 27 | 110 | 50 | 28 | 17 |
| 114.61 | 60 | 46 | 28 | 20 | 70 | 32 | 22 | 10 |
| 101.70 | 60 | 46 | 28 | 19 | 60 | 30 | 20 | <10 |
| 85.10 | 50 | 30 | 22 | 16 | 50 | 28 | 21 | <10 |

**Table 6. Approximate flows at which certain percentages of spawning and incubation habitat are protected, given an initial spawning flow (in cfs) for a "dry" average year.**

| | Existing Substrate | | | | Enhanced Substrate | | | |
|---|---|---|---|---|---|---|---|---|
| **Spawning Flow** | **100%** | **90%** | **80%** | **70%** | **100%** | **90%** | **80%** | **70%** |
| 66.60 | 40 | 24 | 18 | 12 | 40 | 24 | 17 | <10 |
| 62.84 | 40 | 24 | 16 | 11 | 40 | 24 | 15 | <10 |
| 60.54 | 40 | 24 | 16 | 11 | 40 | 24 | 15 | <10 |
| 88.53 | 50 | 35 | 22 | 16 | 60 | 28 | 20 | <10 |
| 123.56 | 60 | 46 | 38 | 12 | 80 | 38 | 23 | 11 |
| 148.79 | 110 | 50 | 42 | 27 | 90 | 48 | 27 | 15 |
| 228.39 | 140 | 98 | 58 | 54 | 180 | 120 | 70 | 40 |
| 229.61 | 140 | 98 | 58 | 54 | 180 | 120 | 70 | 40 |
| 228.21 | 140 | 98 | 58 | 54 | 180 | 120 | 70 | 40 |
| 228.69 | 140 | 98 | 58 | 54 | 180 | 120 | 70 | 40 |
| 179.77 | 110 | 92 | 50 | 40 | 130 | 70 | 40 | 23 |
| 133.47 | 60 | 48 | 40 | 24 | 80 | 40 | 25 | 12 |
| 115.15 | 60 | 40 | 30 | 20 | 70 | 32 | 22 | 10 |
| 93.88 | 60 | 40 | 25 | 17 | 60 | 28 | 20 | <10 |
| 145.03 | 60 | 48 | 40 | 25 | 90 | 48 | 27 | 15 |
| 107.37 | 60 | 44 | 28 | 20 | 60 | 30 | 21 | 11 |
| 94.04 | 60 | 40 | 25 | 17 | 60 | 28 | 20 | <10 |
| 78.60 | 50 | 29 | 20 | 13 | 50 | 28 | 19 | <10 |

**Table 7. Level of protection afforded incubating eggs with a given spawning flow for wet, average, and dry years.**

| Wet Year | | | Average Year | | | Dry Year | | |
|---|---|---|---|---|---|---|---|---|
| Flow | Norm | Enhanced | Flow | Norm | Enhanced | Flow | Norm | Enhanced |
| 84.90 | 100% | 100% | 75.75 | 100% | 100% | 66.60 | 100% | 100% |
| 79.27 | 100% | 100% | 71.06 | 100% | 100% | 62.84 | 100% | 100% |
| 75.81 | 100% | 100% | 68.18 | 100% | 100% | 60.54 | 100% | 100% |
| 102.79 | 100% | 100% | 95.66 | 90% | 90% | 88.53 | 100% | 90% |
| 140.34 | 100% | 90% | 131.95 | 90% | 90% | 123.56 | 90% | 90% |
| 163.18 | 90% | 90% | 155.98 | 90% | 90% | 148.79 | 90% | 90% |
| 242.59 | 80% | 80% | 235.49 | 80% | 80% | 228.39 | 80% | 70% |
| 244.41 | 80% | 80% | 237.01 | 80% | 80% | 229.61 | 90% | 70% |
| 242.32 | 80% | 80% | 235.26 | 80% | 80% | 228.21 | 80% | 70% |
| 243.03 | 80% | 80% | 235.86 | 80% | 80% | 228.69 | 80% | 70% |
| 194.66 | 80% | 90% | 237.21 | 80% | 80% | 179.77 | 80% | 80% |
| 150.20 | 90% | 90% | 221.84 | 80% | 80% | 133.47 | 90% | 90% |
| 132.73 | 90% | 90% | 133.94 | 90% | 90% | 115.15 | 90% | 90% |
| 110.81 | 100% | 100% | 112.34 | 90% | 90% | 93.88 | 90% | 90% |
| 161.49 | 90% | 90% | 153.26 | 90% | 90% | 145.03 | 90% | 90% |
| 121.85 | 100% | 90% | 114.61 | 90% | 90% | 107.37 | 90% | 90% |
| 109.36 | 100% | 100% | 101.70 | 90% | 90% | 94.04 | 90% | 90% |
| 91.59 | 100% | 100% | 85.10 | 100% | 100% | 78.60 | 100% | 100% |

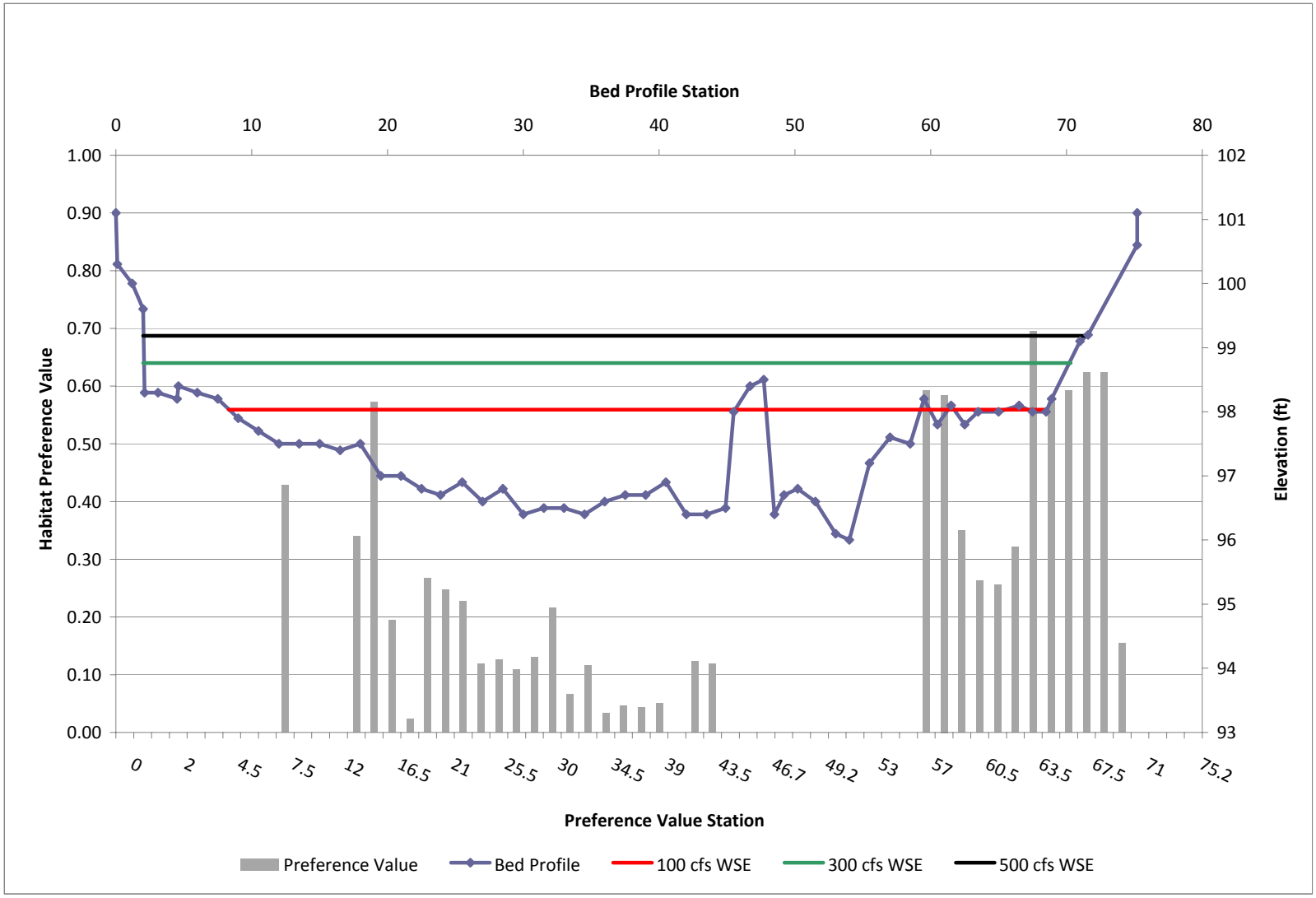



**Figure 1. Bull trout cumulative spawning preference, Transect 1, Study Site 2.**

**Figure 2. Sullivan Creek Incubation Summary for Spawning Occurring in August and September**

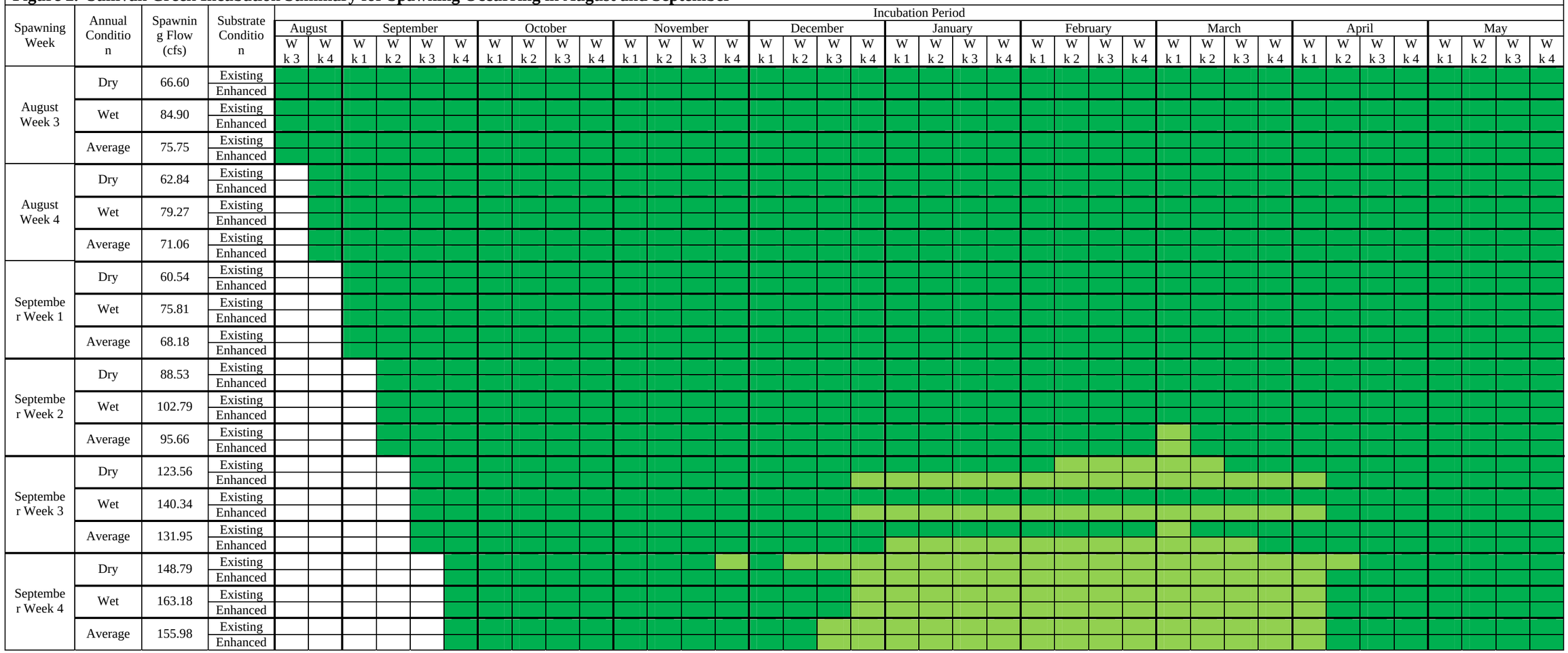
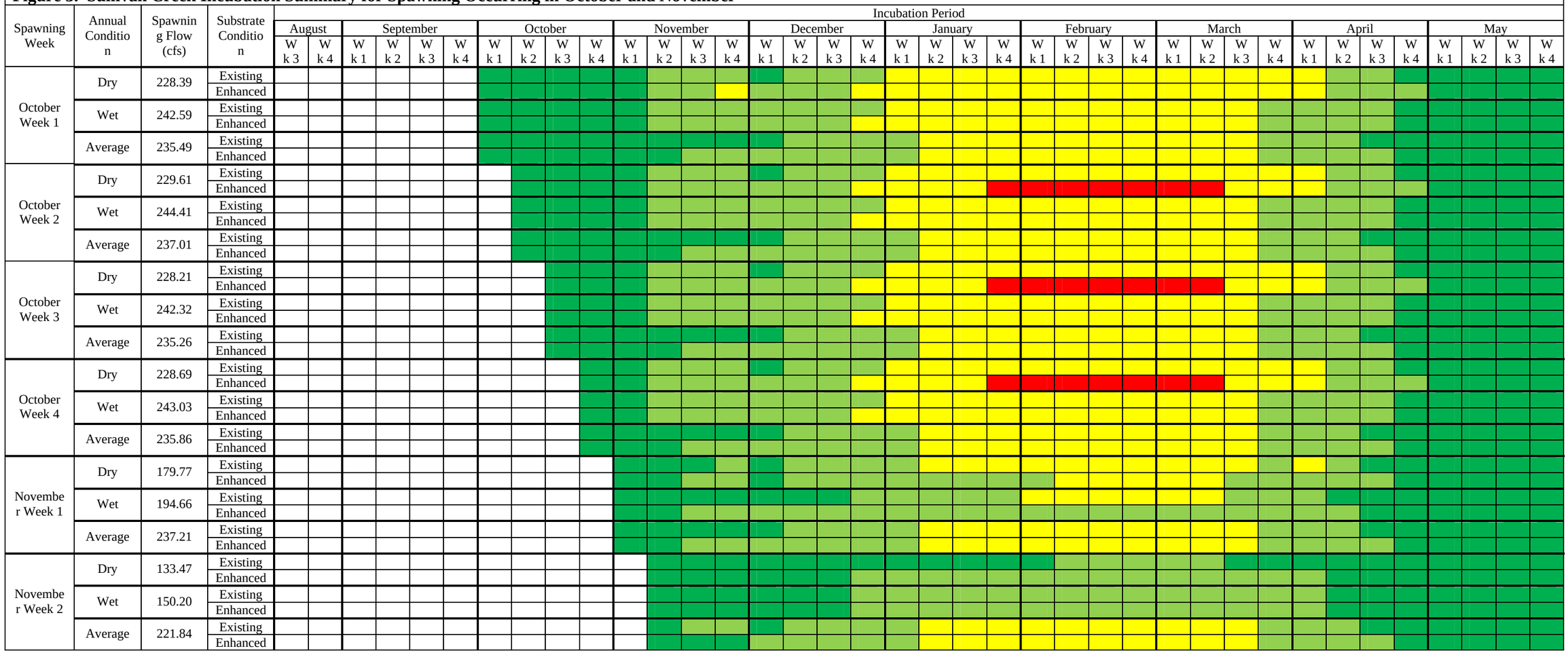
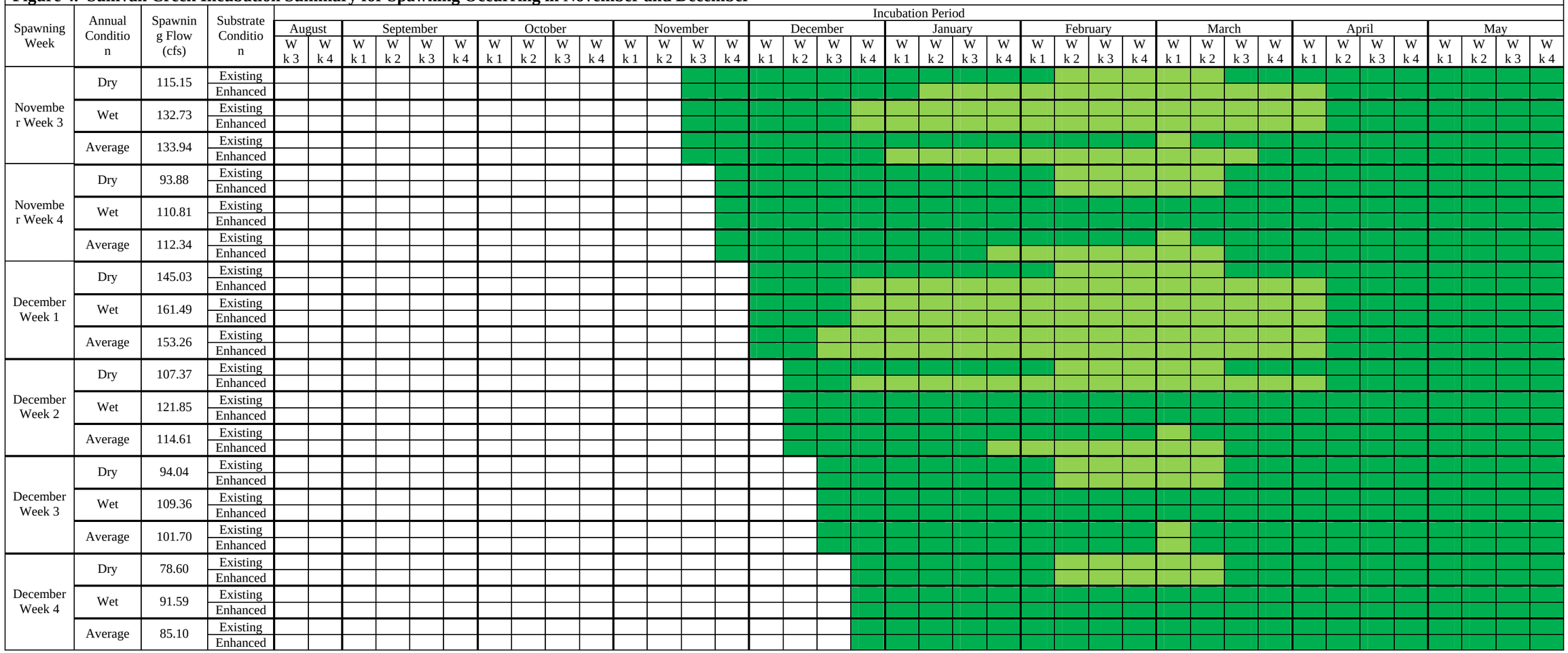


**Figure 3. Sullivan Creek Incubation Summary for Spawning Occurring in October and November**




| | |
|---|---|
| | 100 % of spawning habitat at spawning flow is protected |
| | 86 – 99 % of spawning habitat at spawning flow is protected |
| | 76 – 85 % of spawning habitat at spawning flow is protected |
| | 70 – 75 % of spawning habitat at spawning flow is protected |

## Figure 4. Sullivan Creek Incubation Summary for Spawning Occurring in November and December



# APPLICATION FOR SURRENDER OF LICENSE
# SULLIVAN CREEK PROJECT
# FERC NO. 2225

## APPENDIX E.5-1
### SULLIVAN CREEK COLLABORATION MEETINGS FACT SHEETS, MAY 7, 2008

# SULLIVAN CREEK COLLABORATION MEETINGS
# FACT SHEET

## Sullivan Creek Hydroelectric Project

Pend Oreille County Public Utility District
Colville National Forest

### General Description of Project

- The licensed Project includes: Sullivan Lake and Dam, Mill Pond and Dam, and bridge at Sullivan Creek.
- Project built in 1909. The Project has been maintained and operated by Pend Oreille Public Utility District (PUD) since 1958.
- Portions of the Project are on National Forest System (NFS) lands and on PUD-owned lands.
- The Project stores and releases water (about 31,000 acre feet) from Sullivan Lake in accordance with Pacific Northwest Coordination Agreement and its existing FERC license.
- To the extent possible, Sullivan Lake maintains a constant elevation of 2,588.7 ft msl (mean sea level) from the months of June through September for summer recreation. The gates on the dam are open the remainder of the year to provide water that helps downstream projects (for example, Boundary and Grand Coulee) produce a little extra power. Beginning in October, the reservoir is drawn down to provide storage for spring runoff.

### Project Location (See attached map)

- At Sullivan Lake and Mill Pond along Sullivan Creek in northeastern Washington State, within Pend Oreille County
- Approximately 3 miles east of the town of Metaline Falls, WA.

### Project History

- **1909** – Sullivan Creek Project constructed by Inland Portland Cement Company.
- 1956 – Project operation for power generation discontinued.
- 1958 –PUD began maintaining the Project under a 50-year FERC non-power license.
- 1959 – Project purchased by PUD, including water system, from Lehigh Portland Cement Co.
- 1964 and 1993 – PUD studies the possibility of restoring power generation at the Project but concludes it would be uneconomical.

# SULLIVAN CREEK COLLABORATION MEETINGS
# FACT SHEET

## Sullivan Creek Hydroelectric Project

Pend Oreille County Public Utility District
Colville National Forest

### Fisheries Resources of the Project Area

Fish species found in the Sullivan Creek watershed by location, based upon historical and current records.

| **Fish Species** | **Native** | **Non-native** | **Species Locations** | | | |
|---|---|---|---|---|---|---|
| | | | Upper Sullivan Cr* | Sullivan Lk | Mill Pond | Lower Sullivan Cr* |
| Bull Trout | X | | | | | X |
| Cutthroat Trout | X | | X | X | X | X |
| Rainbow Trout | | X | X | X | X | X |
| Mountain Whitefish | X | | X | X | | X |
| Brown Trout | | X | X | X | X | X |
| Brook Trout | | X | X | | X | X |
| Kokanee | | X | X | X | X | X |
| Slimy Sculpin. | X | | X | X | | X |
| Largescale Sucker | X | | X | | X | X |
| Redside Shiner | X | | | X | | |
| Speckled Dace | X | | | X | | |
| Longnose Sucker | X | | | X | X | |
| Pygmy Whitefish | X | | | X | X | |
| Burbot | X | | | X | | X |
| Tench | | X | | X | | |

.
* Upper Sullivan is above Mill Pond and below Sullivan Lake Dam and Lower Sullivan is below Mill Pond. Sullivan Lake includes Noisy and Harvey Creeks.

# SULLIVAN CREEK COLLABORATION MEETINGS
# FACT SHEET

## Wildlife Resources of the Project Area

Results of wildlife species surveys in the Sullivan Creek watershed, based upon historical and current records.

| Wildlife Species | Threatened or Endangered* | RFSSS* | MIS* | Occurrence in Area |
|---|---|---|---|---|
| Bald eagle | | X | | Documented |
| Gray wolf | E | | | Documented |
| Grizzly bear | T | | | Documented |
| Common loon | | X | | Documented |
| Northern leopard frog | | X | | No |
| Eared Grebe | | X | | Documented |
| Townsend's big-eared bat | | X | | Documented |
| Wolverine | | X | | No |
| Great gray owl | | X | | No |
| Sandhill crane | | X | | No |
| Peregrine falcon | | X | | No |
| Pacific fisher | | X | | No |
| Big Game | | | X | Documented |
| Pileated Woodpecker | | | X | Documented |
| Barred Owl | | | X | Documented |
| Lg Raptors | | | X | Documented |
| Beaver | | | X | Good |

* Threatened or Endangered as listed by the US Fish and Wildlife Service.
* RFSSS - USDA Forest Service Pacific Northwest Region 6 - Regional Forester Special Status Species.
* MIS - Colville National Forest Land and Resource Management Plan Management Indicator Species.

## Botanical Resources of the Project Area

Sensitive botanical species surveyed in the Sullivan Creek watershed, based upon historical and current records.

| Botanical Species RFSSS* | Potential to Occur in Area | Habitats |
|---|---|---|
| Prairie moonwort | Good | Dry meadows, 3000-3400 ft. |
| Crenulate moonwort | Good | Western redcedar-western hemlock forests, streambanks, floodplains, 2030-4600 ft. |
| Skinny moonwort | Good | Western redcedar-western hemlock forests, streambanks, floodplains, 2000-4000 ft. |
| Two-spiked moonwort | Good | Dry meadows, perennial and intermittent streams, 2500-3600 ft. |
| Yellow sedge | Documented | Fens, bogs, wet meadows and ponds, 2420-4300 ft. |

# SULLIVAN CREEK COLLABORATION MEETINGS
# FACT SHEET

| **Botanical Species RFSSS*** | **Potential to Occur in Area** | **Habitats** |
|---|---|---|
| Bronze sedge | Documented | Marshes, 2585 ft. |
| Naked kidney lichen | Good | On branches and twigs of trees, especially conifers. Also on mossy rocks in humid forests. |

The following tables list documented and suspected noxious weeds in the Project Area.

Class "A and B-designate": Weeds in these classes occur at a few sites within Pend Oreille County, are considered an economic threat.

Class "B" and "C": These classes are mostly common in Pend Oreille County and have an overall goal of containment and reducing the negative impact to below and acceptable levels.

| **Class "A" Noxious Weeds – New Invader or Potential New Invader** | |
|---|---|
| Common Name | Scientific Name |
| Salt cedar | *Tamarix ramosissima* |
| Indigo bush | *Amporpha fruiticosa* |
| Pepperweed | *Lepidium latifolium* |
| Garden loosestrife | *Lysimachia vulgaris* |

| **Class "B-designate" Noxious Weeds - New Invader to Area** | |
|---|---|
| Common Name | Scientific Name |
| Policeman's helmet | *Impatiens glandulifer* |
| Leafy spurge | *Euphorbia esula* |
| Plumeless thistle | *Carduus nutans* |
| Meadow knapweed | *Centaurea nigra* |
| Purple loosestrife | *Lythrum salicaria* |
| Yellow hawkweed | *Hieracium caespitosum* |

| **Class "B" Noxious Weeds – Established Infestations** | |
|---|---|
| Common Name | Scientific Name |
| Yellow hawkweed | *Hieracium caespitosum* |
| Japanese knotweed | *Polygonum sachalinense* |
| Giant knotweed | *Polygonum cuspidatum* |
| Diffuse Knapweed | *Centaurea diffusa* |
| Spotted Knapweed | *Centaurea biebersteinii* |
| Oxeye daisy | *Leucanthemum vulgare* |
| Sulfur Cinquefoil | *Potentilla recta* |
| Eurasian water-milfoil | *Myriophyllum spicatum* |

| **Class "C" Noxious Weeds – Established Infestations** | |
|---|---|
| Common Name | Scientific Name |
| Reed canary-grass | *Phalaris arundinacea* |
| Canada thistle | *Cirsium arvense* |
| St. Johns-wort | *Hypericum perforatum* |
| Absinth wormwood | *Artemisia absinthium* |

# SULLIVAN CREEK COLLABORATION MEETINGS
# FACT SHEET

## Geologic and Soil Resources of the Project Area

Harvey Creek and Sullivan Lake:

- Harvey Creek is the largest stream flowing into the lake.
- In some years, Harvey Creek flows subsurface about 600 feet upstream from the County Road 9345 inlet bridge, preventing fish passage.
- Harvey Creek has a history of landslides upstream from the lake, unrelated to this Project. These landslides have provided additional sediment bedload into Harvey Creek, most of which is deposited in Harvey Creek before it enters Sullivan Lake.
- The highest flows, and the most sediment transport, occur in May, and early June

Sullivan Lake:

- The soils on the east and west sides of the lake are shallow and rocky. In many areas, fines and topsoil that may have existed within the lake-level fluctuation zone have been eroded away.
- Sullivan Dam releases some water at all times to keep water in Outlet Creek
- While Sullivan Dam fills from March through June, it captures high flow events, reducing potential for downstream flooding

Outlet Creek and upper Sullivan Creek:

Landslides have occurred along Outlet and upper Sullivan Creek. The historic record and aerial photos show that landslides occurred in these areas prior to the dam.

Mill Pond:

- Mill Pond Dam has changed sediment transport in lower Sullivan Creek. It intercepts and stores bedload (sediment) from Outlet and upper Sullivan Creek.
- Landslides in upper Sullivan Creek in the 1960s and 1970s increased bedload, and a large delta formed near the inlet of Mill Pond. This depositional area is about 1,500 feet long, about 500 feet wide, and covers about 30 acres. Most of the deposits are well-vegetated with riparian vegetation like alder and brush.

Lower Sullivan Creek:

- Landslides occur along lower Sullivan Creek as recently as the mid-nineties.
- North Fork Sullivan Creek enters Sullivan Creek about a mile below Mill Pond Dam.

## Water Quality and Quantity of the Project Area

- Existing water temperature data indicates that summer water temperatures in lower Sullivan Creek exceed the state water quality of 16 Degrees Centigrade.
- Water flow varies in lower Sullivan Creek when the gates of Sullivan Lake Dam are opened or closed, usually during the first weeks in October and March, respectively.
- The municipal water supply for the town of Metaline Falls is provided by a dam on the North Fork of Sullivan Creek. This dam is not considered part of the Sullivan Creek Hydroelectric Project.
- The waters of lower Harvey Creek transition from surface to subsurface flows in most years during late summer through the fall. This transition area blocks any attempted upstream fish passage to over 95% of Harvey Creek and all downstream access to Sullivan Lake and beyond during this time period.

- 2003 – District files notice that it will not apply for a new Project license.

## Project Regulation

- Maintained by Pend Oreille Public Utility District (PUD) under a federal license issued by the Federal Energy Regulatory Commission (FERC) since 1958. Occupancy of National Forest System (NFS) lands is authorized under the terms of the FERC license.
- On September 22, 2003, the PUD filed a notice with FERC stating it would not seek a new license for the Project.
- On October 5, 2006, the PUD filed a Petition for Declaratory Order with FERC. The Petition argued that because FERC lacked jurisdiction to issue a license, the existing license should be annulled and that any and all FERC jurisdiction over the disposition of the Project would cease.
- On July 18, 2007, a FERC Director issued an Order that FERC's jurisdiction over the Project will cease on the date the original project license expires in October, 2008. The FERC Order found the Commission had the authority to issue the original license and agreed that FERC's jurisdiction would end in October, 2008, with no further action required by the "Commission or the licensee."
- On August 17, 2007, the Forest Service, PUD, and American Whitewater filed petitions for rehearing of the FERC July 18, 2007 Order.
- On March 20, 2008 FERC orders PUD to file an application for surrender of license and directs PUD to obtain special use authorization from Forest Service for "any other facilities that will continue to occupy federal land after the effective date of the surrender", reversing its Director's July 18, 2007 decision.
- On April 21, 2008 the PUD filed a Request for Rehearing of the FERC Order of March 20, 2008.
- On October 1, 2008 the Project license expires.

## Project Facilities

- Sullivan Lake – a natural lake, which is increased in size by the presence of the Sullivan Lake Dam. Covers 1,240 acres at elevation of 2,588.7 feet above mean sea level (msl).
- Sullivan Lake Dam - concrete dam 58 feet long and about 29 feet high. Current concrete structure brought to standard in1994.
- Mill Pond – created by a log crib dam in 1909, when Mill Pond Dam backed up Sullivan Creek. Intake structure to wooden flume at Mill Pond is no longer in use.
- Mill Pond Dam – Ungated concrete dam first built in 1921, is 134 feet long and about 55 feet high. Maintains Mill Pond at elevation of 2,506 feet msl. Earthen dike at the left abutment is 850 feet long. Dam fully refurbished in 1974.
- Abandoned Flume and Canal between Mill Pond and Sullivan Creek Powerhouse
- Powerhouse – shut down in 1956. Unused except for a small room that houses a backup pump for the Metaline Falls municipal water supply, and the chlorination facilities.

# SULLIVAN CREEK COLLABORATION MEETINGS
# FACT SHEET

## Sullivan Creek Hydroelectric Project

Pend Oreille County Public Utility District
Colville National Forest

## RECREATION AND CULTURAL RESOURCES

### Historical and Cultural Resources

#### Pre 1909

- Prehistoric use exists in the Project area.

#### 1909 Project Related

- Segment of an old county road which connects Sullivan Lake with the west end of Mill Pond
- Mill Pond, including earthen dike
- Submerged log crib dam
- The remains of the construction camp immediately southwest of the dam (Mill Pond Historic Site)
- The Flume remnant that conveyed water from Mill Pond to the powerhouse (This includes the grade upon which the flume was constructed, the remains of the flume, and various trestles built to carry the flume across intersection drainages)
- A series of telephone poles connected to the flume
- Two log crib structures along flume route.
- The canal at the end of the flume and an associated overflow or waste ditch
- The penstock and tunnel
- The powerhouse
- A remnant of the original fish ladder that was built to pass fish prior to the construction of the concrete dam.
- Sullivan Creek diversion dam (removed) and ditch

#### 1920 Project Related

Flume tender's frame house and outbuildings located west of head of flume, not on NFS land.

# SULLIVAN CREEK COLLABORATION MEETINGS
# FACT SHEET

## Recreational Use of Project

### Facilities

- 2 boat launches at Sullivan Lake
- 14 recreation residences at Sullivan Lake
- 3 developed campgrounds at Sullivan Lake (East Sullivan, West Sullivan, Noisy Creek)
- 1 developed campground at Mill Pond
- 2 group campgrounds at Sullivan Lake (East Sullivan, Noisy Creek)
- Interpretive Trail at Mill Pond Historic Site
- Swim docks at Sullivan Lake
- 3 day use/picnic areas at Sullivan Lake (East Sullivan, West Sullivan, Noisy Creek)
- 1 picnic area at Mill Pond
- Lakeshore National Recreation Trail (#504) along eastern shore of Sullivan Lake (trailheads at East Sullivan and Noisy Creek)
- Dispersed campsites
- Airstrip at Sullivan Lake campground

### Activities

- Boating (motorized and non)
- Water skiing
- Swimming
- Picnicking
- Hiking
- Camping (at both dispersed and developed sites)
- Fishing
- Gold panning

# APPLICATION FOR SURRENDER OF LICENSE
# SULLIVAN CREEK PROJECT
# FERC NO. 2225

## APPENDIX E.5-2
### U.S. FISH AND WILDLIFE SERVICE LIST OF ESA-LISTED WILDLIFE SPECIES; WDFW WASHINGTON STATE SPECIES LISTS

## USFWS ESA Listed Wildlife Species in Washington State
**http://ecos.fws.gov/tess_public/pub/stateListingIndividual.jsp?state=WAstatus=listed**

## Species listed in Washington based on published population data

Notes:

- This report shows the species listed in this state according to the Federal Register listing description.
- This list does not include experimental populations and similarity of appearance listings.
- This list includes species or populations under the sole jurisdiction of the National Marine Fisheries Service.
- Click on the highlighted scientific names below to view a Species Profile for each listing.

### Listed species (based on published population data) -- 44 listings

**Animals -- 35 listings**

| Status | Species/Listing Name |
|---|---|
| E | Albatross, short-tailed (*Phoebastria (=Diomedea) albatrus*) |
| T | Bear, grizzly lower 48 States, except where listed as an experimental population or delisted (*Ursus arctos horribilis*) |
| T | Butterfly, Oregon silverspot (*Speyeria zerene hippolyta*) |
| E | Caribou, woodland Selkirk Mountain population (*Rangifer tarandus caribou*) |
| E | Curlew, Eskimo (*Numenius borealis*) |
| E | Deer, Columbian white-tailed Columbia River DPS (*Odocoileus virginianus leucurus*) |
| T | Lynx, Canada (Contiguous U.S. DPS) (*Lynx canadensis*) |
| T | Murrelet, marbled CA, OR, WA (*Brachyramphus marmoratus*) |
| T | Otter, southern sea except where EXPN (*Enhydra lutris nereis*) |
| T | Owl, northern spotted (*Strix occidentalis caurina*) |
| E | Pelican, brown except U.S. Atlantic coast, FL, AL (*Pelecanus occidentalis*) |
| T | Plover, western snowy Pacific coastal pop. (*Charadrius alexandrinus nivosus*) |
| E | Rabbit, pygmy Columbia Basin DPS (*Brachylagus idahoensis*) |
| T | Salmon, chinook Puget Sound (*Oncorhynchus (=Salmo) tshawytscha*) |
| T | Salmon, chinook fall Snake R. (*Oncorhynchus (=Salmo) tshawytscha*) |
| T | Salmon, chinook lower Columbia R. (*Oncorhynchus (=Salmo) tshawytscha*) |
| E | Salmon, chinook spring upper Columbia R. (*Oncorhynchus (=Salmo) tshawytscha*) |
| T | Salmon, chinook spring/summer Snake R. (*Oncorhynchus (=Salmo) tshawytscha*) |
| T | Salmon, chum Columbia R. (*Oncorhynchus (=Salmo) keta*) |
| T | Salmon, chum summer-run Hood Canal (*Oncorhynchus (=Salmo) keta*) |
| T | Salmon, coho Lower Columbia River (*Oncorhynchus (=Salmo) kisutch*) |

| Status | Species/Listing Name |
|---|---|
| T | Salmon, sockeye U.S.A. (Ozette Lake, WA) (*Oncorhynchus (=Salmo) nerka*) |
| T | Sea turtle, green except where endangered (*Chelonia mydas*) |
| E | Sea turtle, leatherback (*Dermochelys coriacea*) |
| T | Sea-lion, Steller eastern pop. (*Eumetopias jubatus*) |
| E | Sea-lion, Steller western pop. (*Eumetopias jubatus*) |
| T | Steelhead Puget Sound DPS (*Oncorhynchus (=Salmo) mykiss*) |
| T | Steelhead Snake R. Basin (*Oncorhynchus (=Salmo) mykiss*) |
| T | Steelhead lower Columbia R. (*Oncorhynchus (=Salmo) mykiss*) |
| T | Steelhead middle Columbia R. (*Oncorhynchus (=Salmo) mykiss*) |
| T | Steelhead upper Columbia R. Basin (*Oncorhynchus (=Salmo) mykiss*) |
| T | Trout, bull U.S.A., conterminous, lower 48 states (*Salvelinus confluentus*) |
| E | Whale, humpback (*Megaptera novaeangliae*) |
| E | Whale, killer Southern Resident DPS (*Orcinus orca*) |
| E | Wolf, gray Lower 48 States, except where delisted and where EXPN. Mexico. (*Canis lupus*) |

**Plants -- 9 listings**

| Status | Species/Listing Name |
|---|---|
| T | Catchfly, Spalding's (*Silene spaldingii*) |
| T | Checker-mallow, Nelson's (*Sidalcea nelsoniana*) |
| E | Checkermallow, Wenatchee Mountains (*Sidalcea oregana var. calva*) |
| E | Desert-parsley, Bradshaw's (*Lomatium bradshawii*) |
| T | Howellia, water (*Howellia aquatilis*) |
| T | Ladies'-tresses, Ute (*Spiranthes diluvialis*) |
| T | Lupine, Kincaid's (*Lupinus sulphureus (=oreganus) ssp. kincaidii (=var. kincaidii)*) |
| T | Paintbrush, golden (*Castilleja levisecta*) |
| E | Stickseed, showy (*Hackelia venusta*) |

Last updated: November 12, 2009

## Species of Concern in Washington State
### Current through June 1, 2009

| COMMON NAME | SCIENTIFIC NAME | ANIMAL TYPE | FEDERAL STATUS | STATE STATUS | MAPPING CRITERIA |
|---|---|---|---|---|---|
| Cascade torrent salamander | *Rhyacotriton cascadae* | Amphibian | none | SC | IO |
| Columbia spotted frog | *Rana luteiventris* | Amphibian | none | SC | IO |
| Dunn's salamander | *Plethodon dunni* | Amphibian | none | SC | IO |
| Larch Mountain salamander | *Plethodon larselli* | Amphibian | FCo | SS | IO |
| Northern leopard frog | *Rana pipiens* | Amphibian | FCo | SE | IO |
| Oregon spotted frog | *Rana pretiosa* | Amphibian | FC | SE | IO |
| Rocky Mountain tailed frog | *Ascaphus montanus* | Amphibian | FCo | SC | IO |
| Van Dyke's salamander | *Plethodon vandykei* | Amphibian | FCo | SC | IO |
| Western toad | *Bufo boreas* | Amphibian | FCo | SC | IO |
| Giant Palouse earthworm | *Driloleirus americanus* | Annelid | none | SC | IO |
| Leschi's millipede | *Leschius mcallisteri* | Arthropod | none | SC | IO |
| American white pelican | *Pelecanus erythrorhynchos* | Bird | none | SE | B |
| Bald eagle | *Haliaeetus leucocephalus* | Bird | FCo | SS | B |
| Black-backed woodpecker | *Picoides arcticus* | Bird | none | SC | B |
| Brandt's cormorant | *Phalacrocorax penicillatus* | Bird | none | SC | B |
| Brown pelican | *Pelecanus occidentalis* | Bird | FE | SE | RSC |
| Burrowing owl | *Athene cunicularia* | Bird | FCo | SC | B |
| Cassin's auklet | *Ptychoramphus aleuticus* | Bird | FCo | SC | B |
| Common murre | *Uria aalge* | Bird | none | SC | B |
| Common loon | *Gavia immer* | Bird | none | SS | B |
| Ferruginous hawk | *Buteo regalis* | Bird | FCo | ST | B |
| Flammulated owl | *Otus flammeolus* | Bird | none | SC | B |
| Golden eagle | *Aquila chrysaetos* | Bird | none | SC | B |
| Lewis' woodpecker | *Melanerpes lewis* | Bird | none | SC | B |
| Loggerhead shrike | *Lanius ludovicianus* | Bird | FCo | SC | B |
| Marbled murrelet | *Brachyramphus marmoratus* | Bird | FT | ST | B |
| Merlin | *Falco columbarius* | Bird | none | SC | B |
| Northern goshawk | *Accipiter gentilis* | Bird | FCo | SC | B |
| Oregon vesper sparrow | *Pooecetes gramineus affinis* | Bird | FCo | SC | B |
| Peregrine falcon | *Falco peregrinus* | Bird | FCo | SS | B |
| Pileated woodpecker | *Dryocopus pileatus* | Bird | none | SC | B |
| Purple martin | *Progne subis* | Bird | none | SC | B |
| Sage thrasher | *Oreoscoptes montanus* | Bird | none | SC | B |
| Sage grouse | *Centrocercus urophasianus* | Bird | FC | ST | B |
| Sage sparrow | *Amphispiza belli* | Bird | none | SC | B |
| Sandhill crane | *Grus canadensis* | Bird | none | SE | B |
| Sharp-tailed grouse | *Tympanuchus phasianellus* | Bird | FCo | ST | B |
| Short-tailed albatross | *Diomedea albatrus* | Bird | FE | SC | none |
| Slender-billed white-breasted nuthatch | *Sitta carolinensis aculeata* | Bird | FCo | SC | IO |
| Snowy plover | *Charadrius alexandrinus* | Bird | FT | SE | B |
| Spotted owl | *Strix occidentalis* | Bird | FT | SE | IO |
| Streaked horned lark | *Eremophila alpestris strigata* | Bird | FC | SE | B |
| Tufted puffin | *Fratercula cirrhata* | Bird | FCo | SC | RLC |
| Upland sandpiper | *Bartramia longicauda* | Bird | none | SE | B |
| Vaux's swift | *Chaetura vauxi* | Bird | none | SC | B |

| | | | | | |
|---|---|---|---|---|---|
| Western grebe | *Aechmophorus occidentalis* | Bird | none | SC | B |
| White-headed woodpecker | *Picoides albolarvatus* | Bird | none | SC | B |
| Yellow-billed cuckoo | *Coccyzus americanus* | Bird | FC | SC | B |
| Chinquapin hairstreak | *Habrodais grunus herri* | Butterfly/Moth | none | SC | IO |
| Great arctic | *Oeneis nevadensis gigas* | Butterfly/Moth | none | SC | IO |
| Island marble | *Euchloe ausonides insulanus* | Butterfly/Moth | FCo | SC | IO |
| Johnson's hairstreak | *Mitoura johnsoni* | Butterfly/Moth | none | SC | IO |
| Juniper hairstreak | *Mitoura grynea barryi* | Butterfly/Moth | none | SC | IO |
| Makah (Queen Charlotte) Copper | *Lycaena mariposa charlottensis* | Butterfly/Moth | FCo | SC | IO |
| Mardon skipper | *Polites mardon* | Butterfly/Moth | FC | SE | IO |
| Oregon silverspot butterfly | *Speyeria zerene hippolyta* | Butterfly/Moth | FT | SE | IO |
| Puget blue | *Plebejus icarioides blackmorei* | Butterfly/Moth | none | SC | IO |
| Sand-verbena moth | *Copablepharon fuscum* | Butterfly/Moth | none | SC | IO |
| Shepard's parnassian | *Parnassius clodius shepardi* | Butterfly/Moth | none | SC | IO |
| Silver-bordered fritillary | *Boloria selene atrocostalis* | Butterfly/Moth | none | SC | IO |
| Taylor's checkerspot | *Euphydryas editha taylori* | Butterfly/Moth | FC | SE | IO |
| Valley silverspot | *Speyeria zerene bremnerii* | Butterfly/Moth | FCo | SC | IO |
| Yuma skipper | *Ochlodes yuma* | Butterfly/Moth | none | SC | IO |
| Black rockfish | *Sebastes melanops* | Fish | none | SC | IO |
| Bocaccio rockfish | *Sebastes paucispinis* | Fish | none | SC | IO |
| Brown rockfish | *Sebastes auriculatus* | Fish | FCo | SC | IO |
| Bull trout | *Salvelinus confluentus* | Fish | FT | SC | none |
| Canary rockfish | *Sebastes pinniger* | Fish | none | SC | IO |
| China rockfish | *Sebastes nebulosus* | Fish | none | SC | IO |
| Chinook salmon (Upper Columbia Sp) | *Oncorhynchus tshawytscha* | Fish | FE | SC | none |
| Chinook salmon (Snake R. Sp/Su) | *Oncorhynchus tshawytscha* | Fish | FT | SC | none |
| Chinook salmon (Puget Sound) | *Oncorhynchus tshawytscha* | Fish | FT | SC | none |
| Chinook salmon (Snake R. Fall) | *Oncorhynchus tshawytscha* | Fish | FT | SC | none |
| Chinook salmon (Lower Columbia) | *Oncorhynchus tshawytscha* | Fish | FT | SC | none |
| Chum salmon (Lower Columbia) | *Oncorhynchus keta* | Fish | FT | SC | none |
| Chum salmon (Hood Canal Su) | *Oncorhynchus keta* | Fish | FT | SC | none |
| Coastal cutthroat | *Oncorhynchus clarki clarki* | Fish | FCo | none | none |
| Coho salmon (Puget Sound) | *Oncorhynchus kisutch* | Fish | FCo | none | none |
| Coho salmon (Lower Columbia/SW WA) | *Oncorhynchus kisutch* | Fish | FT | none | none |
| Copper rockfish | *Sebastes caurinus* | Fish | FCo | SC | IO |
| Eulachon | *Thaleichthys pacificus* | Fish | none | SC | RC |
| Greenstriped rockfish | *Sebastes elongatus* | Fish | none | SC | IO |
| Lake chub | *Couesius plumbeus* | Fish | none | SC | IO |
| Leopard dace | *Rhinichthys falcatus* | Fish | none | SC | IO |
| Margined sculpin | *Cottus marginatus* | Fish | FCo | SS | IO |
| Mountain sucker | *Catostomus platyrhynchus* | Fish | none | SC | IO |
| Olympic mudminnow | *Novumbra hubbsi* | Fish | none | SS | IO |
| Pacific cod | *Gadus macrocephalus* | Fish | FCo | SC | IO |
| Pacific hake | *Merluccius productus* | Fish | FCo | SC | IO |
| Pacific herring | *Clupea pallasi* | Fish | FCo | SC | none |
| Pygmy whitefish | *Prosopium coulteri* | Fish | FCo | SS | IO |
| Quillback rockfish | *Sebastes maliger* | Fish | FCo | SC | IO |
| Redstripe rockfish | *Sebastes proriger* | Fish | none | SC | IO |
| River lamprey | *Lampetra ayresi* | Fish | FCo | SC | IO |

| | | | | | |
|---|---|---|---|---|---|
| Sockeye salmon (Snake R.) | *Oncorhynchus nerka* | Fish | FE | SC | none |
| Sockeye salmon (Ozette Lake) | *Onchorhynchus nerka* | Fish | FT | SC | none |
| Steelhead (Puget Sound) | *Oncorhynchus mykiss* | Fish | FT | none | none |
| Steelhead (Upper Columbia) | *Oncorhynchus mykiss* | Fish | FT | SC | none |
| Steelhead (Snake River) | *Oncorhynchus mykiss* | Fish | FT | SC | none |
| Steelhead (Middle Columbia) | *Oncorhynchus mykiss* | Fish | FT | SC | none |
| Steelhead (Lower Columbia) | *Oncorhynchus mykiss* | Fish | FT | SC | none |
| Tiger rockfish | *Sebastes nigrocinctus* | Fish | none | SC | IO |
| Umatilla dace | *Rhinichthys umatilla* | Fish | none | SC | IO |
| Walleye pollock | *Theragra chalcogramma* | Fish | FCo | SC | IO |
| Widow rockfish | *Sebastes entomelas* | Fish | none | SC | IO |
| Yellowtail rockfish | *Sebastes flavidus* | Fish | none | SC | IO |
| Yelloweye rockfish | *Sebastes ruberrimus* | Fish | none | SC | IO |
| Black right whale | *Balaena glacialis* | Mammal | FE | SE | IO |
| Black-tailed jackrabbit | *Lepus californicus* | Mammal | none | SC | IO |
| Blue whale | *Baleonoptera musculus* | Mammal | FE | SE | IO |
| Columbian white-tailed deer | *Odocoileus virginianus leucurus* | Mammal | FE | SE | IO |
| Fin whale | *Baleonoptera physalus* | Mammal | FE | SE | IO |
| Fisher | *Martes pennanti* | Mammal | FC | SE | IO |
| Gray wolf | *Canis lupus* | Mammal | FE | SE | IO |
| Gray whale | *Eschrichtius robustus* | Mammal | none | SS | IO |
| Gray-tailed vole | *Microtus canicaudus* | Mammal | none | SC | IO |
| Grizzly bear | *Ursus arctos* | Mammal | FT | SE | IO |
| Humpback whale | *Megaptera novaeangliae* | Mammal | FE | SE | IO |
| Keen's myotis | *Myotis keenii* | Mammal | none | SC | B |
| Killer whale | *Orcinus orca* | Mammal | FE | SE | IO |
| Lynx | *Lynx canadensis* | Mammal | FT | ST | IO |
| Mazama (Western) pocket gopher | *Thomomys mazama* | Mammal | FC | ST | IO |
| Merriam's shrew | *Sorex merriami* | Mammal | none | SC | IO |
| Olympic marmot | *Marmota olympus* | Mammal | none | SC | IO |
| Pacific harbor porpoise | *Phocoena phocoena* | Mammal | none | SC | RSC |
| Preble's shrew | *Sorex preblei* | Mammal | FCo | SC | IO |
| Pygmy rabbit | *Brachylagus idahoensis* | Mammal | FE | SE | IO |
| Sea otter | *Enhydra lutris* | Mammal | FCo | SE | B |
| Sei whale | *Baleonoptera borealis* | Mammal | FE | SE | IO |
| Sperm whale | *Physeter macrocephalus* | Mammal | FE | SE | IO |
| Steller sea lion | *Eumetopias jubatus* | Mammal | FT | ST | RSC |
| Townsend's ground squirrel | *Spermophilus townsendii* | Mammal | FCo | SC | IO |
| Townsend's big-eared bat | *Corynorhinus townsendii* | Mammal | FCo | SC | B |
| Washington ground squirrel | *Spermophilus washingtoni* | Mammal | FC | SC | IO |
| Western gray squirrel | *Sciurus griseus* | Mammal | FCo | ST | IO |
| White-tailed jackrabbit | *Lepus townsendii* | Mammal | none | SC | IO |
| Wolverine | *Gulo gulo* | Mammal | FCo | SC | IO |
| Woodland caribou | *Rangifer tarandus* | Mammal | FE | SE | IO |
| Blue-gray taildropper | *Prophysaon coeruleum* | Mollusk | none | SC | IO |
| California floater | *Anodonta californiensis* | Mollusk | FCo | SC | IO |
| Columbia oregonian | *Cryptomastix hendersoni* | Mollusk | none | SC | IO |
| Columbia pebblesnail | *Fluminicola columbiana* | Mollusk | FCo | SC | IO |
| Dalles sideband (snail) | *Monadenia fidelis* | Mollusk | none | SC | none |

| | | | | | |
|---|---|---|---|---|---|
| Giant Columbia River limpet | *Fisherola nuttalli* | Mollusk | none | SC | IO |
| Newcomb's littorine snail | *Algamorda subrotundata* | Mollusk | FCo | SC | IO |
| Northern abalone | *Haliotis kamtschatkana* | Mollusk | FCo | SC | IO |
| Olympia oyster | *Ostrea conchaphila* | Mollusk | none | SC | none |
| Poplar oregonian | *Cryptomastix populi* | Mollusk | none | SC | IO |
| Beller's ground beetle | *Agonum belleri* | Other Insect | FCo | SC | IO |
| Columbia clubtail (dragonfly) | *Gomphus lynnae* | Other Insect | FCo | SC | IO |
| Columbia River tiger beetle | *Cicindela columbica* | Other Insect | none | SC | IO |
| Hatch's click beetle | *Eanus hatchi* | Other Insect | FCo | SC | IO |
| Long-horned leaf beetle | *Donacia idola* | Other Insect | none | SC | IO |
| Mann's mollusk-eating ground beetle | *Scaphinotus manni* | Other Insect | none | SC | IO |
| Pacific clubtail | *Gomphus kurilis* | Other Insect | none | SC | IO |
| California mountain kingsnake | *Lampropeltis zonata* | Reptile | none | SC | IO |
| Green sea turtle | *Chelonia mydas* | Reptile | FT | ST | IO |
| Leatherback sea turtle | *Dermochelys coriacea* | Reptile | FE | SE | IO |
| Loggerhead sea turtle | *Caretta caretta* | Reptile | FT | ST | IO |
| Sagebrush lizard | *Sceloporus graciosus* | Reptile | FCo | SC | IO |
| Sharptail snake | *Contia tenuis* | Reptile | FCo | SC | IO |
| Striped whipsnake | *Masticophis taeniatus* | Reptile | none | SC | IO |
| Western pond turtle | *Actinemys marmorata* | Reptile | FCo | SE | IO |

## Status Codes:

**FE: Federal Endangered**
**FT: Federal Threatened**
**FC: Federal Candidate**
**FCo: Federal Species of Concern**
**SE: State Endangered**
**ST: State Threatened**
**SC: State Candidate**
**SS: State Sensitive**

**Washington Natural Heritage Information System**
**List of Known Occurrences of Rare Plants in Washington**
**February 2009**

## Pend Oreille County http://www1.dnr.wa.gov/nhp/refdesk/lists/plantsxco/pend.html

| Scientific Name | Common Name | State Status | Federal Status | Historic Record |
|---|---|---|---|---|
| Anagallis minima | chaffweed | T | | |
| Antennaria corymbosa | meadow pussy-toes | T | | |
| Antennaria parvifolia | Nuttall's pussy-toes | S | | |
| Anthoxanthum hirtum | common northern sweet grass | R1 | | H |
| Astragalus microcystis | least bladdery milk-vetch | S | | |
| Botrychium ascendens | triangular-lobed moonwort | S | SC | |
| Botrychium crenulatum | crenulate moonwort | S | SC | |
| Botrychium hesperium | western moonwort | T | | |
| Botrychium paradoxum | two-spiked moonwort | T | SC | |
| Botrychium pedunculosum | stalked moonwort | S | SC | |
| Carex comosa | bristly sedge | S | | |
| Carex flava | yellow sedge | S | | |
| Carex magellanica ssp. irrigua | poor sedge | S | | |
| Carex praeceptorum | Teacher's sedge | R1 | | |
| Carex rostrata | beaked sedge | S | | |
| Carex sychnocephala | many-headed sedge | S | | |
| Carex tenera var. tenera | quill sedge | T | | |
| Cicuta bulbifera | bulb-bearing water-hemlock | S | | |
| Cryptogramma stelleri | Steller's rockbrake | S | | |
| Dryas drummondii var. drummondii | yellow mountain-avens | S | | |
| Dryopteris carthusiana | toothed wood fern | R1 | | H |
| Dryopteris cristata | crested shield-fern | S | | |
| Eriophorum viridicarinatum | green keeled cotton-grass | S | | |
| Gaultheria hispidula | creeping snowberry | S | | |
| Geum rivale | water avens | S | | |
| Hypericum majus | Canadian St. John's-wort | S | | |
| Lomatium sandbergii | Sandberg's desert-parsley | T | | H |
| Lycopodium dendroideum | treelike clubmoss | S | | |
| Muhlenbergia glomerata | marsh muhly | S | | |
| Ophioglossum pusillum | Adder's-tongue | T | | |
| Salix candida | hoary willow | T | | |
| Salix maccalliana | Maccall's willow | S | | |
| Salix pseudomonticola | false mountain willow | S | | |

| | | |
|---|---|---|
| Sanicula marilandica | black snake-root | S |
| Scutellaria angustifolia ssp. micrantha | narrowleaf skullcap | R1 |
| Sisyrinchium montanum | strict blue-eyed-grass | T |
| Sisyrinchium septentrionale | blue-eyed grass | S |
| Spartina pectinata | prairie cordgrass | S |
| Subularia aquatica var. americana | water awlwort | R1 |
| Symphyotrichum boreale | rush aster | T |
| Utricularia intermedia | flat-leaved bladderwort | S |
| Utricularia minor | lesser bladderwort | R1 |
| Viola renifolia | kidney-leaved violet | S |

**Description of Codes**

**Historic Record:**

H indicates most recent sighting in the county is before 1977.

**State Status**

**State Status** of plant species is determined by the Washington Natural Heritage Program. Factors considered include abundance, occurrence patterns, vulnerability, threats, existing protection, and taxonomic distinctness. Values include:

E = Endangered. In danger of becoming extinct or extirpated from Washington.
T = Threatened. Likely to become Endangered in Washington.
S = Sensitive. Vulnerable or declining and could become Endangered or Threatened in the state.
X = Possibly extinct or Extirpated from Washington.
R1 = Review group 1. Of potential concern but needs more field work to assign another rank.
R2 = Review group 2. Of potential concern but with unresolved taxonomic questions.

**Federal Status**

**Federal Status** under the U.S. Endangered Species Act(USESA) as published in the Federal Register:

LE = Listed Endangered. In danger of extinction.
LT = Listed Threatened. Likely to become endangered.
PE = Proposed Endangered.
PT = Proposed Threatened.
C = Candidate species. Sufficient information exists to support listing as Endangered or Threatened.
SC = Species of Concern. An unofficial status, the species appears to be in jeopardy, but insufficient information to support listing.

# APPLICATION FOR SURRENDER OF LICENSE
# SULLIVAN CREEK PROJECT
# FERC NO. 2225

## APPENDIX E.6-1
### 1996 POPUD WETLAND REPORT

# SULLIVAN CREEK WETLANDS REPORT

Prepared for:

Public Utility District No. 1 of Pend Oreille County
Newport, WA

Prepared by:

Cascades Environmental Services Inc.
1111 N. Forest St.
Bellingham, WA 98225

September 1996

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## 1.0 INTRODUCTION

This report is in response to the FERC Additional Information Request dated February 16, 1996. It provides complete descriptions of all wetlands found within or adjacent to the proposed Project and includes:

- Methods used to delineate wetlands.
- A description of wetlands in relation to Project features.
- Potential impacts of the Project on wetlands.
- Plans to minimize impacts, restore wetlands, and replace wetlands that are unavoidably impacted.

This report is supplemental and revises the wetland delineation report (Appendix J) contained in the original License Amendment Application.

## 2.0 METHODS

Wetlands were originally delineated in September 1994. The results were presented in the License Amendment Application Section E3, Existing Conditions. On May 27 to May 31, 1996, the project area was re-examined to confirm wetland determinations, to more accurately map wetlands, and to describe the likely effects of the project on wetlands.

The wetland determinations used the Routine Onsite Determination method described in the *Corps of Engineers Wetland Delineation Manual* (Environmental Laboratory, 1987). To qualify as a wetland, an area must have hydrophytic vegetation, hydric soil, and wetland hydrology. In some areas where all criteria are not met but wetland indications are otherwise strong, best professional judgement based on experience in other wetlands is used to make a wetland determination.

Sample plots to describe wetland conditions and to define the wetlands boundaries were located in a representative area of each wetland and in the adjoining upland area. More than one wetland plot was used in relatively large wetlands or those with more than one distinct vegetation community. Data forms are included as Appendix 1 of this report.

Soil type and color were determined from a pit dug to a depth of 18 inches. Indicators of wetland hydrology include inundation, saturation, percolation into the soil pit, strand lines, water staining, or other signs of prior inundation. Soils along the pipeline route tended to be relatively bright due to a high mineral content, probably calcium carbonate. Because of this, other criteria were sometimes given greater weight in determining wetland boundaries.

The dominant plant species in each area investigated as a wetland were listed, and Indicator Status (a wetland fidelity rating based on the tendency of species to occur in wetlands) was recorded from Reed (1988). Where a majority of the dominant species had an Indicator Status of *facultative* (FAC) (species equally likely to occur in wetlands or non-wetlands), *facultative wetland* (FACW) (species

usually occurring in wetlands but occasionally found in non-wetlands), or *obligate wetland* (OBL) (species almost always found in wetlands), the vegetation was considered hydrophytic. Other plant species in the sample plot area were also recorded for descriptive purposes.

After wetland boundaries were marked with flagging, distances and compass bearings were measured in relation to the centerline of the pipeline and fixed points (hubs). These hubs will facilitate monitoring of restored wetlands after construction. The areas of wetlands were calculated by digitizer from maps drawn from the field measures. Estimated areas of disturbance are based on project drawings presented in the License Amendment Application or as subsequently modified.

## 3.0 EXISTING CONDITIONS

### 3.1 General Comments

A total of eight wetlands were identified within the project area. The locations of the delineated wetlands are indicated on maps comprising Appendix 2 of this report. Included are the center line of the pipeline and other project features, pipeline station numbers, the clearing limits, and the location of wetland sample plots. Refer to the License Amendment Application for complete project area maps.

The numerical designations of wetlands follow those used in the License Amendment Application. At that time, eleven wetlands were described. Note that there was no Wetland 4. The wetlands originally designated as Wetland 11 and Wetland 12 were depicted as being less than 100 feet apart in the original report. A hydrological connection between these two wetland areas was evident in May 1996. Accordingly they have been combined as Wetland 11. One new wetland area was located and was designated Wetland 13. It lies within the old canal extending from the terminus of the old flume to the forebay ponds. Wetland 1, which is at the western fringe of Mill Pond, was inaccessible due to inundation by unusually high water levels in May 1996, and thus could not be inspected.

Three putative wetlands originally described as Wetlands 2, 7, and 8 fail to meet the criteria of wetlands, and thus are not included in the final inventory of wetlands in the project area. The following section explains why these areas are not wetlands.

### 3.2 Areas Not Included as Wetlands

#### 3.2.1 Wetland 2

This is a very narrow band of riparian habitat along Outlet Creek (area originally calculated as 0.03 acres) and is not a wetland. Riparian habitats are often subject to periodic inundation as was evident during the 1996 survey. Plants may also be scoured during high flows. Wetlands and riparian areas share certain features, and some riparian areas can be classified as wetlands. However, the stream bank along Outlet Creek is best considered as part of the stream. The plant community was typical of a riparian area in that both upland and hydrophytic species were observed. This area will be

restored by revegetation following construction except for the area permanently occupied by a new bridge over Outlet Creek.

### 3.2.2 Wetland 7

This putative wetland consists of small, parallel surface drainages on a steep slope (55 percent or greater). The wetland as originally described extended from above the flume bench across the bench to Sullivan Creek. However, this area does not meet the criteria of a wetland. It is instead best described as a seasonal stream. The plant communities around the incised stream channels are not hydrophytic. Below the flume bench and extending almost to Sullivan Creek the stream terminates in an alluvial fan with large amounts of woody debris. This drainage will be culverted at the pipeline route crossing and any other affected habitat along the stream will be restored by revegetation.

Adjacent to "Wetland 7" there is zone of groundwater discharge on the hillslope above the flume bench. The latter area of less than 5,000 $ft^2$ was not originally included in the delineated wetland. The soils in this zone were saturated and there was surface flow. However, the vegetation in the seep was not distinctly different from the surrounding western red cedar upland forest. Dominant plant species in a sample plot were western red cedar (*Thuja plicata*), Engelmann spruce (*Picea engelmannii*), and western hemlock (*Tsuga heterophylla*). As a result of substantial erosion, groundcover was sparse (less than 25 percent), primarily moss, with some sedge-like horsetail (*Equisetum scirpoides*), twisted stalk (*Streptopus* sp.), and western rattlesnake-plantain (*Goodyera oblongifolia*). Based on the lack of hydrophytic vegetation distinguishable from surrounding upland forests, this seep is best interpreted as an area of mass wasting and not a wetland.

### 3.2.3 Wetland 8

This is a well-defined headwater stream confined to an incised channel (about 1-foot deep) at about 30 percent gradient. It is accurately depicted in the License Amendment Application, Section E3.2.7, Figure 8, where it is labeled, "small drainage." Probable high-water width ranges between 3-5 feet. There are numerous cascades formed by woody debris in the stream channel. In one area high water overflows and trickles through rocks and woody debris, but there were no seepages (groundwater discharge).

The vegetation community immediately flanking the stream is diverse and includes both upland and facultative hydrophytic species. Species include grand fir (*Abies grandis*), western red cedar, Douglas maple (*Acer glabrum*), western service berry (*Amelanchier alnifolia*), red-osier dogwood (*Cornus stolonifera*), prickly currant (*Ribes lacustre*), snowberry (*Symphoricarpos albus*), twinflower (*Linnaea borealis*), Queen's cup beadlily (*Clintonia uniflora*), common dandelion (*Taraxacum officinale*), wild ginger (*Asarum caudatum*), mitrewort (*Mitella* sp.), wild sarsparilla (*Aralia nudicaulis*), lady fern (*Athyrium filix-femina*), twisted stalk, trillium (*Trillium ovatum*), and baneberry (*Actaea rubra*). This drainage will be culverted at the pipeline route crossing and any other affected habitat along the stream will be restored by revegetation.

## 3.3 Wetlands in the Project Area

### 3.3.1 Wetland 1

The area of this wetland along the western edge of Mill Pond as reported in the License Application was 1.4 acres. As indicated above, high water completely inundated the wetland as well as apparent upland areas in May 1996. The wetland evidently includes an area of young alder, scrub-shrub, and shoreline dominated by herbaceous vegetation. Prior to construction, Wetland 1 will be inspected to determine total area and the area which will likely be affected by project construction.

### 3.3.2 Wetland 3

Wetland 3, located at the confluence of Sullivan Creek and Outlet Creek, is the second largest wetland in or adjacent to the project area (47,710 $ft^2$ or 1.10 acres). It is bisected by an existing unpaved road. The same portion of this wetland to be impacted by upgrading of the existing access road was graded and disturbed under permit as part of the Outlet Creek Mitigation Project, August 1995. Wetland 3 is mostly shrubby, with small trees, and areas dominated by herbaceous species. Two wetland plots (Plots 2 and 3) and an upland plot (Plot 1) were used to describe this wetland and the adjacent upland area. Owing to a hummocky surface, small areas with upland characteristics are included in the delineated wetland.

At Plot 2 hydric indicators included soil of a low chroma (color 2.5Y 3/1) and mottles (2.5Y 3/2). There was saturation to the surface and small areas of standing water near the plot. The dominant plant species were Sitka alder, snowberry, lady-fern, cow-parsnip (*Heracleum lanatum*), and enchanter's nightshade (*Circaea alpina*), a prevalence of hydrophytic species. Other plant species recorded were starry Solomon-plume (*Smilacina stellata*), thistle (*Cirsium* sp.), common horsetail (*Equisetum arvense*), avens (*Geum macrophyllum*), bedstraw (*Galium* sp.), and cow-parsnip.

The second wetland plot (Plot 3) was located between an excavated channel and Sullivan Creek. Soil was sand with low chroma (2.5Y 4/1) and mottles (10YR 3/3). There was saturation to the surface and areas of standing water. The dominant plant species were Sitka alder, red-osier dogwood, and a tall grass not yet in flower (possibly *Festuca* sp.). Other plants recorded were Douglas maple, western red cedar, thimbleberry, salmonberry, snowberry, cow-parsnip, thistle, starry Solomon-plume, mitrewort, enchanter's nightshade, common horsetail, and wheatgrass (*Agropyron* sp.).

At the upland plot (Plot 1) a majority of the dominant plant species (Engelmann spruce, starry Solomon-plume, smooth yellow violet [*Viola glabella*], and bracken [*Pteridium aquilinum*]) were hydrophytic. However, an abundance of bracken usually indicates upland conditions. An upland determination was based on the absence of wetland hydrology or hydric soil indicators (soil color 2.5Y 4/4).

### 3.3.2 Wetland 5

This wetland of approximately 2,750 $ft^2$ (0.06 acres) is associated with an active surface drainage (seasonal stream). It is located at about Station 8+00 on the pipeline route. At the flume bench the drainage spreads to form a wetland. Downslope of the flume bench the drainage returns to a seasonal stream. Wetland conditions are enhanced on the flume bench by the cut bank and the change in grade. The dominant vegetation is shrubs and sapling trees, in part because this wetland is located on and around the flume bench.

The wetland soils at Plot 1 were relatively bright probably due to a very high mineral content (assumed to be calcium carbonate), but had a low chroma indicating a hydric soil (color 7.5YR 8/1). There was flowing water with inundation of about 1 inch. At the original grade the wetland is expressed as seepage. A majority of the dominant plant species (Douglas maple, prickly currant, thimbleberry, and red-osier dogwood) were hydrophytic. Total coverage by mosses and liverworts was also high. Herbaceous species and other groundcover, including sedge-like horsetail and common horsetail, bog-orchid (slender bog-orchid [*Platanthera saccata*] or similar species), twin flower, and willow (*Salix* sp.) seedlings, had a low coverage.

The upland sample plot was located in conifer forest where shrubs and forbs were sparse. Dominant plant species are western red cedar and western hemlock. Other species are Engelmann spruce, Queen's cup beadlily, twinflower, sweet-root (*Osmorhiza* sp.), little pipsissewa (*Chimaphila menzeisii*), twisted stalk, and western rattlesnake-plantain.

### 3.3.3 Wetland 6

Wetland 6 is a small wetland (approximately 4,230 $ft^2$ or 0.10 acre) originating in a groundwater discharge zone in the forest above the flume bench. Drainage flows via a seasonal stream to a second area of wetland that intersects the pipeline route along the flume bench at about Station 12+00. Below the flume bench the wetland once again drains to a small, seasonal stream. Approximately 150-200 feet below the flume bench, the stream disappears on a flat terrace. The latter feature was interpreted to be an old glacial or fluvial terrace comprised of porous, uncompacted material. An alluvial fan has formed at the base of the slope. This feature was not considered to be part of the wetland.

Debris from the old flume covers a large portion of this wetland on the flume bench. Two wetland sample plots, Plot 1 and 3, were used to describe the major components of this wetland around the flume bench and at the groundwater discharge area, respectively.

Plot 1 was located in an area of hillslope seepage below the flume bench. Here the soil was saturated to the surface or flowing. Hydric soil was indicated by a low chroma (5Y 5/2) and higher chroma (5Y 5/3) mottling. The dominant plant species were all hydrophytic (western red cedar, red-osier dogwood, starry Solomon-plume, mitrewort, and common horsetail). Other plant species were Sitka alder, sedge-like horsetail, sedge (*Carex* sp.), and fairy-bell (*Disporum* sp.). Mosses and liverworts covered 90 percent of the plot.

The second wetland area described by Plot 3 was located in the area of groundwater discharge which is surrounded by upland conifer forest. Soil (an organic muck to about 10 inches over a mottled 5Y 5/2 sandy loam) was inundated with 1 inch of standing or flowing water. Trees were mostly restricted to the edges of this wetland area. A majority of the dominant plant species were hydrophytic (western red cedar, starry Solomon-plume, western wild ginger, and oak-fern). Other plant species were paper birch (*Betula papyrifera*), rose (*Rosa* [*gymnocarpa*?]), twayblade (*Listera* sp.), wild sarsparilla, fairy-bell, twisted stalk, enchanter's nightshade, bedstraw, and trail plant (*Adenocaulon bicolor*).

The upland plot (Plot 2) was located in adjacent conifer forest. Soil was saturated at 10 inches, probably reflecting proximity to the stream. Soil color (5Y 4/3 with 10YR 4/4 mottles) was not within the range of hydric soils. Dominant plant species were western red cedar, Queen's-cup beadlily, and mitrewort, with wild sarsparilla, bunchberry (*Cornus canadensis*), and starry Solomon-plume also well-represented. A majority of these plant species are facultative hydrophytes. An upland determination was based on a lack of other hydric indicators.

### 3.3.4 Wetland 9

This wetland occupies about 2,390 $ft^2$ (0.06 acres) and is located at about Station 10+00 on the pipeline route. It emerges as a seep with the strongest flow from a steep undercut bank above the flume bench. Water evidently flows along the flume route (obscured by debris) impeded by a berm on the north side of the flume, then extends approximately 20 feet below the flume where the water disappears below the surface. It was apparent that the old flume cut had intercepted subsurface flow to create this wetland.

In the wetland plot (Plot 1) the soil was saturated to the surface and elsewhere there was surface flowing water or standing water to about 2 inches deep. Soils were relatively bright (5Y 7/2) due to very high mineral content, but mottled (5Y 5/3). All of the dominant plant species were hydrophytic (red-osier dogwood, Douglas maple, and common horsetail). Other plant species were thimbleberry (*Rubus parviflorus*), huckleberry (*Vaccinium parvifolium*), snowberry, prickly currant, lady-fern, starry Solomon-plume, western wild ginger, bedstraw, mitrewort, and little buttercup (*Ranunculus uncinatus*). Coverage by mosses and liverworts was 90 percent.

The upland plot (Plot 2) was in upland conifer forest where herbaceous species (starry Solomon-plume, Queen's cup beadlily, clasping twisted stalk, and western rattlesnake-plantain) were very sparse. Dominant species were western red cedar and western hemlock. Soil was a 10YR 2/2 gravelly loam with no mottles. There were no indicators of wetland hydrology.

### 3.3.5 Wetland 10

Wetland 10 is a small (1070 $ft^2$ or 0.02 acres) erosional feature on the slope above the flume bench at about Station 11+00 on the pipeline route. The wetland extends to the base of the slope and does not appear to extend underneath the flume debris. A slump block with dry soils and upland vegetation is surrounded on three sides by the wetland. Because of the proximity of the wetland to

the project alignment, the entire wetland may be affected by the project. The extent of effect depends upon final construction plans (i.e., pipeline burial or spanning).

The wetland plot (Plot 1) was characterized by a gravelly sand (colluvium) with a matrix chroma of 2 (color 5Y 3/2) and 2.5Y 4/3 mottles. Soil was saturated to the surface and there was surface flow under the moss layer. Dominant plant species were Sitka alder, common horsetail, and an unidentified composite (family Asteracae) not yet in flower, at least 67 percent hydrophytic dominant species. Other species noted were willow, prickly currant, black twin-berry (*Lonicera involucrata*), ragwort (*Senecio* sp.), starry Solomon-plume, bog-orchid, twinflower, and bedstraw. Coverage by mosses and liverworts was about 90 percent.

The upland plot (Plot 2) was located in the adjacent upland conifer forest. The soil, moist but not saturated, was a gravelly loam with a high (10YR 4/4) chroma. Dominant plant species were western red cedar, grand fir, thimbleberry, and Queen's cup beadlily. Other species present were red-osier dogwood, bedstraw, bracken, sweet-root, and western rattlesnake-plantain.

### 3.3.6 Wetland 11

This wetland occupies about 12,690 $ft^2$ (0.29 acres) and is approximately located between Stations 20+00 and 21+00 on the pipeline route. The original Wetland 11 was combined with Wetland 12 because the two areas are hydrologically connected.

The area originally described as Wetland 12 contains a small stream. A low ridge that evidently separated Wetland 12 from Wetland 11 in September 1994 is now breached providing a hydrological connection between the two areas.

Three plots were used to describe conditions in this wetland (Plot 1 and 3) and adjacent upland area (Plot 2). Plot 1 is located on a mossy seepage on an active landslide deposit. Surface soil is water saturated. There was trickling surface flow. Soil (color 5Y 5/1) was a gravelly sandy clay. The entire surface was moss-covered. Dominant higher plants were hydrophytic (western red cedar, Sitka alder, and common horsetail). Other plant species were twinflower, prickly currant, willow-herb (*Epilobium* sp.), black twin-berry, and coolwort foamflower (*Tiarella trifoliata*).

The second wetland plot (Plot 3) is in an area of seepage and stream-edge. The soil had a low chroma (2.5Y 4/1 and 2.5Y 5/2), with white mineral deposits (possibly tufa). There was saturation with flowing water. Dominant tree species were western red cedar and western hemlock; the dominant shrub was red-osier dogwood; and the dominant herbaceous or ground species were sedge-like horsetail, common horsetail, and twinflower. Other species were aster, prickly currant, twayblade, and sweet-root. Groundcover by mosses and liverworts is about 60 percent.

The upland plot was located on a low ridge between wetland areas. Soil was a dry, gravelly sandy clay (color 2.5Y 4/2 with white mineral deposits). Dominant plants were western red cedar, western hemlock, paper birch, and grand fir. There were no shrubs or herbaceous species. Moss cover was about 15 percent.

### 3.3.7 Wetland 13

Wetland 13 in located within the old, constructed canal that once conveyed water from the flume to the forebays and powerplant (between Stations 132+00 and 151+00). The wetland occupies about 32,520 $ft^2$ (0.75 acres). Except at its extreme eastern end, there was water in the canal in May 1996. The canal bottom is a sandy gravel sufficiently impermeable to hold water well into the growing season. Evidence that inundation is persistent included observed water depths of 12-18 inches, generally sparse vegetation in inundated areas, the presence of obligate aquatic plants, and a well-developed, pond-type invertebrate fauna, including fingernail clams, pond snails, diving beetles, dragonfly larvae, water striders, and microcrustacea. The width of the inundated area was on average about 15 feet (range from less than 10 feet to 20 feet). No current was evident. At the extreme western end of the canal emergent vegetation was more abundant including a stand of bulrush (*Scirpus* sp.).

Wetland Plot 1 was located on the edge of the canal (soil pit in shallow water). The soil (a sandy gravel) did not exhibit hydric characteristics (color 7.5YR 3/2) despite inundation. This may reflect the relatively recent exposure of excavated non-hydric soils to hydric conditions. In the center of the canal water was about 1 foot deep. Trees along the canal were water-stained indicating that the water was about 10 inches below maximum depth. The dominant plant species was black cottonwood. Other species were Sitka alder, red-osier dogwood, Douglas maple, Oregon ash (*Fraxinus latifolia*), common horsetail, sedge, water hyssop (*Bacopa rotundifolia*), and bog-orchid. Bittercress (*Cardamine* sp.) was growing completely submerged in deep water.

The adjacent upland plot was dry and the soil was a silt loam (color 2.5Y 4/3). Dominant plant species were black cottonwood, Oregon ash, red-osier dogwood, common dandelion, and bracken.

## 3.4 Wetland Functions and Values

### 3.4.1 Wetland 1

Wetland 1 occurs on the edge of Mill Pond. No groundwater recharge or discharge occurs in the wetland. Of greater importance is the habitat function provided by the wetland. Songbirds were observed in the wetland and some nesting may occur in the immature forest canopy. Amphibians (western toad and Pacific chorus frog) also occur and may breed in the wetland. Portions of the wetland are sparsely vegetated and provide reduced cover for amphibian species. Fish are also probable inhabitants of the boundary between the wetland and Mill Pond.

The wetland is used as a minor water-storage area during times of high lake levels. Because the area is small, water storage is limited. Sediment and nutrients could potentially be stored in the wetland, but the opportunity for such functions is limited. Nearby uplands are densely vegetated and only small amounts of sediment are available for transport.

Nutrients within the wetland are annually produced, stored, and utilized by the existing vegetation. Some of the nutrient content is likely introduced into Mill Pond and is transported downstream.

However, the small size of the wetland in relation to the pond suggests that nutrient production-export is a low-value function.

Human use of the area is for recreation. Fishing may be the most important use, but a nearby historical interpretive trail provides a second use of the area. The wetland is also located in the vicinity of the intake of the old flume. Other human uses may include hiking, photography, birding, and other recreational uses.

### 3.4.2 Wetland 3

This wetland is influenced by the two adjacent streams (Sullivan Creek and Outlet Creek). There is an excavated channel from Sullivan Creek through the wetland to Outlet Creek. This channel floods into a portion of the wetland. Sediment stabilization is a minor function in that there is no significant source of sediment other than the access road across Outlet Creek, and the wetland basin receives minimal surface runoff from the surrounding area.

Groundwater may be recharged in the wetland during periods of high flows in the streams, but large volumes of recharge are not expected because of limited aquifer sizes and because most water runs off directly to streams. Similarly, groundwater discharge is limited in the wetland.

Floodflow alteration occurs in the wetland during peak stream flows. The effectiveness of alteration of floods within the wetland is limited in part by its location between Sullivan Lake and Mill Pond, which are both dammed. The small size of the wetland also inhibits significant flood flow alteration.

Nutrient removal and production export are also limited functions performed in the wetland. Nutrients are only trapped and utilized by plants in the wetland during high flows. Most nutrient transport is presumed to be into the wetland where the nutrients are taken up by the vegetation. Seasonal export of nutrients would occur as high flows occasionally flush nutrients into Sullivan Creek.

Deer and songbirds were evident in May 1996. Standing water may be used by amphibians; however, the connection of some areas to the creeks (allowing entry by fish) is a negative factor. In addition, the pools may not be flooded for a sufficient period to support aquatic and amphibian species.

This wetland is easily accessible from County Road No. 9345 (Sullivan Lake Road) and an existing FS road (#230) bisects the wetland. Human use of the area may be for scientific purposes, access to forest practice areas, hunting or fishing access, hiking and other outdoor recreation forms. Nearby areas provide higher recreation values and probably contribute to a reduced use of Wetland 3 for such purposes. Other forms of human use were not observed and suggest that the wetland is not actively used for human purposes.

### 3.4.3 Wetlands Along the Flume Bench

All of the wetlands along the old flume route share structural and functional features. Accordingly, the functions and values of these wetlands (Wetland 5, 6, 9, 10, and 11) are discussed together. Each is small in area and associated with groundwater discharge or surface drainage. Given the shallow soils which are mostly underlain by bedrock, discharge rates will reflect annual and recent precipitation events.

The effectiveness of these wetlands for sediment retention is low because of the steep slopes at each wetland and the small area where standing water can accumulate. In fact, some of these wetlands are sources of sediment to Sullivan Creek. Erosion and mass wasting were particularly evident at Wetlands 5 and 11.

The habitat values of these wetlands for wildlife species is limited by their small size and the absence of persistent standing water that could be used by breeding amphibians. However, they do provide sources of drinking water. The habitat structure (shrubby, edge habitat) of the wetlands is not distinctly different from the prevalent type along the rest of the flume bench. This is suitable nesting habitat for songbirds. Habitat conditions will be replicated in time after revegetation.

Because the collapsed flume makes travel along the flume bench difficult, it is unlikely that these wetlands are presently much used for hiking or other recreational activities, although there is evidence of limited hunting in the area. With a clear travel path along the route, recreational opportunities would be greatly enhanced. Past logging of surrounding forests reflects timber harvesting has been a human use of the area.

### 3.4.4 Wetland 13 (Canal)

Wetland 13 functions as a shallow pond. The hydrological behavior is not known but water was observed in the canal in May 1996 and the pond is presumed to persist into the growing season during most years. Groundwater is probably recharged from the wetland, but the recharge of groundwater from water infiltrating through the associated uplands is considered to be of greater value because of the much greater upland area. Groundwater may also discharge locally into the wetland from water that has infiltrated from nearby uplands.

Wildlife use of the area is probably limited. The narrow width of the pool and generally shallow water may not provide sufficient protection from predators and may discourage use as waterfowl nesting and rearing habitat. However, waterfowl may use the wetland as a resting and feeding habitat during migrations.

No amphibians were observed but they may occur. Although habitat appears to be suitable for all of the native species (long-toed salamander, Pacific chorus frog, western toad, and spotted frog), no adult amphibians or larvae were observed, despite searching with a dipnet by a qualified biologist.

Habitat for plants is limited in the wetland by its location beneath an upland forest canopy. Populations of plants are restricted by shade and the plant community is of low complexity as a result.

Wetland 13 has no opportunity to alter floodflows, stabilize sediment, or to retain and export nutrients. The canal is primarily a self-contained, constructed drainage basin, with the exception of a small overflow channel that was constructed as part of the original hydroelectric project. Flow from the overflow channel is directed toward Sullivan Creek through a small ravine. The concrete lined channel appears to hold water on an infrequent basis.

Human uses of the wetland are currently limited. The wetland is located on privately owned land and access is restricted. Some hunting may occur but the area is otherwise not open to the public. The canal may have some historical value because of its association with the historical development of Pend Oreille County. No current exploitation of the historical aspects of the canal such as interpretative trails has taken place.

## 4.0 POTENTIAL IMPACTS TO WETLANDS

The total area of wetlands that will be affected by the project is estimated to be about 53,045 $ft^2$ or 1.22 acres plus an estimated 1.4 acres of Wetland 1. The areas of each wetland that will be affected are summarized in Table 1. Impacts will result from vegetation removal, excavation, grading, and filling. With the exception of a portion of Wetland 3, and the entirety of Wetland 13 (or a total of about 0.94 acres), impacts to wetlands will entail a temporary loss of wildlife habitat. The hydrological functions of these wetlands should be uninterrupted. Given the small size of wetlands to be affected and the relatively young stage of vegetation in these wetlands (mostly small trees and shrubs), habitat values should be largely replaced within 5 years or less. The wetland areas unavoidably lost will be replaced in-kind at equal or greater value.

It has been assumed that the entirety of Wetland 1 will be temporarily impacted by project construction due to its close proximity to intensive construction activities associated with construction of the intake. Actual area impacted will be minimized to the extent practicable and the entire wetland can be restored on site following construction. Wetlands 5-11 will also be restored within their existing delineated boundaries following construction.

Impacts to Wetland 3 will result through upgrading of the existing road. The gravel roadbed qualifies as part of this wetland since seasonal inundation of this approach to the stream ford creates hydric conditions and some plant growth is present. The area to be permanently impacted by upgrading the access road is superimposed upon the existing access road which is part of the FS road system. This same wetland area was also recently disturbed and graded under permit for the Outlet Creek Mitigation Project (August 1995). Functions and conditions of Wetland 3 outside of the clearing limits will remain unimpacted.

Wetland 13 will be permanently filled. The functions of this isolated wetland created as a constructed canal can be replaced through construction of similar habitat of equal or higher function.

No threatened, endangered, or sensitive species of wildlife or plant has been documented in the wetlands in the project area. None of the wetlands represent unique or irreplaceable habitats. There will be minimal disruption to the hydrological and water quality functions of these wetlands. Improved slope stability and erosion control along the pipeline alignment will substantially improve the water quality of Wetlands 5, 6, 9, 10, and 11.

**TABLE 1. ESTIMATED AREAS OF WETLANDS TO BE AFFECTED BY PROJECT**

| WETLAND[1] | LOCATION | TOTAL AREA ($ft^2$) | IMPACT AREA[5] |
|---|---|---|---|
| 3 | AR 3+00 | 47,710 | 13070[2] |
| 5 | STA 8+00 | 2,750 | 1,350[3] |
| 6 | STA 12+00 | 4,230 | 500[3] |
| 9 | STA 10+00 | 2,390 | 1,150[3] |
| 10 | STA 11+00 | 1,070 | 970[3] |
| 11 | STA 20+00-21+00 | 12,690 | 3,485[3] |
| 13 | STA 132+00-151+00 | 32,520 | 32,520[4] |
| **TOTAL AREA** | | 103,360 (2.37 acres) | 53,045 (1.22 acres) |

[1]The area of Wetland 1 and area to be impacted will be calculated before construction begins.
[2]Includes estimated clearing limits. Permanent loss of wetlands equals 8490 $ft^2$.
[3]Temporary. Area to be restored.
[4]Permanent loss.
[5]Impact area equals portion of wetland within the clearing limits.

## 5.0 MEASURES TO AVOID AND PROTECT WETLANDS

An environmental biologist will be on-site prior to ground disturbing activities to ensure that the boundaries of wetlands are clearly flagged, and to establish and flag the minimum necessary clearing limits within and near wetlands. Flagging will be maintained throughout the construction period. Clearing and other construction activities will be restricted to within the clearing limits area. Staging and turn-around areas will be situated outside of wetland areas to minimize disturbance. Construction practices to further avoid and minimize impacts to wetlands are detailed in the Erosion and Sediment Control Plan.

Upon completion of construction activities disturbed areas will be revegetated wherever feasible. Revegetation will be designed to establish quickly to stabilize soil and prevent erosion, minimize aesthetic and visual impacts of the project, and also benefit wildlife by providing forage and cover.

Subsequent to submission of the License Application, the intake was redesigned and will now extend out into Mill Pond, thus greatly reducing direct impacts to Wetland 1. However, it is anticipated that

this wetland will be temporarily affected by construction activities. Prior to construction the boundaries of Wetland 1 will be flagged. An on-site environmental biologist will establish and flag the minimum necessary clearing limits. The area of wetland that will be affected will then be calculated. Following construction this wetland will be restored.

The old canal (Wetland 13) will be used for the disposal of excavated spoils from the pipeline trench. This wetland occupies about 0.75 acres. The entire wetland area will be permanently lost and the loss will be compensated through wetland replacement elsewhere. The replacement of functions and values will require that the replacement wetlands include an area of standing water (pond) habitat equal or greater to that lost.

## 6.0 RESTORATION OF WETLANDS

### 6.1 Goals of Restoration

All of the wetlands will be restored with the following exceptions. An estimated 0.19 acres of Wetland 3 (or about 18 percent of the wetland) will be permanently occupied by upgrading the existing access road and constructing a bridge across Outlet Creek. The area of Wetland 3 within the access road clearing limits is superimposed on the existing road and was recently impacted by permit as part of the Outlet Creek Mitigation Project (August 1995), a stream habitat improvement project. Wetland 13 will be used for disposal of excavated spoils, with the resulting loss of all wetland area. Wetland areas that are not to be restored will be replaced in-kind (1:1 ratio) at equal or greater value (See Section 7.0, Replacement of Wetlands). A 1:1 ratio for wetland replacement is recommended since the areas of permanent wetland loss are currently strongly affected by constructed features and functions within the affected areas are generally low. Wetland habitats within the existing roadbed at Wetland 3 and the constructed canal at Wetland 13 can readily be replicated elsewhere with improved wetland functions.

For Wetlands 1 and 5-11, the habitat values of scrub-shrub and young forested wetlands can be restored in a relatively short time by revegetation and vegetation management. Hydrology will be maintained, and this should insure the continued integrity of wetlands.

### 6.2 Site Preparation

Where materials are present, excavated duff, top soil, and subsoils in wetlands will be temporarily stored separately for use during restoration. Duff and top soil will be placed in small stockpiles no more than 36 inches deep to avoid over-compaction. Stockpiles will be situated in shade or covered to prevent desiccation. Care will be taken to avoid compaction of backfill. If any surplus top soil and duff remains, the stockpiles will be graded to match surrounding contours. Soils will be regraded to match pre-construction contours except as necessary to improve slope stability and reduce erosion. All equipment rutting will be smoothed.

Prior to re-spreading the topsoil, subsoils within the wetlands will be scarified by ripping or chiseling to loosen compacted areas from equipment traffic. Scarifying the subsoil will promote water infiltration, soil aeration and root penetration, and provide a rough interface between topsoil

and subsoil to reduce the potential for soil slippage. Scarification will be at least 12 inches deep with rippers spaced not more than 16 inches apart. Ripping and chisel plowing will also be used when materials are dry to promote the shattering of compacted soil layers. Effort will be made to scarify along the contour to reduce erosion potential and enough passes will be made with scarification equipment to relieve compaction. Chiseling may be used on compacted areas where soils are shallow.

Seedbed preparation within the wetland will be conducted immediately prior to seeding to prepare a firm seedbed conducive to proper placement and moisture retention. Seedbed preparation will also be performed to break surface crusts and to eliminate weeds which may have developed between initial reclamation and seeding. In most areas, chisel plowing or hand tools will be used to achieve this surface. Any equipment rutting of the topsoil should also be smoothed prior to seeding.

Seeded coconut cloth or jute mats will be staked on steep slopes immediately following construction. A weed-free straw or hay mulch will be used on all exposed, disturbed soil surfaces immediately following construction to reduce the potential for erosion and enhance seedling establishment. Mulch will be spread uniformly over the area so that at least 75 percent of the ground surface is covered. Mulch will need to be pulled back for seeding and re-spread if weather conditions require a time lapse between initial mulching and seeding.

## 6.3 Revegetation of Wetlands

### 6.3.1 Hand-seeding

All disturbed ground that is currently vegetated will be replanted. Revegetation should maintain the integrity of existing vegetation communities and avoid introduction of exotic species. Revegetation of wetlands will be accomplished with grass-legume seed mixture (Table 2) designed for use on wet sites, and by planting cuttings of wetland shrubs. The seed mixture was developed in consultation with WDFW, WDOE, FS and ACOE for the Outlet Creek Mitigation Project. An erosion control seed mix for upland areas will be applied in adjoining upland areas (See Erosion and Sediment Control Plan). The recommended application rate is 18 pounds per acre.

**TABLE 2**
**WETLAND RESTORATION SEED MIXTURE**

| SEED VARIETY | POUNDS/ACRE |
|---|---|
| Western mannagrass (*Glyceria occidentalis*) or Fowl mannagrass (*G. striata*) | 3.0 |
| Tufted hairgrass (*Deschampsia cespitosa*) | 4.0 |
| Redtop (*Agrostis alba*) or blue wild rye (*Elymus glaucus*) | 6.0 |
| Sterile Winter wheat (*Triticum* var.) | 3.0 |
| White Dutch clover (*Trifolium repens*) | 2.0 |
| **TOTAL** | 18.0 |

This mixture should provide strong seedling vigor to quickly establish cover for erosion protection and resistance to weed invasion. This will allow time for native species to re-establish. Seed will be by hand-broadcasted, and the seed lightly covered by dragging with a chain or hand raked. Jute matting or other erosion control fabrics may be used as needed to enhance seedling establishment. If revegetation must be repeated in any area, this will occur as soon as conditions are again suitable for seed growth.

Immediately prior to seeding, clover seed will be inoculated with a species-specific inoculant according to the manufacturer's recommendations. Procedures for legume inoculation recommended by the Soil Conservation Service will be followed.

### 6.3.2 Cuttings and Live-staking

A quick and effective means of achieving a vegetative cover for erosion control and restoration of wetland vegetation is planting or driving unrooted cuttings, sprigs or willow stakes. It is well known that most willow and cottonwoods, as well as other woody wetland species will grow readily from cuttings when they are set in moist soil. Procedures for live-staking or sprigging adapted from Gray and Leiser (1989) and McCluskey et al. (1984) are presented in Appendix 3 of this report. Wetlands being restored will be staked with one or more of the following species: willows, Sitka alder, and red-osier dogwood. Affected areas of Wetland 1 will be replanted with nursery stock to restore the existing vegetation composition.

### 6.3.3 Planting Container Stock

Container stock and cut plugs will be used along with reseeding of Wetland 1 in order to accelerate revegetation at this site which is more visible to the public than other wetlands and is adjacent to the large water body of Mill Pond. Container stock will include 1 gallon *Cornus stolonifera* planted at equaldistant six foot centers. Scirpus and Carex cut plugs will also be planted. Plant materials and the source will be approved by the FS. Plantings will occur at the first suitable opportunity following completion of construction; late spring after peak runoff is anticipated as the appropriate planting period.

## 6.4 Monitoring of Restored Wetlands

Monitoring of revegetated areas is essential for evaluating the effectiveness of revegetation efforts and to determine if planting must be repeated. The short-term goal will be establishment of cover, whereas the long-term goal will be re-establishment of a vegetation comparable or greater in function to the pre-existing vegetation communities. The success of revegetation will be monitored for the first three years following planting and seeding. In the first year after revegetation, monitoring will occur once in spring and once in late summer or early autumn. If revegetation by the seeded mix is assured after one year, monitoring during the second year will take place twice annually. Those areas that must be replanted will be monitored twice in spring and once in late summer or early autumn in the year after replanting.

During each monitoring visit, all of the revegetated areas will be examined for signs of erosion, and to identify any areas where revegetation may need to be repeated. Permanent monitoring points to be marked by a stake or rebar will be established at important and representative sites. The Licensee will consult with the agencies on the best locations of monitoring points following construction. Monitoring at these points will provide a photographic record of changing conditions and repeated assessments of the success of seedings and plantings. Quantitative measures of percentage cover by species will be made in a sample plot adjacent to each monitoring point. Each monitoring plot will be a quadrangle of about 80 $ft^2$ with dimensions that fit the revegetated area at each site. Monitoring of a larger predetermined area around each station will include coverage estimates of dominant species, and notes on the condition (viability and growth) of plantings, invasion by native species, and emerging problems (e.g., bare soil, heavily browsed vegetation, or erosion).

The criteria for successfully establishing cover after one year will be 75% coverage of seeded and/or planted vegetation. Shrub cover percentages are not expected to achieve this same target percentage cover until plants become fully established by or before year 3. Annually inundated portions of Wetland 1 which are now unvegetated will likely remain unvegetated following restoration. In very heavily shaded areas it may not be possible or desirable to establish 75% vegetation coverage. In these areas, the target criteria will be based on existing ground cover in comparable areas. The target criteria will in no case be contradictory to erosion control. Access routes and staging areas are adjacent to active roads affected by ongoing road maintenance programs. Control of exotic weeds will only be implemented if growth of such weeds on ground disturbed by this project is in marked contrast to surrounding vegetation including adjacent road shoulders.

### 6.5 Schedule

The following schedule will apply to scoping, construction, revegetation, monitoring and reports.

- Revegetation will begin at the first seasonal opportunity following construction completion. In the Sullivan Creek drainage basin, September 1 to September 30 is typically the most desirable period for fall planting of grasses. Seed application will be delayed until after the first fall rains, if possible.
- Mulching will be done immediately upon construction completion and repeated, if necessary, following seeding.
- The cutting and staking of willows and other live sprigging will be done in the spring prior to break from dormancy.
- All applicable protection and mitigation measures described in the Erosion and Sediment Control Plan will be complied with.
- The locations of monitoring points and the size of each monitoring area will be approved by the agencies prior to the onset of monitoring.
- Monitoring will begin immediately following revegetation and will continue for two years following the last seeding or planting.

- An annual status report on revegetation will be submitted to USFS, USFWS, WDFW, and WDOE. The report will incorporate agency comments on a draft report.

## 7.0 REPLACEMENT OF UNAVOIDABLE LOSSES TO WETLANDS

Prior to ground disturbance, a final plan for the creation of in-kind replacement wetlands will be submitted after consultation with the agencies. Replacement wetlands will provide habitat of equal or greater value than the lost wetlands. The replacement ratio for permanently lost wetlands will be 2:1 with wetland construction to occur concurrent with project construction. Alternatively, the replacement ratio will be 1:1 with a goal of improving functional quality of the replacement wetland to have two or more classes of wetland vegetation cover as defined by the Washington State Wetlands Rating System for Eastern Washington. The selection between these two options for the replacement ratio will be made in consultation with the agencies. The total estimated area of wetlands to be replaced is 0.94 acres. The location of replacement wetlands cannot be determined at this time as it will depend on the availability of potential sites where lost wetland functions and values can best be replaced. In general, the highest preference will be given to creating wetlands close to the project. Where this is not feasible or not the best option, replacement will be elsewhere within the Sullivan Creek drainage. If this option cannot be achieved, sites where existing wetlands can be enhanced will then be considered. Selection of replacement sites, grading and planting plans will be done in consultation with the appropriate agencies.

Replacement will be necessary for permanently lost areas of Wetland 3 (estimated at 0.19 acres) and Wetland 13 (0.75 acres). To replace the habitat values lost the replacement wetlands or enhancement area should include shrub-scrub wetlands and standing water (pond) habitat that could be used by amphibians and waterfowl. The plan for replacement wetlands will include methods for wetland creation, or enhancement of existing wetlands, location(s) of replacement wetlands, monitoring and reporting to the agencies, and estimated costs.

The following list of potential wetland replacement sites was developed in consultation with the FS. Additional sites may also be available and will be considered during agency consultation for the detailed mitigation plan.

1. Enhancement and/or enlargement of existing seasonally saturated wetland in shrub/meadow area east of County Road and south of Sullivan Creek. (T39N,R44E,SE1/4 Sec 30)
2. 27 acres of District-owned land at mouth of Harvey Creek (T38N,R44E, Sec 19)
3. Edge and banks of Mill Pond (various locations)

# APPENDIX 1
# WETLAND DETERMINATION DATA FORMS

W-3
Plot #1
(upland)

# DATA FORM
## ROUTINE ONSITE DETERMINATION METHOD[1]

Field Investigator(s): S. Nyman, W. Watts Date: 5-27-96
Project/Site: SULLIVAN CREEK HYDRO State: WA County: POC
Applicant/Owner: P.O. PUD Plant Community #/Name: Wetland 3
*Note:* If a more detailed site description is necessary, use the back of data form or a field notebook.

Do normal environmental conditions exist at the plant community?
Yes ✓ No ____ (If no, explain on back)
Has the vegetation, soils, and/or hydrology been significantly disturbed?
Yes ____ No ✓ (If yes, explain on back)

### VEGETATION

| Dominant Plant Species | Indicator Status | Stratum | Dominant Plant Species | Indicator Status | Stratum |
|---|---|---|---|---|---|
| ✓ 1. PICEA ENGELMANII 60% | FAC | T | 11. Carex sp. | | H |
| 2. CORNUS STOLONIFERA 10% | | S | 12. RUBUS PARVIFLORUS | | S |
| 3. CRATAEGUS SP. | | | 13. CIRSIUM SP. | | H |
| 4. BETULA PARVIFLORA 10% | | T | 14. BOTRYCHIUM VIRGINIANUM | | H |
| ✓ 5. SMILACINA STELLATA 20% | FAC- | H | 15. | | |
| ✓ 6. VIOLA (GLABELLA?) 40% | FACW+ | H | 16. | | |
| fiddle heads ✓ 7. PTERIDIUM AQUILINUM 730% | FACU | H | 17. | | |
| not expanded 8. ARALIA NUDICAULIS | | H | 18. | | |
| 9. EQUISETUM ARVENSE | | H | 19. | | |
| 10. ADENOCAULON BICOLOR | | H | 20. | | |

Percent of dominant species that are OBL, FACW, and/or FAC 75%
Is the hydrophytic vegetation criterion met? Yes ✓ No ____
Rationale: 750% hydrophytic species

### SOILS

Series/phase: Xerochrepts-Aquic Xerofluvents, 0-5% Subgroup:[2] Undetermined
Is the soil on the hydric soils list? Yes ____ No ✓ Undetermined ____
Is the soil a Histosol? Yes ____ No ✓ Histic epipedon present? Yes ____ No ✓
Is the soil: Mottled? Yes ____ No ✓ Gleyed? Yes ____ No ✓
Matrix Color: 2.5 Y 4/4 Mottle Colors: —
Other hydric soil indicators: silt loam
Is the hydric soil criterion met? Yes ____ No ✓
Rationale: Lacks hydric characteristics

### HYDROLOGY

Is the ground surface inundated? Yes ____ No ✓ Surface water depth: —
Is the soil saturated? Yes ____ No ✓
Depth to free-standing water in pit/soil probe hole: ____
List other field evidence of surface inundation or soil saturation.

Is the wetland hydrology criterion met? Yes ____ No ✓
Rationale: No hydrology indicators

### JURISDICTIONAL DETERMINATION AND RATIONALE

Is the plant community a wetland? Yes ____ No ✓
Rationale for jurisdictional decision: lacks soil, hydrology

[1] This data form can be used for the Hydric Soil Assessment Procedure and the Plant Community Assessment Procedure.
[2] Classification according to "Soil Taxonomy."

W-3
Plot #2
(Wetland)

# DATA FORM
## ROUTINE ONSITE DETERMINATION METHOD[1]

Field Investigator(s): S. NYMAN, W. WATTS Date: 5-27-96
Project/Site: SULLIVAN CREEK HYDRO. State: WA County: POC
Applicant/Owner: P.O. PUD Plant Community #/Name: Wetland 3
*Note:* If a more detailed site description is necessary, use the back of data form or a field notebook.

Do normal environmental conditions exist at the plant community?
Yes ✓ No ____ (If no, explain on back)
Has the vegetation, soils, and/or hydrology been significantly disturbed?
Yes ____ No ✓ (If yes, explain on back)

### VEGETATION

| Dominant Plant Species | Indicator Status | Stratum | Dominant Plant Species | Indicator Status | Stratum |
|---|---|---|---|---|---|
| ✓1. ALNUS SINUATA 30% | FACW | T/S | 11. CAREX SP. | | H |
| ✓2. SYMPHORICARPOS ALBUS 40% | FACU | S | 12. VIOLA SP. (yellow) | | H |
| (still emerging) ✓3. ATHYRIUM FILIX-FEMINA 20%+ | FAC | H | 13. PTERIDIUM AQUILINUM | | H |
| ✓4. HERACLEUM LANATUM 20% | FACU | H | 14. OSMORHIZA SP. | | H |
| ✓5. CIRCAEA ALPINA 60% | FACW | H | 15. | | |
| 6. SMILACINA STELLATA | | H | 16. | | |
| 7. CIRSIUM SP. | | H | 17. | | |
| 8. GEUM (MACROPHYLLUM?) | | H | 18. | | |
| 9. EQUISETUM ARVENSE | | H | 19. | | |
| 10. GALIUM SP. | | H | 20. | | |

Percent of dominant species that are OBL, FACW, and/or FAC 80%
Is the hydrophytic vegetation criterion met? Yes ✓ No ____
Rationale: >50% of dominant sp. are hydrophytic

### SOILS

Series/phase: Xerochrepts - Aquic Xerofluvents, 0-5% Subgroup:[2] Undetermined
Is the soil on the hydric soils list? Yes ____ No ✓ Undetermined ____
Is the soil a Histosol? Yes ____ No ✓ Histic epipedon present? Yes ____ No ✓
Is the soil: Mottled? Yes X No ____ Gleyed? Yes ____ No X
Matrix Color: 2.5Y 3/1 Mottle Colors: 2.5Y 3/2 silt loam
Other hydric soil indicators: ____
Is the hydric soil criterion met? Yes ✓ No ____
Rationale: Chroma = 1, mottled

### HYDROLOGY

Is the ground surface inundated? Yes ____ No ✓ Surface water depth: (there are areas of standing water outside the plot)
Is the soil saturated? Yes ✓ No ____ to surface
Depth to free-standing water in pit/soil probe hole: standing water to 3" below surface in pit
List other field evidence of surface inundation or soil saturation.
Small puddles nearby
Is the wetland hydrology criterion met? Yes X No ____
Rationale: Soil saturation; standing water in places

### JURISDICTIONAL DETERMINATION AND RATIONALE

Is the plant community a wetland? Yes ✓ No ____
Rationale for jurisdictional decision: All three criteria met.

[1] This data form can be used for the Hydric Soil Assessment Procedure and the Plant Community Assessment Procedure.
[2] Classification according to "Soil Taxonomy."

W-3
Plot #3

# DATA FORM
## ROUTINE ONSITE DETERMINATION METHOD[1]

Field Investigator(s): S. Nyman, W. Watts Date: 5-28-96
Project/Site: SULLIVAN CREEK HYDRO State: WA County: POC
Applicant/Owner: P.O. PUD Plant Community #/Name: Wetland 3
*Note:* If a more detailed site description is necessary, use the back of data form or a field notebook.

Do normal environmental conditions exist at the plant community?
Yes ✓ No ____ (If no, explain on back)
Has the vegetation, soils, and/or hydrology been significantly disturbed?
Yes ____ No ✓ (If yes, explain on back)

### VEGETATION

| Dominant Plant Species | Indicator Status | Stratum | Dominant Plant Species | Indicator Status | Stratum |
|---|---|---|---|---|---|
| ✓1. ALNUS SINUATA 70% | FACW | T | ✓11. FESTUCA SP ? 80% | FAC ? | H |
| ✓2. CORNUS STOLONIFERA 30% | FACW | S | 12. HOLCUS | | H |
| 3. ACER GLABRUM | | | 13. AGROPYRON SP. | | H |
| 4. RUBUS PARVIFLORUS | | S | 14. CIRCAEA ALPINA | | H |
| 5. THUJA PLICATA | | | 15. EQUISETUM ARVENSE | | H |
| 6. RUBUS SPECTABILIS | | S | 16. MITELLA SP. | | H |
| 7. SYMPHORICARPOS ALBUS | | S | 17. LIVERWORTS | | |
| 8. HERACLEUM LANATUM | | H | 18. | | |
| 9. CIRSIUM SP. | | H | 19. | | |
| 10. SMILACINA STELLATA | | H | 20. | | |

Percent of dominant species that are OBL, FACW, and/or FAC at least 66%
Is the hydrophytic vegetation criterion met? Yes ✓ No ____
Rationale: ____

### SOILS

Series/phase: Xerochrepts - Aquic XeroFluvents Subgroup:[2] Undetermined
Is the soil on the hydric soils list? Yes ____ No ✓ Undetermined ____
Is the soil a Histosol? Yes ____ No ✓ Histic epipedon present? Yes ____ No ____
Is the soil: Mottled? Yes ✓ No ____ Gleyed? Yes ____ No ✓
Matrix Color: 2.5 Y 4/1 Mottle Colors: 10 YR 3/3
Other hydric soil indicators: sand
Is the hydric soil criterion met? Yes ✓ No ____
Rationale: Chroma of "1" and mottles

### HYDROLOGY

Is the ground surface inundated? Yes ____ No ✓ Surface water depth: —
Is the soil saturated? Yes ✓ No ____ to surface
Depth to free-standing water in pit/soil probe hole: ~10 inches after 10 minutes
List other field evidence of surface inundation or soil saturation.
Scattered standing water (low spots)
Is the wetland hydrology criterion met? Yes ✓ No ____
Rationale: Soil saturation

### JURISDICTIONAL DETERMINATION AND RATIONALE

Is the plant community a wetland? Yes ✓ No ____
Rationale for jurisdictional decision: All criteria met

[1] This data form can be used for the Hydric Soil Assessment Procedure and the Plant Community Assessment Procedure.
[2] Classification according to "Soil Taxonomy."

W-5
Plot #1

# DATA FORM
## ROUTINE ONSITE DETERMINATION METHOD[1]

Field Investigator(s): S. NYMAN W. WATTS Date: 5-29-96
Project/Site: SULLIVAN CREEK HYDRO State: WA County: POC
Applicant/Owner: P.O. PUD Plant Community #/Name: Wetland 5
*Note:* If a more detailed site description is necessary, use the back of data form or a field notebook.

Do normal environmental conditions exist at the plant community?
Yes ✓ No ____ (If no, explain on back)
Has the vegetation, soils, and/or hydrology been significantly disturbed?
Yes ____ No ✓ (If yes, explain on back)

### VEGETATION

| Dominant Plant Species | Indicator Status | Stratum | Dominant Plant Species | Indicator Status | Stratum |
|---|---|---|---|---|---|
| ✓1. ACER GLABRUM 50% | FAC | | 11. | | |
| ✓2. RIBES LACUSTRE 30% | FAC+ | S | 12. | | |
| ✓3. RUBUS PARVIFLORUS 15% | FACU+ | S | 13. | | |
| ✓4. CORNUS STOLONIFERA 10% | FACW | S | 14. | | |
| 5. EQUISETUM SCIRPOIDES | | H | 15. | | |
| 6. E. ARVENSE | | H | 16. | | |
| 7. PLATANTERA SACCATA (?) | | H | 17. | | |
| 8. SALIX SP. (SEEDLINGS) | | H | 18. | | |
| 9. LINNAEA BOREALIS | | H | 19. | | |
| 10. DISPORUM SP. | | H | 20. | | |

Percent of dominant species that are OBL, FACW, and/or FAC 75%
Is the hydrophytic vegetation criterion met? Yes ✓ No ____
Rationale: ____

### SOILS

Series/phase: Manley silt loam 40-65% Subgroup:[2] ____
Is the soil on the hydric soils list? Yes ____ No ✓ Undetermined ____
Is the soil a Histosol? Yes ____ No ✓ Histic epipedon present? Yes ____ No ____
Is the soil: Mottled? Yes ____ No ✓ Gleyed? Yes ____ No ✓ v. high mineral content ($CaCO_3$)
Matrix Color: 7.5 YR 8/1 Mottle Colors: –
Other hydric soil indicators: ____
Is the hydric soil criterion met? Yes ✓ No ____
Rationale: Chroma 1 Soil

### HYDROLOGY

Is the ground surface inundated? Yes ✓ No ____ Surface water depth: ____
Is the soil saturated? Yes ✓ No ____
Depth to free-standing water in pit/soil probe hole: ____
List other field evidence of surface inundation or soil saturation.

Is the wetland hydrology criterion met? Yes ____ No ____
Rationale: ____

### JURISDICTIONAL DETERMINATION AND RATIONALE

Is the plant community a wetland? Yes ✓ No ____
Rationale for jurisdictional decision: all parameters met

[1] This data form can be used for the Hydric Soil Assessment Procedure and the Plant Community Assessment Procedure.
[2] Classification according to "Soil Taxonomy."

W-5 Plot #2
upland plot

# DATA FORM
## ROUTINE ONSITE DETERMINATION METHOD[1]

Field Investigator(s): S. NYMAN W. WATTS Date: 5-29-96
Project/Site: SULLIVAN CREEK HYDRO State: WA County: POC
Applicant/Owner: P.O. PUD Plant Community #/Name: Wetland 5
*Note:* If a more detailed site description is necessary, use the back of data form or a field notebook.

Do normal environmental conditions exist at the plant community?
Yes ✓ No ____ (If no, explain on back)
Has the vegetation, soils, and/or hydrology been significantly disturbed?
Yes ____ No ✓ (If yes, explain on back)

### VEGETATION

| Dominant Plant Species | Indicator Status | Stratum | Dominant Plant Species | Indicator Status | Stratum |
|---|---|---|---|---|---|
| ✓1. THUJA PLICATA 70% | FAC | T | 11. MOSSES 30% | – | |
| ✓2. TSUGA HETEROPHYLLA 40% | FACU- | T | 12. | | |
| 3. PICEA ENGELMANNII | | | 13. | | |
| 4. LINNAEA BOREALIS | | H | 14. | | |
| 5. OSMORHIZA SP. | | H | 15. | | |
| 6. CHIMAPHILA MENZ. | | H | 16. | | |
| 7. GOODYERA OBLONGIFOLIA | | H | 17. | | |
| 8. CORNUS CANADENSIS | | H | 18. | | |
| 9. STREPTOPUS SP. | | H | 19. | | |
| 10. CLINTONIA ~~BOREALIS~~ UNIFLORA | | H | 20. | | |

forbs are v. sparse

Percent of dominant species that are OBL, FACW, and/or FAC 50%
Is the hydrophytic vegetation criterion met? Yes ____ No ✓
Rationale: 50% of dominant species hydrophytic

### SOILS

Series/phase: Manley silt loam 40-60% Subgroup:[2]
Is the soil on the hydric soils list? Yes ____ No ✓ Undetermined ____
Is the soil a Histosol? Yes ____ No ✓ Histic epipedon present? Yes ____ No ____
Is the soil: Mottled? Yes ____ No ✓ Gleyed? Yes ____ No ✓
Matrix Color: 10 YR 4/6 Mottle Colors: ____
Other hydric soil indicators: ____
Is the hydric soil criterion met? Yes ____ No X gravelly loam
Rationale: Chroma 6 soil

### HYDROLOGY

Is the ground surface inundated? Yes ____ No X Surface water depth: —
Is the soil saturated? Yes ____ No X
Depth to free-standing water in pit/soil probe hole: —
List other field evidence of surface inundation or soil saturation.

Is the wetland hydrology criterion met? Yes ____ No X
Rationale: No indicators

### JURISDICTIONAL DETERMINATION AND RATIONALE

Is the plant community a wetland? Yes ____ No X
Rationale for jurisdictional decision: meets all parameters

[1] This data form can be used for the Hydric Soil Assessment Procedure and the Plant Community Assessment Procedure.
[2] Classification according to "Soil Taxonomy."

W-6
Plot #1

# DATA FORM
## ROUTINE ONSITE DETERMINATION METHOD[1]

Field Investigator(s): S. Nyman, W. Watts Date: 5-29-96
Project/Site: SULLIVAN CREEK HYDRO State: WA County: POC
Applicant/Owner: P.O. PUD Plant Community #/Name: Wetland 6
*Note:* If a more detailed site description is necessary, use the back of data form or a field notebook.

Do normal environmental conditions exist at the plant community?
Yes ✓ No ____ (If no, explain on back)
Has the vegetation, soils, and/or hydrology been significantly disturbed?
Yes ____ No ✓ (If yes, explain on back)

### VEGETATION

| Dominant Plant Species | Indicator Status | Stratum | Dominant Plant Species | Indicator Status | Stratum |
|---|---|---|---|---|---|
| ✓1. THUJA PLICATA 60% | FAC | T | 11. | | |
| ✓2. CORNUS STOLONIFERA 20% | FACW | S | 12. | | |
| 3. ALNUS SINUATA | | | 13. | | |
| ✓4. EQUISETUM ARVENSE 20% | FAC | H | 14. | | |
| 5. E. SCIRPOIDES 10% | | H | 15. | | |
| ✓6. MITELLA SP. 20% | FAC-FACW | H | 16. | | |
| 7. CAREX SP. | | H | 17. | | |
| ✓8. SMILACINA STELLATA 40% | FAC- | H | 18. | | |
| 9. DISPORUM SP. | | H | 19. | | |
| 10. MOSSES/LIVERWORTS 90% | — | | 20. | | |

Percent of dominant species that are OBL, FACW, and/or FAC 100%
Is the hydrophytic vegetation criterion met? Yes ✓ No ____
Rationale: All dominant species hydrophytic

### SOILS

Series/phase: Manley silt loam 40-65% Subgroup:[2]
Is the soil on the hydric soils list? Yes ____ No ✓ Undetermined ____
Is the soil a Histosol? Yes ____ No ✓ Histic epipedon present? Yes ____ No ____ OA horizon 6" DEEP
Is the soil: Mottled? Yes ✓ No ____ Gleyed? Yes ____ No ✓
Matrix Color: 5Y 5/2 Mottle Colors: 5Y 5/3 50% mottled
Other hydric soil indicators: gravelly clay (compacted)
Is the hydric soil criterion met? Yes ✓ No ____
Rationale: Chroma 2, mottled soil

### HYDROLOGY

Is the ground surface inundated? Yes ____ No ____ Surface water depth: ____
Is the soil saturated? Yes ✓ No ____
Depth to free-standing water in pit/soil probe hole: ____
List other field evidence of surface inundation or soil saturation.
elsewhere flowing. Hillslope seepage associated with seasonal stream
Is the wetland hydrology criterion met? Yes ✓ No ____
Rationale: water present

### JURISDICTIONAL DETERMINATION AND RATIONALE

Is the plant community a wetland? Yes ✓ No ____
Rationale for jurisdictional decision: all parameters met

[1] This data form can be used for the Hydric Soil Assessment Procedure and the Plant Community Assessment Procedure.
[2] Classification according to "Soil Taxonomy."

W-6
Plot #2
(upland plot)

# DATA FORM
## ROUTINE ONSITE DETERMINATION METHOD[1]

Field Investigator(s): S. Nyman, W. Watts Date: 5-29-96
Project/Site: SULLIVAN CREEK HYDRO State: WA County: POC
Applicant/Owner: P.O. PUD Plant Community #/Name:
*Note:* If a more detailed site description is necessary, use the back of data form or a field notebook.

Do normal environmental conditions exist at the plant community?
Yes ✓ No ____ (If no, explain on back)
Has the vegetation, soils, and/or hydrology been significantly disturbed?
Yes ____ No ✓ (If yes, explain on back)

## VEGETATION

| Dominant Plant Species | Indicator Status | Stratum | Dominant Plant Species | Indicator Status | Stratum |
|---|---|---|---|---|---|
| ✓ 1. THUJA PLICATA 80% | FAC | T | 11. | | |
| 2. CORNUS CANADENSIS 15% | | H | 12. | | |
| ✓ 3. CLINTONIA ~~BOREALIS~~ UNIFLORA 30% | NI | H | 13. | | |
| 4. ARALIA NUDICAULIS 15% | | H | 14. | | |
| 5. SMILACINA STELLATA 15% | | H | 15. | | |
| 6. ADENOCAULON BICOLOR | | H | 16. | | |
| ✓ 7. MITELLA SP. 20% | FAC-FACW | H | 17. | | |
| 8. LINNAEA BOREALIS | | H | 18. | | |
| 9. DISPORUM SP. | | H | 19. | | |
| 10. BOTRYCHIUM VIRGINIANUM | | H | 20. | | |

Percent of dominant species that are OBL, FACW, and/or FAC 66%
Is the hydrophytic vegetation criterion met? Yes ✓ No ____
Rationale: >50 FAC or wetter

## SOILS

Series/phase: Manley silt loam 40-65% Subgroup:[2]
Is the soil on the hydric soils list? Yes ____ No ✓ Undetermined ____
Is the soil a Histosol? Yes ____ No ✓ Histic epipedon present? Yes ____ No ____
Is the soil: Mottled? Yes ✓ No ____ Gleyed? Yes ____ No ✓
Matrix Color: 5Y 4/3 Mottle Colors: 10 YR 4/4
Other hydric soil indicators:
Is the hydric soil criterion met? Yes ____ No ✓
Rationale: Chroma 3 soil

## HYDROLOGY

Is the ground surface inundated? Yes ____ No ✓ Surface water depth: —
Is the soil saturated? Yes ____ No ✓ saturated at 10 inches
Depth to free-standing water in pit/soil probe hole:
List other field evidence of surface inundation or soil saturation.

Is the wetland hydrology criterion met? Yes ____ No ✓
Rationale: Saturated soil at 10" only.

## JURISDICTIONAL DETERMINATION AND RATIONALE

Is the plant community a wetland? Yes ____ No ✓
Rationale for jurisdictional decision: Lacks soil hydrology parameters

[1] This data form can be used for the Hydric Soil Assessment Procedure and the Plant Community Assessment Procedure.
[2] Classification according to "Soil Taxonomy."

W-6
plot #3

# DATA FORM
## ROUTINE ONSITE DETERMINATION METHOD[1]

Field Investigator(s): S. Nyman, W. Watts Date: 5-29-96
Project/Site: SULLIVAN CREEK HYDRO State: WA County: POC
Applicant/Owner: P.O. PUD Plant Community #/Name: Wetland 6
*Note:* If a more detailed site description is necessary, use the back of data form or a field notebook.

Do normal environmental conditions exist at the plant community?
Yes ✓ No ____ (If no, explain on back)
Has the vegetation, soils, and/or hydrology been significantly disturbed?
Yes ____ No ✓ (If yes, explain on back)

### VEGETATION

| Dominant Plant Species | Indicator Status | Stratum | Dominant Plant Species | Indicator Status | Stratum |
|---|---|---|---|---|---|
| ✓1. THUJA PLICATA 60% | FAC | | 11. DISPORUM SP. | | |
| 2. ROSA (GYMNOCARPIUM ?) | | | 12. CIRCAEA ALPINA | | |
| 3. BETULA PAPYRIFERA 10% | | | 13. GALIUM SP. | | |
| 4. RIBES LACUSTRE | | | 14. ADENOCAULON BICOLOR | | |
| ✓5. SMILACINA STELLATA 40% | FAC- | | 15. STREPTOPUS SP. | | |
| ✓6. MITELLA SP. 20% | FAC-FACW | | 16. | | |
| ✓7. GYMNOCARPIUM DRYOP. 20% | FAC | | 17. | | |
| ✓8. ASARUM CAUDATUM 20% | NI | | 18. | | |
| 9. LISTERA CORDATA 10% | | | 19. | | |
| 10. ARALIA NUDICAULIS | | | 20. | | |

Percent of dominant species that are OBL, FACW, and/or FAC 80%
Is the hydrophytic vegetation criterion met? Yes ✓ No ____
Rationale: ____

### SOILS

Series/phase: Mankey silt loam, 40-65% Subgroup:[2] ____
Is the soil on the hydric soils list? Yes ____ No ✓ Undetermined ____
Is the soil a Histosol? Yes ____ No ✓ Histic epipedon present? Yes ____ No ✓
Is the soil: Mottled? Yes ✓ No ____ Gleyed? Yes ____ No ✓
Matrix Color (0-10" 10YR 2/1) >10" 5Y 3/2 Mottle Colors: 5Y 4/3
Other hydric soil indicators: Sandy loam
Is the hydric soil criterion met? Yes ✓ No ____
Rationale: low chroma with mottles

### HYDROLOGY

Is the ground surface inundated? Yes ✓ No ____ Surface water depth: 1" standing and flowing water
Is the soil saturated? Yes ✓ No ____ to surface
Depth to free-standing water in pit/soil probe hole: ____
List other field evidence of surface inundation or soil saturation.

Is the wetland hydrology criterion met? Yes ✓ No ____
Rationale: Hydrology present

### JURISDICTIONAL DETERMINATION AND RATIONALE

Is the plant community a wetland? Yes ✓ No ____
Rationale for jurisdictional decision: All parameters met

[1] This data form can be used for the Hydric Soil Assessment Procedure and the Plant Community Assessment Procedure.
[2] Classification according to "Soil Taxonomy."

W-9
Plot #1

# DATA FORM
## ROUTINE ONSITE DETERMINATION METHOD[1]

Field Investigator(s): S. Nyman, W. Watts Date: 5-29-96
Project/Site: SULLIVAN CREEK HYDRO State: WA County: POC
Applicant/Owner: PO PUD Plant Community #/Name:
*Note:* If a more detailed site description is necessary, use the back of data form or a field notebook.

Do normal environmental conditions exist at the plant community?
Yes ✓ No ____ (If no, explain on back)
Has the vegetation, soils, and/or hydrology been significantly disturbed?
Yes ____ No ✓ (If yes, explain on back)

## VEGETATION

| | Dominant Plant Species | Indicator Status | Stratum | | Dominant Plant Species | Indicator Status | Stratum |
|---|---|---|---|---|---|---|---|
| ✓ 1. | CORNUS STOLONIFERA 30% | FACW | S | 11. | MITELLA | | H |
| ✓ 2. | ACER GLABRUM 20% | FAC | T/S | 12. | RANUNCULUS UNCINATUS | | H |
| 3. | RUBUS PARVIFLORUS | | S | 13. | MOSSES/LIVERWORTS 90% | – | |
| 4. | SYMPHORICARPOS ALBUS tr | | S | 14. | | | |
| 5. | RIBES LACUSTRE 10% | | S | 15. | | | |
| ✓ 6. | EQUISETUM ARVENSE 20% | FAC | H | 16. | | | |
| 7. | ATHYRIUM FILIX-FEMINA | | H | 17. | | | |
| 8. | SMILACINA STELLATA | | H | 18. | | | |
| 9. | ASARUM CAUDATUM | | H | 19. | | | |
| 10. | GALIUM SP. | | H | 20. | | | |

Percent of dominant species that are OBL, FACW, and/or FAC 100%
Is the hydrophytic vegetation criterion met? Yes ✓ No ____
Rationale: 100% FAC, wetter dominants

## SOILS

Series/phase: Manley silt loam, 40-65% Subgroup:[2]
Is the soil on the hydric soils list? Yes ____ No ✓ Undetermined ____
Is the soil a Histosol? Yes ____ No ✓ Histic epipedon present? Yes ____ No ✓
Is the soil: Mottled? Yes ✓ No ____ Gleyed? Yes ____ No ✓
Matrix Color: 5Y 7/2 Mottle Colors: 5Y 5/3
Other hydric soil indicators:
Is the hydric soil criterion met? Yes ✓ No ____
Rationale: low chroma, mottled

Sandy clay; probably v. high mineral content. Color may indicate $CaCO_3$

## HYDROLOGY

Is the ground surface inundated? Yes ____ No ✓ Surface water depth: but elsewhere surface flowing and standing water to 2" deep
Is the soil saturated? Yes ✓ No ____ to surface
Depth to free-standing water in pit/soil probe hole:
List other field evidence of surface inundation or soil saturation.

Is the wetland hydrology criterion met? Yes ✓ No ____
Rationale: Indicators observed

Old flume bench construction intercepted subsurface flow

## JURISDICTIONAL DETERMINATION AND RATIONALE

Is the plant community a wetland? Yes ✓ No ____
Rationale for jurisdictional decision: All 3 parameters observed

[1] This data form can be used for the Hydric Soil Assessment Procedure and the Plant Community Assessment Procedure.
[2] Classification according to "Soil Taxonomy."

W-9
plot #2
(upland)

# DATA FORM
## ROUTINE ONSITE DETERMINATION METHOD[1]

Field Investigator(s): S. Nyman, W. Watts Date: 5-29-96
Project/Site: SULLIVAN CREEK HYDRO State: WA County: POC
Applicant/Owner: PO PUD Plant Community #/Name: Wetland 9
*Note:* If a more detailed site description is necessary, use the back of data form or a field notebook.

Do normal environmental conditions exist at the plant community?
Yes ✓ No ____ (If no, explain on back)
Has the vegetation, soils, and/or hydrology been significantly disturbed?
Yes ____ No ✓ (If yes, explain on back)

### VEGETATION

| Dominant Plant Species | Indicator Status | Stratum | Dominant Plant Species | Indicator Status | Stratum |
|---|---|---|---|---|---|
| ✓1. THUJA PLICATA 90% | FAC | T | 11. | | |
| ✓2. TSUGA HETEROPHYLLA 60% | FACU- | T | 12. | | |
| 3. SMILACINA STELLATA | FAC- | H | 13. | | |
| 4. CLINTONIA UNIFLORA | NI | H | 14. | | |
| 5. STREPTOPUS AMPLEXIFOLIUS | FAC- | H | 15. | | |
| 6. GOODYERA OBLONGIFOLIA | FACU- | H | 16. | | |
| 7. | | | 17. | | |
| 8. | | | 18. | | |
| 9. | | | 19. | | |
| 10. | | | 20. | | |

Percent of dominant species that are OBL, FACW, and/or FAC 50 % forbs are very sparse
Is the hydrophytic vegetation criterion met? Yes ____ No ✓
Rationale: 50% dominant species hydrophytic. (Goodyera rarely found in wetlands)

### SOILS

Series/phase: Manley silt loam 40-60% Subgroup:[2]
Is the soil on the hydric soils list? Yes ____ No ✓ Undetermined ____
Is the soil a Histosol? Yes ____ No ✓ Histic epipedon present? Yes ____ No ✓
Is the soil: Mottled? Yes ____ No ✓ Gleyed? Yes ____ No ✓
Matrix Color: 10YR 2/2 Mottle Colors: —
Other hydric soil indicators: —
Is the hydric soil criterion met? Yes ____ No ✓ gravelly loam
Rationale: No indicators

### HYDROLOGY

Is the ground surface inundated? Yes ____ No ✓ Surface water depth: —
Is the soil saturated? Yes ____ No ✓
Depth to free-standing water in pit/soil probe hole: —
List other field evidence of surface inundation or soil saturation.

Is the wetland hydrology criterion met? Yes ____ No ✓
Rationale: No indicators

### JURISDICTIONAL DETERMINATION AND RATIONALE

Is the plant community a wetland? Yes ____ No ✓
Rationale for jurisdictional decision: lacks 3 parameters

[1] This data form can be used for the Hydric Soil Assessment Procedure and the Plant Community Assessment Procedure.
[2] Classification according to "Soil Taxonomy."

W-10
plot #1

# DATA FORM
## ROUTINE ONSITE DETERMINATION METHOD[1]

Field Investigator(s): S. Nyman, W. Watts Date: 5-29-96
Project/Site: SULLIVAN CREEK HYDRO State: WA County: POC
Applicant/Owner: PO PUD Plant Community #/Name: Wetland 10
*Note:* If a more detailed site description is necessary, use the back of data form or a field notebook.

Do normal environmental conditions exist at the plant community?
Yes ✓ No ____ (If no, explain on back)
Has the vegetation, soils, and/or hydrology been significantly disturbed?
Yes ____ No ✓ (If yes, explain on back)

### VEGETATION

| Dominant Plant Species | | Indicator Status | Stratum | Dominant Plant Species | | Indicator Status | Stratum |
|---|---|---|---|---|---|---|---|
| ✓1. ALNUS SINUATA | 30% | FACW | T | 11. LINNAEA BOREALIS | | | |
| ↗2. THUJA PLICATA | 10% | FAC | T | 12. GALIUM SP. | | | |
| 3. SALIX SP. | 10% | | | 13. RIBES LACUSTRE | | | |
| 4. ABIES GRANDIS | | | | 14. LONICERA | | | |
| 5. SMILACINA STELLATA | 10% | | | 15. MOSSES/LIVERWORTS | 90% | – | |
| ✓6. EQUISETUM ARVENSE | 50% | FAC | H | 16. | | | |
| 7. SENECIO SP. | 15% | | | 17. | | | |
| ✓8. ASTER SP (?) | 20% | ? | H | 18. | | | |
| 9. OSMORHIZA SP. | | | | 19. | | | |
| 10. PLATANTHERA SACCATA (?) | | | | 20. | | | |

rooted on a slump block (higher ground)

Aster ? – linear, slightly toothed lvs.

Percent of dominant species that are OBL, FACW, and/or FAC 75%
Is the hydrophytic vegetation criterion met? Yes ✓ No ____
Rationale: > 50% FAC or better dominants

### SOILS

Series/phase: Mankey silt loam, 40-65% Subgroup:[2]
Is the soil on the hydric soils list? Yes ____ No ✓ Undetermined ____
Is the soil a Histosol? Yes ____ No ✓ Histic epipedon present? Yes ____ No ✓
Is the soil: Mottled? Yes ✓ No ____ Gleyed? Yes ____ No ✓
Matrix Color: 5Y 3/2 Mottle Colors: 2.5Y 4/3
Other hydric soil indicators:
Is the hydric soil criterion met? Yes ✓ No ____
Rationale: Mottled low chroma soil

gravelly sand (colluvium) active slump

### HYDROLOGY

Is the ground surface inundated? Yes ____ No ✓ Surface water depth: –
Is the soil saturated? Yes ✓ No ____ to surface (surface flow under layer of moss)
Depth to free-standing water in pit/soil probe hole:
List other field evidence of surface inundation or soil saturation.

Is the wetland hydrology criterion met? Yes ✓ No ____
Rationale: Saturation to surface

### JURISDICTIONAL DETERMINATION AND RATIONALE

Is the plant community a wetland? Yes ✓ No ____
Rationale for jurisdictional decision: all parameters observed

[1] This data form can be used for the Hydric Soil Assessment Procedure and the Plant Community Assessment Procedure.
[2] Classification according to "Soil Taxonomy."

W-10
plot #2
(upland)

# DATA FORM
## ROUTINE ONSITE DETERMINATION METHOD[1]

Field Investigator(s): S. Nyman, W. Watts Date: 5-29-96
Project/Site: SULLIVAN CREEK HYDRO State: WA County: POC
Applicant/Owner: P.O. PUD Plant Community #/Name:
*Note:* If a more detailed site description is necessary, use the back of data form or a field notebook.

Do normal environmental conditions exist at the plant community?
Yes ✓ No ____ (If no, explain on back)
Has the vegetation, soils, and/or hydrology been significantly disturbed?
Yes ____ No ✓ (If yes, explain on back)

### VEGETATION

| Dominant Plant Species | Indicator Status | Stratum | Dominant Plant Species | Indicator Status | Stratum |
|---|---|---|---|---|---|
| ✓1. THUJA PLICATA 40% | FAC | T | 11. | | |
| ✓2. ABIES GRANDIS 30% | FACU- | T | 12. | | |
| ✓3. RUBUS PARVIFLORUS 20% | FACU+ | S | 13. | | |
| 4. GALIUM SP. | | H | 14. | | |
| 5. PTERIDIUM AQUILINUM | | H | 15. | | |
| 6. GOODYERA OBLONGIFOLIA | | H | 16. | | |
| 7. OSMORHIZA SP. | | H | 17. | | |
| 8. STREPTOPUS SP | | H | 18. | | |
| ✓9. CLINTONIA UNIFLORA 20% | NI | H | 19. | | |
| 10. ALNUS SINUATA 10% | | S | 20. | | |

Percent of dominant species that are OBL, FACW, and/or FAC ✓ 25%
Is the hydrophytic vegetation criterion met? Yes ____ No ✓
Rationale: < 50% FAC or wetter

### SOILS

Series/phase: Manley silt loam 40-65% Subgroup:[2]
Is the soil on the hydric soils list? Yes ____ No ✓ Undetermined
Is the soil a Histosol? Yes ____ No ✓ Histic epipedon present? Yes ____ No ✓
Is the soil: Mottled? Yes ____ No ✓ Gleyed? Yes ____ No ✓
Matrix Color: 10 YR 4/4 Mottle Colors: —
Other hydric soil indicators:
Is the hydric soil criterion met? Yes ____ No ✓ gravelly loam
Rationale: High Chroma

### HYDROLOGY

Is the ground surface inundated? Yes ____ No ✓ Surface water depth: —
Is the soil saturated? Yes ____ No ✓ moist
Depth to free-standing water in pit/soil probe hole:
List other field evidence of surface inundation or soil saturation.

Is the wetland hydrology criterion met? Yes ____ No ✓
Rationale: No Indicators

### JURISDICTIONAL DETERMINATION AND RATIONALE

Is the plant community a wetland? Yes ____ No ✓
Rationale for jurisdictional decision: Fails soil, hyd., veg

[1] This data form can be used for the Hydric Soil Assessment Procedure and the Plant Community Assessment Procedure.
[2] Classification according to "Soil Taxonomy."

W-11
Plot #1

# DATA FORM
## ROUTINE ONSITE DETERMINATION METHOD[1]

Field Investigator(s): S. Nyman, W. Watts Date: 5-30-96
Project/Site: SULLIVAN CREEK HYDRO State: WA County: POC
Applicant/Owner: PO PUD Plant Community #/Name: Wetland 11
*Note:* If a more detailed site description is necessary, use the back of data form or a field notebook.

Do normal environmental conditions exist at the plant community?
Yes ✓ No ____ (If no, explain on back)
Has the vegetation, soils, and/or hydrology been significantly disturbed?
Yes ____ No ✓ (If yes, explain on back)

### VEGETATION

| Dominant Plant Species | Indicator Status | Stratum | Dominant Plant Species | Indicator Status | Stratum |
|---|---|---|---|---|---|
| ✓1. THUJA PLICATA 20% | FAC | T/S | 11. | | |
| ✓2. ALNUS SINUATA 10% | FACW | T/S | 12. | | |
| ✓3. EQUISETUM ARVENSE 30% | FAC | H | 13. | | |
| 4. LINNAEA BOREALIS | | H | 14. | | |
| 5. RIBES LACUSTRE | | | 15. | | |
| 6. EPILOBIUM SP | | H | 16. | | |
| 7. LONICERA INVOLUCRATA | | H | 17. | | |
| 8. TIARELLA TRIFOLIATA | | H | 18. | | |
| 9. MOSSES 100% | | | 19. | | |
| 10. | | | 20. | | |

Percent of dominant species that are OBL, FACW, and/or FAC 100
Is the hydrophytic vegetation criterion met? Yes ✓ No ____
Rationale: >50% FAC or wetter

### SOILS

Series/phase: Mankey silt loam 40-65% Subgroup:[2]
Is the soil on the hydric soils list? Yes ____ No ✓ Undetermined ____
Is the soil a Histosol? Yes ____ No ✓ Histic epipedon present? Yes ____ No ✓
Is the soil: Mottled? Yes ____ No ✓ Gleyed? Yes ____ No ✓
Matrix Color: 5Y 5/1 Mottle Colors: —
Other hydric soil indicators: —
Is the hydric soil criterion met? Yes ✓ No ____
Rationale: low chroma gravelly sandy clay (colluvium — landslide deposits)

### HYDROLOGY

Is the ground surface inundated? Yes ____ No ____ Surface water depth: ____
Is the soil saturated? Yes ✓ No ____ to surface, with flow
Depth to free-standing water in pit/soil probe hole: ____
List other field evidence of surface inundation or soil saturation.

Is the wetland hydrology criterion met? Yes ✓ No ____
Rationale: Saturation and surface flow

### JURISDICTIONAL DETERMINATION AND RATIONALE

Is the plant community a wetland? Yes ✓ No ____
Rationale for jurisdictional decision: all parameters met

[1] This data form can be used for the Hydric Soil Assessment Procedure and the Plant Community Assessment Procedure.
[2] Classification according to "Soil Taxonomy."

W-11
Plot #2
(upland)

# DATA FORM
## ROUTINE ONSITE DETERMINATION METHOD[1]

Field Investigator(s): S. NYMAN, W. WATTS Date: 5-30-96
Project/Site: Sullivan Creek Hydro State: WA County: POC
Applicant/Owner: PO PUD Plant Community #/Name: Wetland 11
*Note:* If a more detailed site description is necessary, use the back of data form or a field notebook.

Do normal environmental conditions exist at the plant community?
Yes ✓ No ____ (If no, explain on back)
Has the vegetation, soils, and/or hydrology been significantly disturbed?
Yes ____ No ✓ (If yes, explain on back)

### VEGETATION

| Dominant Plant Species | | Indicator Status | Stratum | Dominant Plant Species | Indicator Status | Stratum |
|---|---|---|---|---|---|---|
| ✓1. THUJA PLICATA | 80% | FAC | T | 11. | | |
| ✓2. TSUGA HETEROPHYLLA | 20% | FACU- | T | 12. | | |
| ✓3. BETULA PAPYRIFERA | 20% | FACU | T | 13. | | |
| ✓4. ABIES GRANDIS | 20% | FACU- | T | 14. | | |
| 5. ALNUS SINUATA | 10% | FACW | T | 15. | | |
| 6. moss | 15% | | | 16. | | |
| 7. | | | | 17. | | |
| 8. | | | | 18. | | |
| 9. | | | | 19. | | |
| 10. | | | | 20. | | |

Percent of dominant species that are OBL, FACW, and/or FAC ✓ 25% no forbs or shrubs
Is the hydrophytic vegetation criterion met? Yes ____ No ✓
Rationale: <50% FAC or better

### SOILS

Series/phase: Mashel silt loam 40-65% Subgroup:[2]
Is the soil on the hydric soils list? Yes ____ No ✓ Undetermined ____
Is the soil a Histosol? Yes ____ No ✓ Histic epipedon present? Yes ____ No ✓
Is the soil: Mottled? Yes ____ No ✓ Gleyed? Yes ____ No ✓
Matrix Color: 2.5 Y 4/2 Mottle Colors: (with white mineral deposits
Other hydric soil indicators: —
Is the hydric soil criterion met? Yes ____ No ✓ gravelly sandy clay
Rationale: No indicators

### HYDROLOGY

Is the ground surface inundated? Yes ____ No ✓ Surface water depth: —
Is the soil saturated? Yes ____ No ✓
Depth to free-standing water in pit/soil probe hole: —
List other field evidence of surface inundation or soil saturation.
—

Is the wetland hydrology criterion met? Yes ____ No ✓
Rationale: No indicators

### JURISDICTIONAL DETERMINATION AND RATIONALE

Is the plant community a wetland? Yes ____ No ✓
Rationale for jurisdictional decision: lacks all parameters

[1] This data form can be used for the Hydric Soil Assessment Procedure and the Plant Community Assessment Procedure.
[2] Classification according to "Soil Taxonomy."

W-11
Plot #3
(wetland)

# DATA FORM
## ROUTINE ONSITE DETERMINATION METHOD[1]

Field Investigator(s): S. NYMAN, W. WATTS Date: 5-30-96
Project/Site: SULLIVAN CREEK HYDRO State: WA County: POC
Applicant/Owner: P.O. PUD Plant Community #/Name: Wetland 11
*Note:* If a more detailed site description is necessary, use the back of data form or a field notebook.

Do normal environmental conditions exist at the plant community?
Yes ✓ No ____ (If no, explain on back)
Has the vegetation, soils, and/or hydrology been significantly disturbed?
Yes ____ No ✓ (If yes, explain on back)

### VEGETATION

| Dominant Plant Species | Indicator Status | Stratum | Dominant Plant Species | Indicator Status | Stratum |
|---|---|---|---|---|---|
| ✓1. THUJA PLICATA 60% | FAC | T | 11. MOSSES/LIVERWORTS 60% | – | |
| ✓2. TSUGA HETEROPHYLLA 20% | FACU- | T | 12. | | |
| ✓3. CORNUS STOLONIFERA 40% | FACW | S | 13. | | |
| ✓4. LINNAEA BOREALIS 50% | FACU- | H | 14. | | |
| ✓5. EQUISETUM ARVENSE 40% | FAC | H | 15. | | |
| ✓6. E. SCIRPOIDES 40% | FAC | H | 16. | | |
| 7. RIBES LACUSTRE | | | 17. | | |
| 8. ASTER SP. (?) | | | 18. | | |
| 9. OSMORHIZA SP. | | | 19. | | |
| 10. LISTERA CORDATA | | | 20. | | |

Percent of dominant species that are OBL, FACW, and/or FAC 67
Is the hydrophytic vegetation criterion met? Yes ✓ No ____
Rationale: >50% FAC or wetter

### SOILS

Series/phase: Marley silt loam 40-65% Subgroup:[2]
Is the soil on the hydric soils list? Yes ____ No ✓ Undetermined ____
Is the soil a Histosol? Yes ____ No ✓ Histic epipedon present? Yes ____ No ✓
Is the soil: Mottled? Yes ____ No ✓ Gleyed? Yes ____ No ✓
Matrix Color: 2.5Y 4/1 Mottle Colors: ____
Other hydric soil indicators: ____
Is the hydric soil criterion met? Yes ✓ No ____
Rationale: Chroma 1 soil

### HYDROLOGY

Is the ground surface inundated? Yes ✓ No ____ Surface water depth: (Flowing w/seasonal drainage)
Is the soil saturated? Yes ✓ No ____
Depth to free-standing water in pit/soil probe hole: ____
List other field evidence of surface inundation or soil saturation.

Is the wetland hydrology criterion met? Yes ✓ No ____
Rationale: Soil saturated, with flowing water

### JURISDICTIONAL DETERMINATION AND RATIONALE

Is the plant community a wetland? Yes ✓ No ____
Rationale for jurisdictional decision: all parameters met

[1] This data form can be used for the Hydric Soil Assessment Procedure and the Plant Community Assessment Procedure.
[2] Classification according to "Soil Taxonomy."

## DATA FORM
## ROUTINE ONSITE DETERMINATION METHOD[1]

Field Investigator(s): S. Nyman, W. Watts Date: 5-31-96
Project/Site: Sullivan Creek Hydro State: WA County: POC
Applicant/Owner: PO PUD Plant Community #/Name: Wetland 13
*Note:* If a more detailed site description is necessary, use the back of data form or a field notebook.

Do normal environmental conditions exist at the plant community?
Yes ✓ No ____ (If no, explain on back)
Has the vegetation, soils, and/or hydrology been significantly disturbed?
Yes ____ No ✓ (If yes, explain on back)

### VEGETATION

| Dominant Plant Species | Indicator Status | Stratum | Dominant Plant Species | Indicator Status | Stratum |
|---|---|---|---|---|---|
| ✓ 1. Populus trichocarpa 20% | FAC | T | 11. | | |
| 2. Salix sp. | | S | 12. | | |
| 3. Alnus sinuata | | T/S | 13. | | |
| 4. Cornus stolonifera | | S | 14. | | |
| 5. Acer glabrum | | T/S | 15. | | |
| 6. Platanthera sp. | | H | 16. | | |
| 7. Cardamine sp. | | H | 17. | | |
| 8. | | | 18. | | |
| 9. | | | 19. | | |
| 10. | | | 20. | | |

Percent of dominant species that are OBL, FACW, and/or FAC 100%
Is the hydrophytic vegetation criterion met? Yes ✓ No ____
Rationale: 100% FAC

### SOILS

Series/phase: Scotia fine sandy loam 7-15% Subgroup:[2]
Is the soil on the hydric soils list? Yes ____ No ✓ Undetermined ____
Is the soil a Histosol? Yes ____ No ✓ Histic epipedon present? Yes ____ No ✓
Is the soil: Mottled? Yes ____ No ✓ Gleyed? Yes ____ No ✓
Matrix Color: 7.5 YR 3/2 Mottle Colors: —
Other hydric soil indicators: sandy gravel
Is the hydric soil criterion met? Yes ✓ No ____
Rationale: may be insufficient time has elapsed since soil was excavated and canal inundated, but related to growing season inundation – waterlogged over most of canal

### HYDROLOGY

Is the ground surface inundated? Yes ✓ No ____ Surface water depth: 1 ft. deep in center of canal
Is the soil saturated? Yes ✓ No ____
Depth to free-standing water in pit/soil probe hole: ____
List other field evidence of surface inundation or soil saturation.
Water marks on trees 10" above current water level
Is the wetland hydrology criterion met? Yes ✓ No ____
Rationale: ____

### JURISDICTIONAL DETERMINATION AND RATIONALE

Is the plant community a wetland? Yes ✓ No ____
Rationale for jurisdictional decision: FAC dominant veg, growing season hyd., waterlogged soil

[1] This data form can be used for the Hydric Soil Assessment Procedure and the Plant Community Assessment Procedure.
[2] Classification according to "Soil Taxonomy."

W-13
plot # 2
(upland plot)

# DATA FORM
## ROUTINE ONSITE DETERMINATION METHOD[1]

Field Investigator(s): S. Nyman, W. Watts Date: 5-31-96
Project/Site: SULLIVAN CREEK HYDRO State: WA County: POC
Applicant/Owner: P.O. PUD Plant Community #/Name: Wetland 13
*Note:* If a more detailed site description is necessary, use the back of data form or a field notebook.

Do normal environmental conditions exist at the plant community?
Yes ✓ No ____ (If no, explain on back)
Has the vegetation, soils, and/or hydrology been significantly disturbed?
Yes ____ No ✓ (If yes, explain on back)

### VEGETATION

| Dominant Plant Species | Indicator Status | Stratum | Dominant Plant Species | Indicator Status | Stratum |
|---|---|---|---|---|---|
| ✓ 1. POPULUS TRICHOCARPA 20% | FAC | T | 11. GNAPHALIUM SP. | | H |
| ✓ 2. FRAXINUS LATIFOLIA 20% | FACW | | 12. CHRYSANTHEMUM LEUCANTHEMUM | | H |
| ✓ 3. CORNUS STOLONIFERA 20% | FACW | S | ✓ 13. PTERIDIUM AQUILINUM 20% | FACU | H |
| 4. RUBUS PARVIFLORUS | | S | 14. | | |
| 5. EQUISETUM ARVENSE | | H | 15. | | |
| 6. TRIFOLIUM REPENS | | H | 16. | | |
| ✓ 7. TARAXACUM OFFICINALIS 20% | FACU | H | 17. | | |
| 8. GALIUM SP. | | H | 18. | | |
| 9. POA SP. | | H | 19. | | |
| 10. GRASS SPP | | H | 20. | | |

Percent of dominant species that are OBL, FACW, and/or FAC 75
Is the hydrophytic vegetation criterion met? Yes ✓ No ____
Rationale: > 50% FAC or wetter

### SOILS

Series/phase: Scotts fine sandy loam 7-15% Subgroup:[2]
Is the soil on the hydric soils list? Yes ____ No ✓ Undetermined ____
Is the soil a Histosol? Yes ____ No ✓ Histic epipedon present? Yes ____ No ✓
Is the soil: Mottled? Yes ____ No ✓ Gleyed? Yes ____ No ✓
Matrix Color: 2.5Y 4/3 Mottle Colors: —
Other hydric soil indicators:
Is the hydric soil criterion met? Yes ____ No ✓ silt loam
Rationale: High chroma, no mottles

### HYDROLOGY

Is the ground surface inundated? Yes ____ No ✓ Surface water depth: —
Is the soil saturated? Yes ____ No ✓
Depth to free-standing water in pit/soil probe hole: —
List other field evidence of surface inundation or soil saturation.

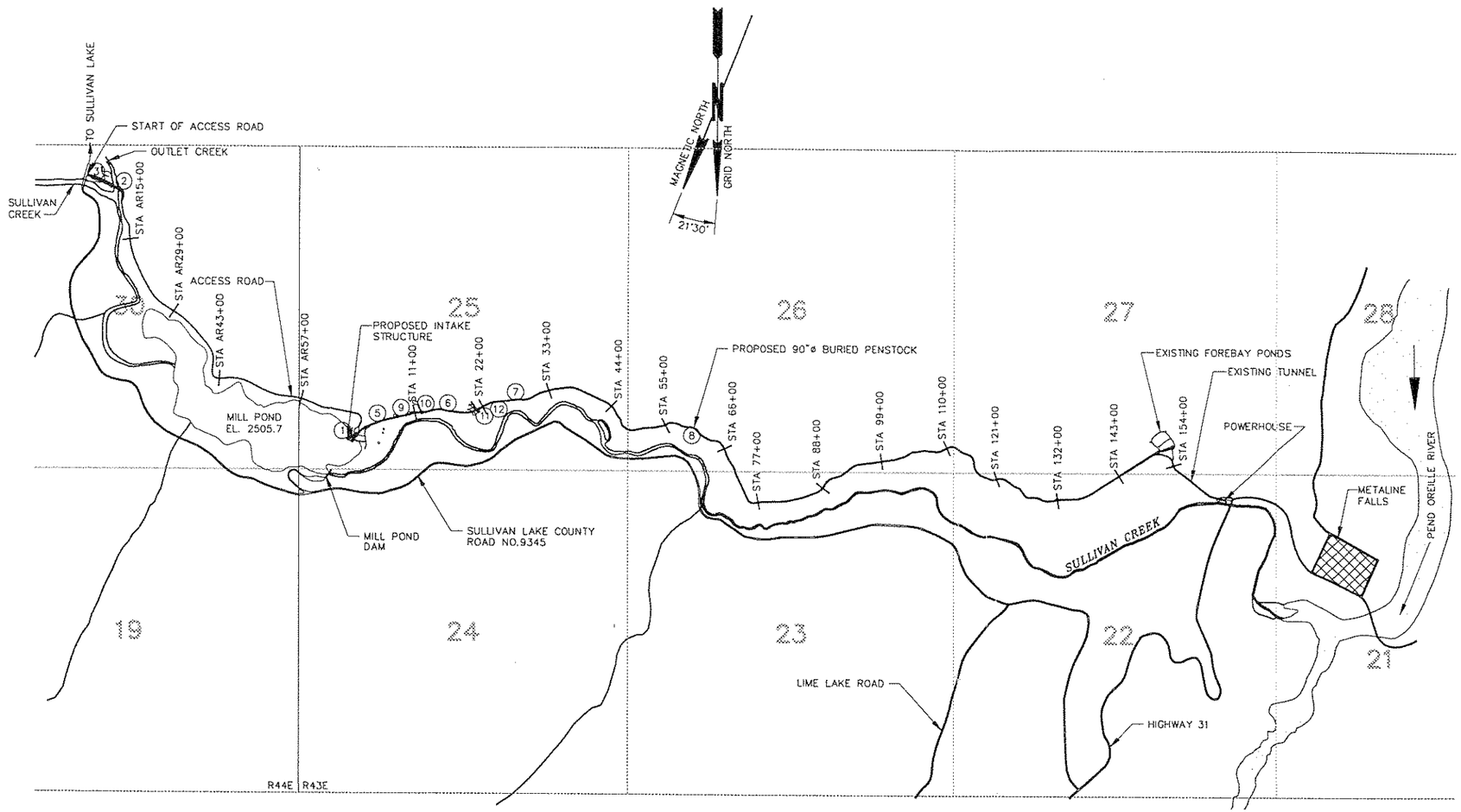
Is the wetland hydrology criterion met? Yes ____ No ✓
Rationale: dry

### JURISDICTIONAL DETERMINATION AND RATIONALE

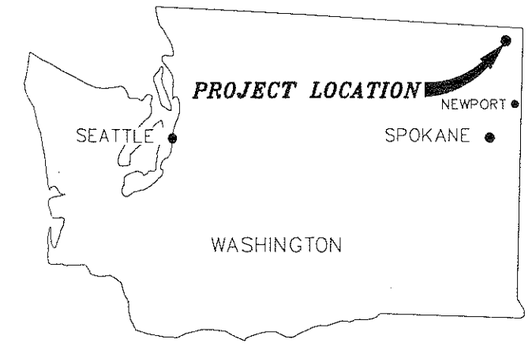
Is the plant community a wetland? Yes ____ No ✓
Rationale for jurisdictional decision: lacks soil, hyd

[1] This data form can be used for the Hydric Soil Assessment Procedure and the Plant Community Assessment Procedure.
[2] Classification according to "Soil Taxonomy."

# APPENDIX 2
# WETLAND MAPS




SITE PLAN




LOCATION MAP

NOTE:
1. WETLAND 4 WAS OMITTED.

1000 0 1000 2000 3000
SCALE IN FEET

PUD NO.1 OF PEND OREILLE COUNTY
APPLICATION FOR AMENDMENT OF LICENSE
SULLIVAN CREEK HYDROELECTRIC PROJECT
FERC PROJECT NO. 2225

LOCATION OF WETLAND SITES
FIGURE 1

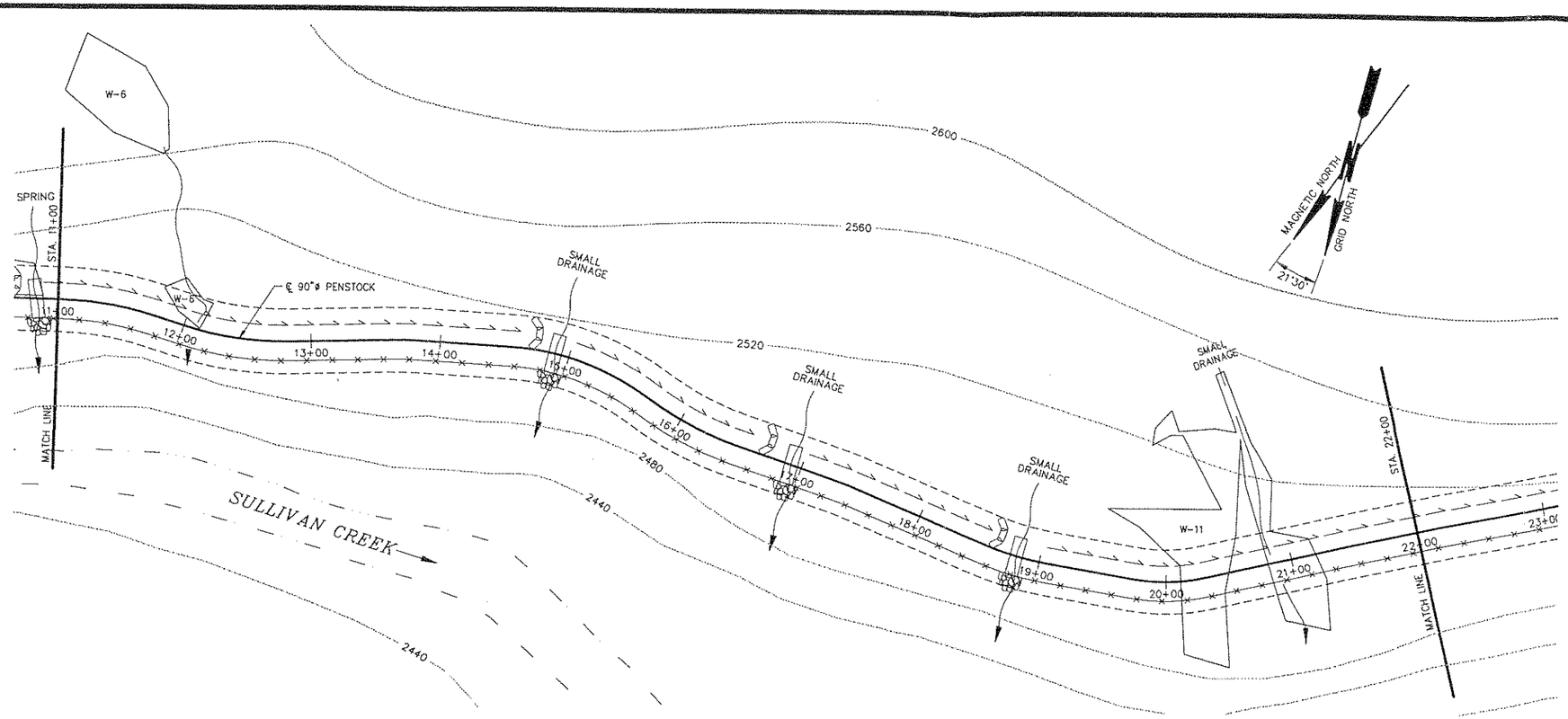
FILE: SI-F1.DWG PLOT SCALE: 1=1 DATE: 11/03/94 TIME: 10:52am PATH: H:\SULLIVAN\DWGS\

XREF/S:SL-BASE / SL-PROF

SCALE: 1 = 1

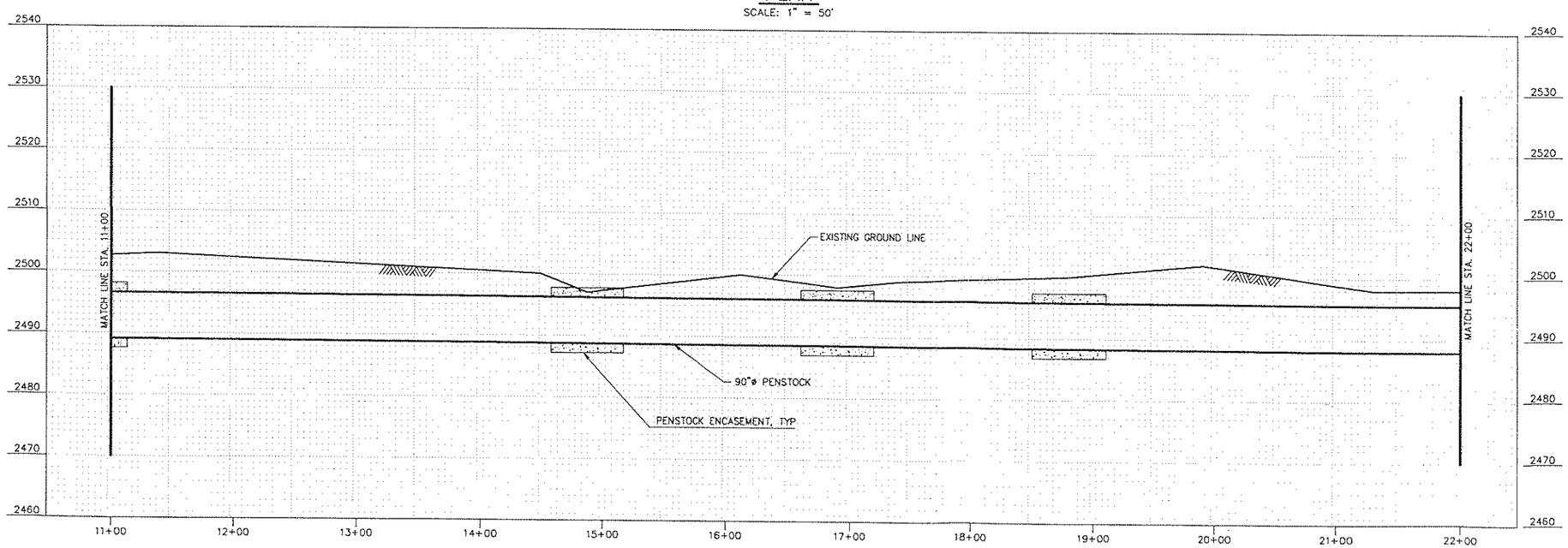
DATE PLOTTED: 6/30/93

FILENAME: P:\SULLIVAN\SL-ESC03




## PLAN

SCALE: 1" = 50'




## PROFILE

SCALE: HORIZ. 1" = 50', VERT. 1" = 10'

LEGEND:

- CLEARING LIMITS
- PERMANENT SPOILS AREA
- LIMITS OF TEMPORARY SPOILS/LAYDOWN AREA
- OPEN DRAINAGE
- TIGHTLINE DRAINAGE
- SILT FENCE
- STRAW BALES
- CULVERT
- RIPRAP
- WATER BAR
- RETAINING WALL

NOTES:

1. PLAN VIEW CONTOURS ARE APPROXIMATE BASED ON A COMPOSITE OF PAST SURVEYS. EXISTING GROUND SURFACE PROFILE ALONG PENSTOCK ROUTE BASED ON 1992 SURVEY BY RAMER & ASSOCIATES.
2. THIS DRAWING IS A PART OF THE APPLICATION FOR LICENSE MADE BY THE UNDERSIGNED THIS _____ DAY OF _____, 19____.

PUD NO.1 OF PEND OREILLE COUNTY

VERTICAL: 10 0 10 20 30

HORIZONTAL: 50 0 50 100 150

PUD NO.1 OF PEND OREILLE COUNTY
APPLICATION FOR AMENDMENT OF LICENSE
SULLIVAN CREEK HYDROELECTRIC PROJECT
FERC PROJECT NO. 2225

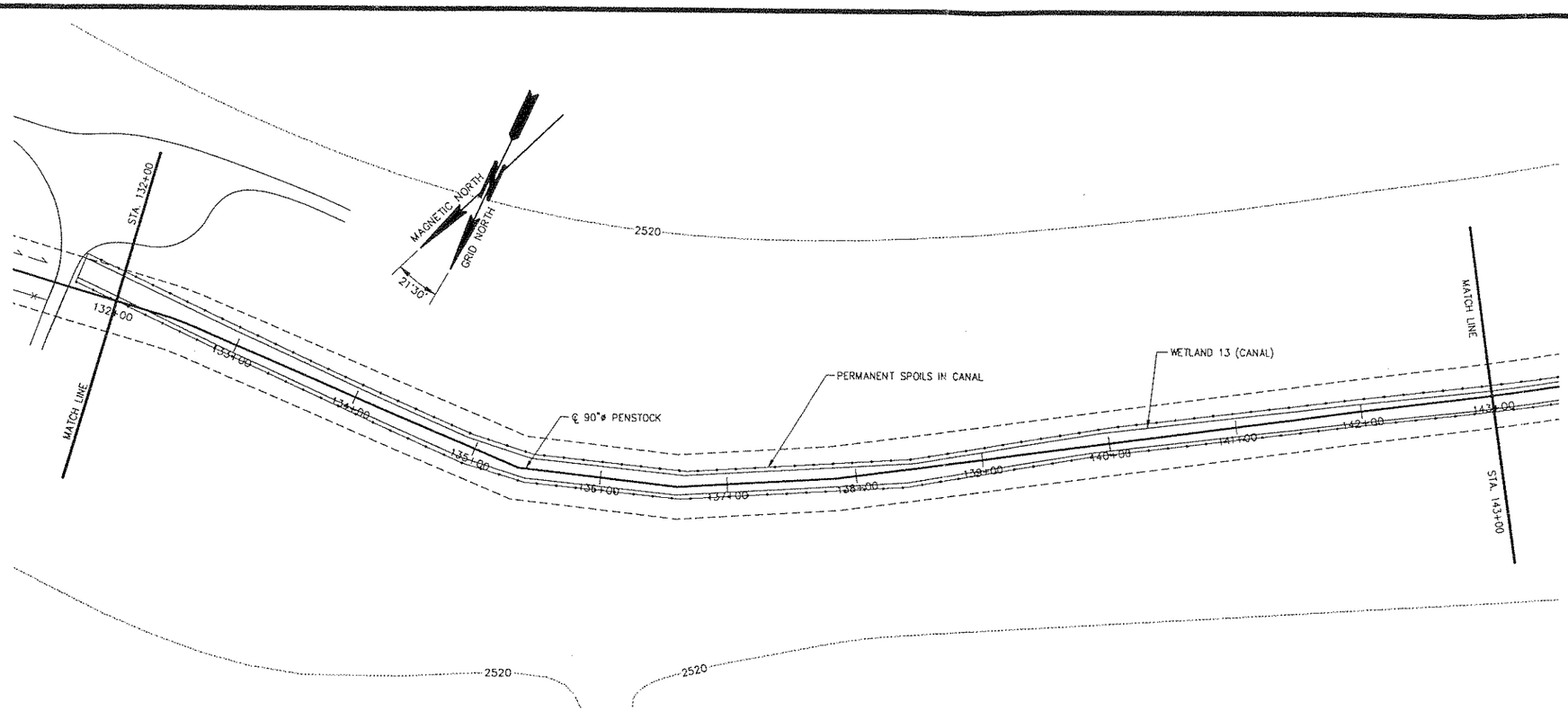
**WETLAND VICINITY MAP**
**2 OF 5**
**FIGURE 3**

XREF/S: SL-BASE / SL-PROF

SCALE: 1 = 1

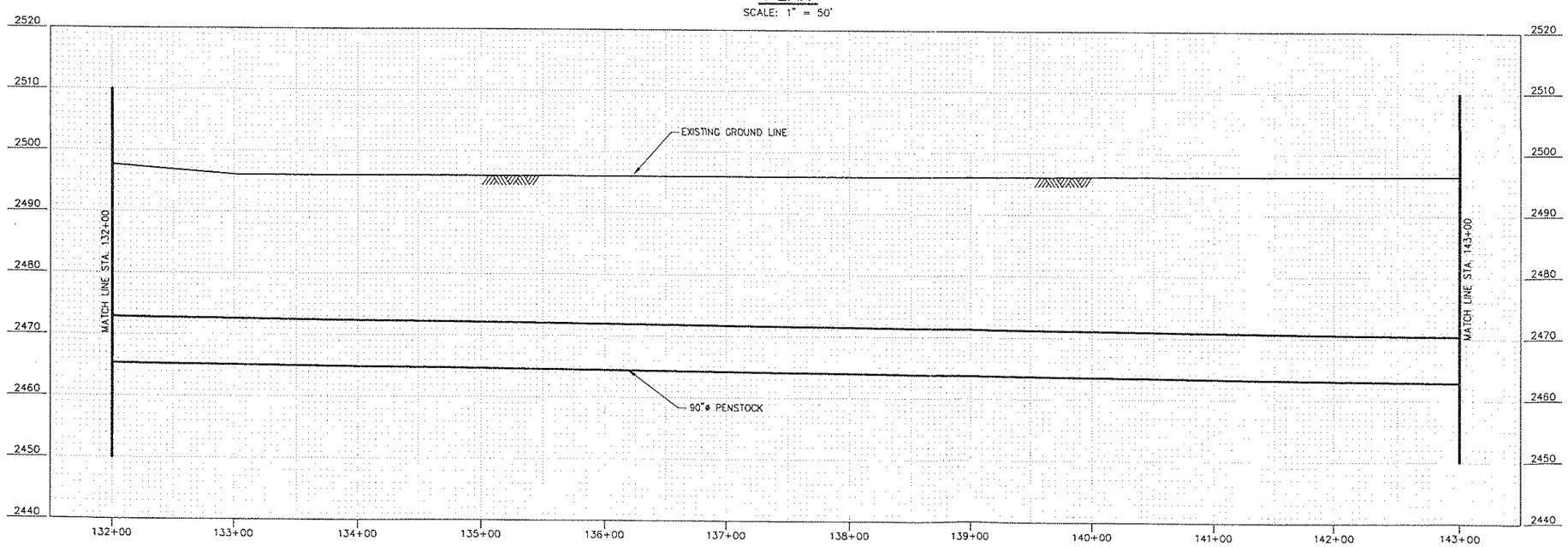
DATE PLOTTED: 6/30/93

FILENAME: P:\SULLIVAN\SL-ESC14




## PLAN

SCALE: 1" = 50'




## PROFILE

SCALE: HORIZ. 1" = 50', VERT. 1" = 10'

LEGEND:

- CLEARING LIMITS
- PERMANENT SPOILS AREA
- LIMITS OF TEMPORARY SPOILS/LAYDOWN AREA
- OPEN DRAINAGE
- TIGHTLINE DRAINAGE
- SILT FENCE
- STRAW BALES
- CULVERT
- RIPRAP
- WATER BAR
- RETAINING WALL

NOTES:

1. PLAN VIEW CONTOURS ARE APPROXIMATE BASED ON A COMPOSITE OF PAST SURVEYS. EXISTING GROUND SURFACE PROFILE ALONG PENSTOCK ROUTE BASED ON 1992 SURVEY BY RAMER & ASSOCIATES.

VERTICAL: 10 0 10 20 30

HORIZONTAL: 50 0 50 100 150

PUD NO.1 OF PEND OREILLE COUNTY
APPLICATION FOR AMENDMENT OF LICENSE
SULLIVAN CREEK HYDROELECTRIC PROJECT
FERC PROJECT NO. 2225

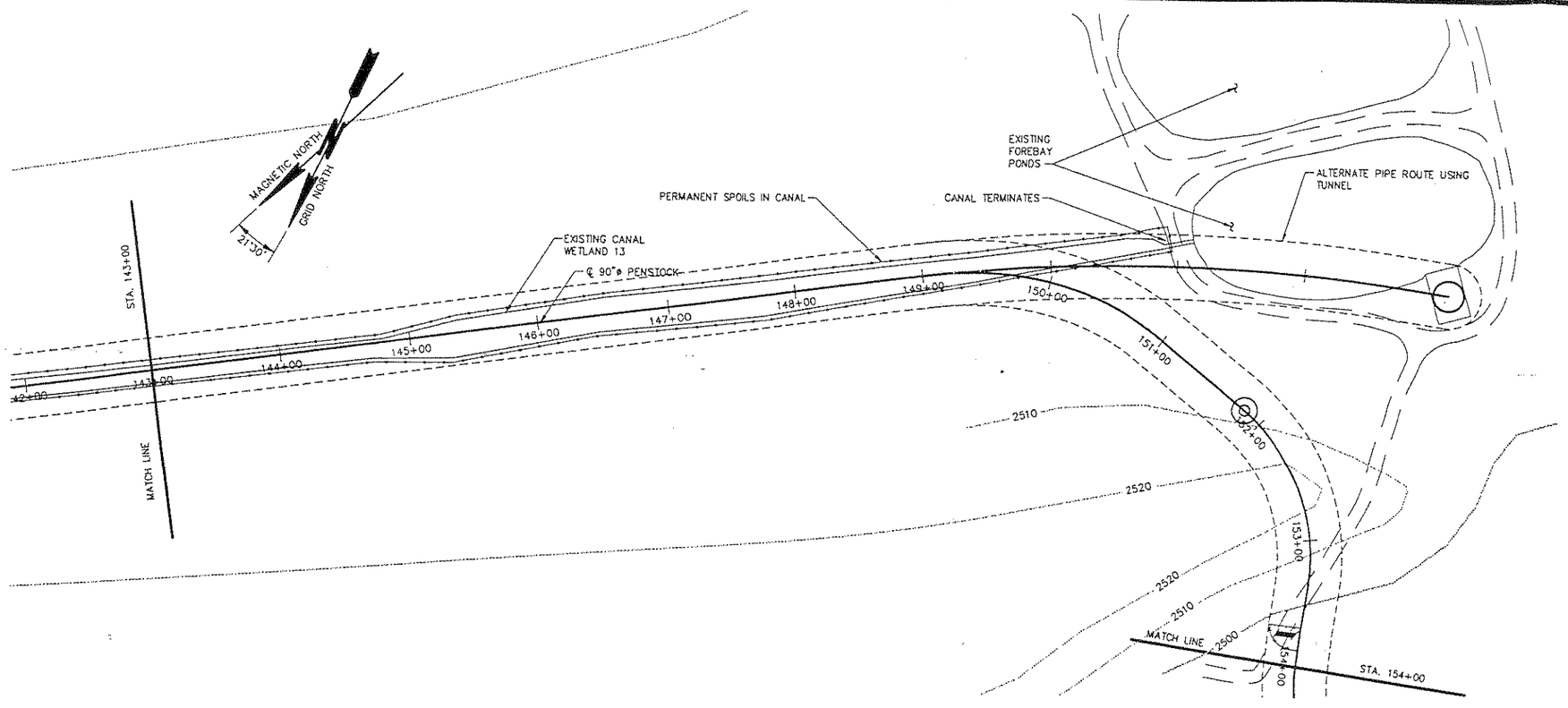
**WETLAND VICINITY MAP**
**3 OF 5**
**FIGURE 4**

XREF/S:SL-BASE / SL-PROF

SCALE: 1 = 1

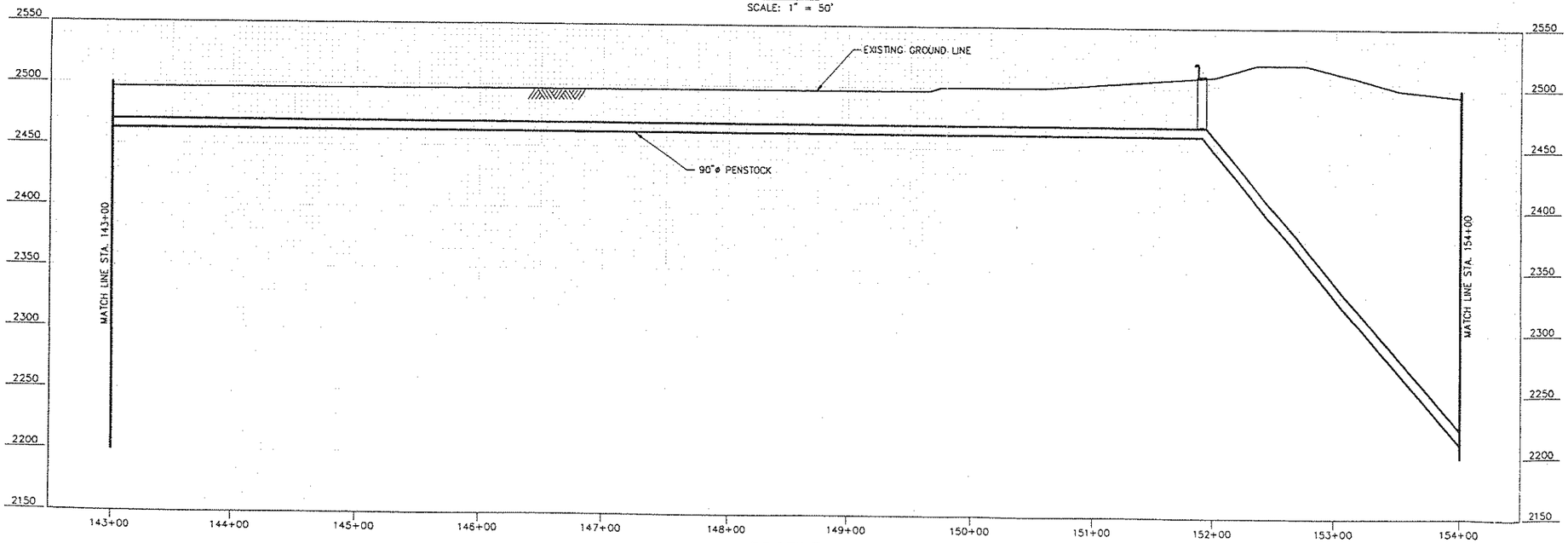
DATE PLOTTED: 6/30/93

FILENAME: P:\SULLIVAN\SL-ESC15




## PLAN

SCALE: 1" = 50'




## PROFILE

SCALE: 1" = 50'

LEGEND:

- CLEARING LIMITS
- PERMANENT SPOILS AREA
- LIMITS OF TEMPORARY SPOILS/LAYDOWN AREA
- OPEN DRAINAGE
- TIGHTLINE DRAINAGE
- SILT FENCE
- STRAW BALES
- CULVERT
- RIPRAP
- WATER BAR
- RETAINING WALL

NOTES:

1. PLAN VIEW CONTOURS ARE APPROXIMATE BASED ON A COMPOSITE OF PAST SURVEYS. EXISTING GROUND SURFACE PROFILE ALONG PENSTOCK ROUTE BASED ON 1992 SURVEY BY RAMER & ASSOCIATES.

50 0 50 100 150

SCALE IN FEET

PUD NO.1 OF PEND OREILLE COUNTY
APPLICATION FOR AMENDMENT OF LICENSE
SULLIVAN CREEK HYDROELECTRIC PROJECT
FERC PROJECT NO. 2225

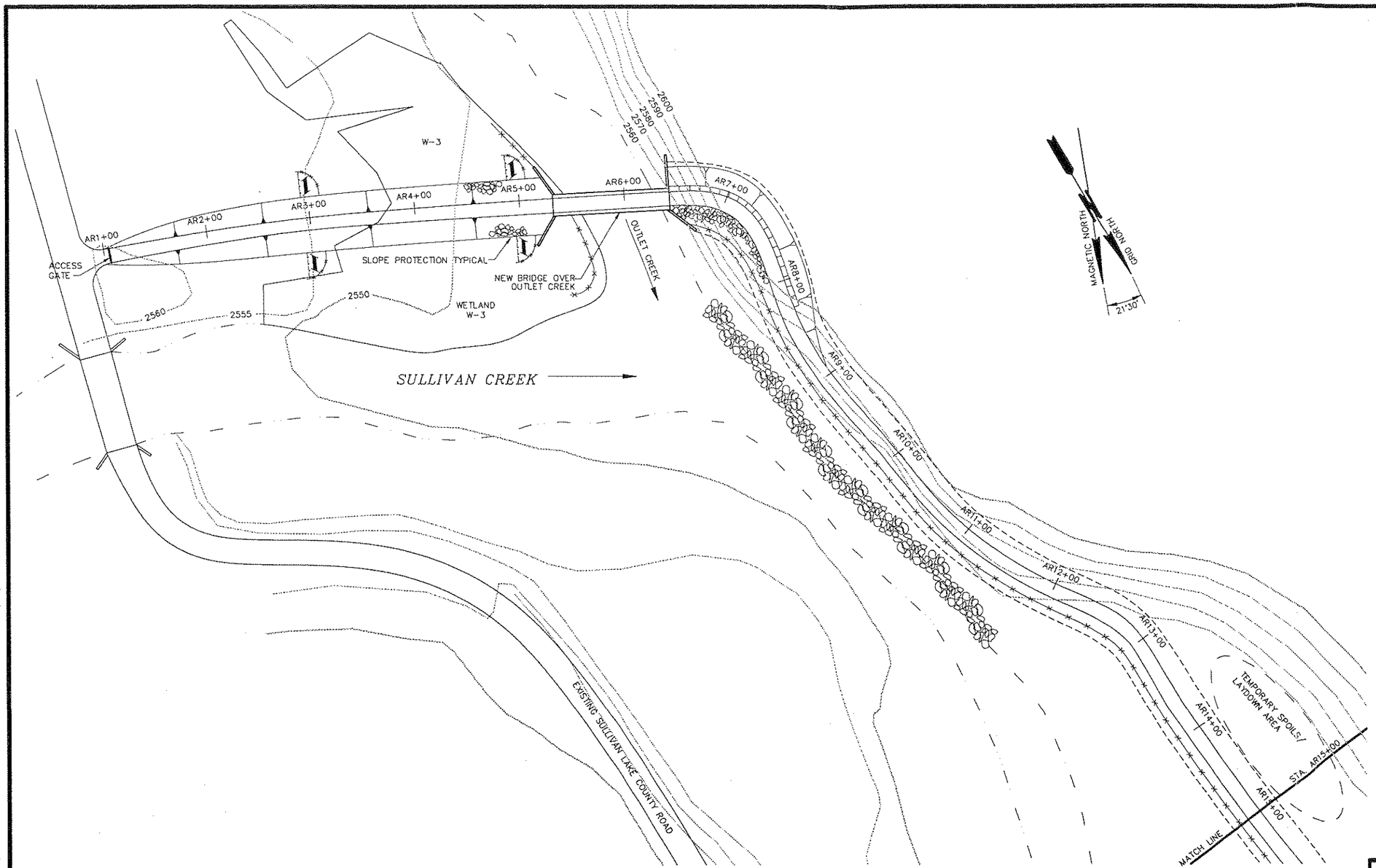
**WETLAND VICINITY MAP**
**4 OF 5**
**FIGURE 5**

SL-BASE

1 = 1

11/02/94

SL-ESC18




PLAN
SCALE: 1" = 50'

LEGEND:

- CLEARING LIMITS
- PERMANENT SPOILS AREA
- LIMITS OF TEMPORARY SPOILS/LAYDOWN AREA
- OPEN DRAINAGE
- TIGHTLINE DRAINAGE
- SILT FENCE
- STRAW BALES
- CULVERT
- RIPRAP
- WATER BAR
- RETAINING WALL

NOTES:

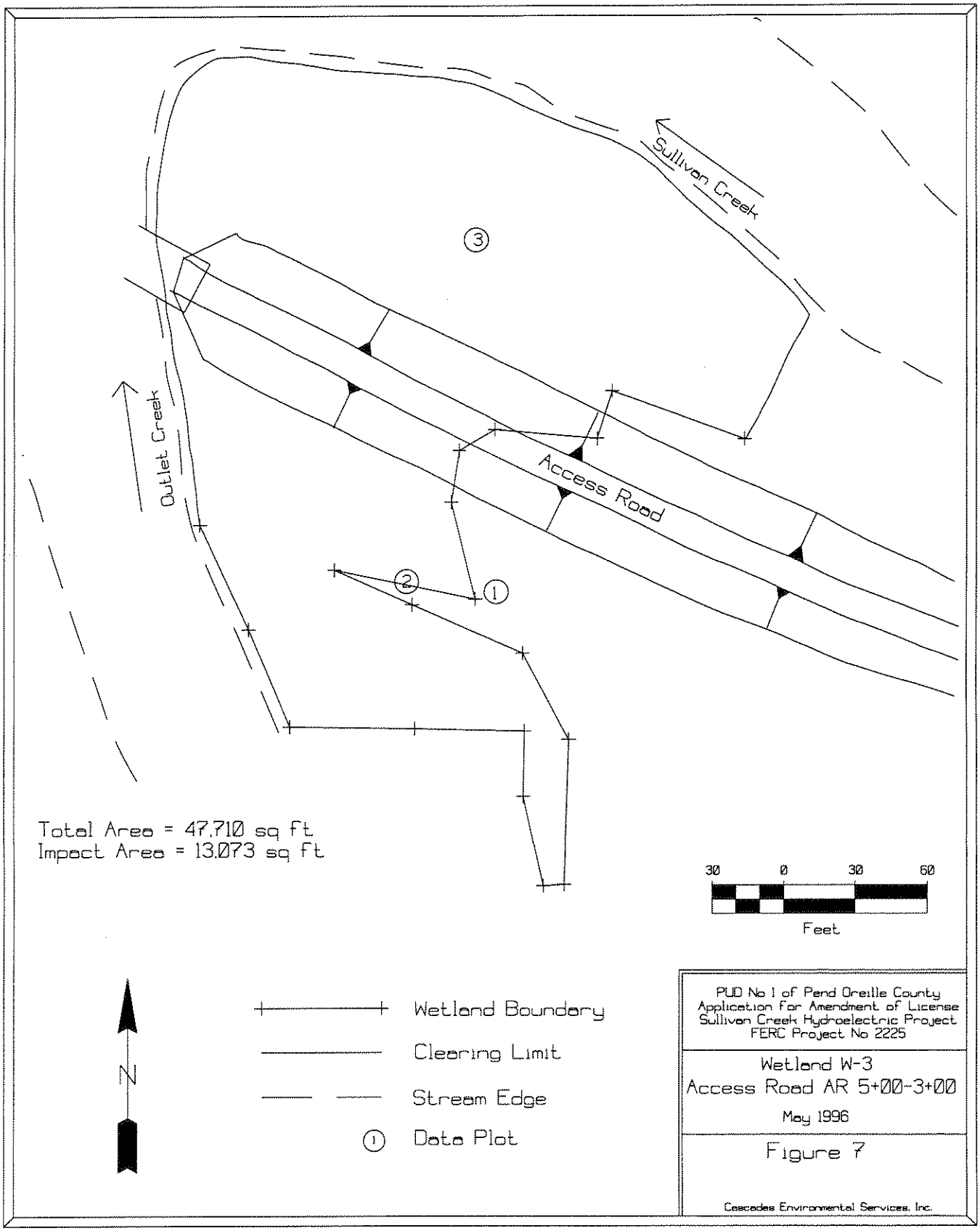
1. PLAN VIEW CONTOURS ARE APPROXIMATE BASED ON A COMPOSITE OF PAST SURVEYS. EXISTING GROUND SURFACE PROFILE ALONG PENSTOCK ROUTE BASED ON 1992 SURVEY BY RAMER & ASSOCIATES.

50 0 50 100 150
SCALE IN FEET

PUD NO.1 OF PEND OREILLE COUNTY
APPLICATION FOR AMENDMENT OF LICENSE
SULLIVAN CREEK HYDROELECTRIC PROJECT
FERC PROJECT NO. 2225

**WETLAND VICINITY MAP**
**5 OF 5**
**FIGURE 6**

FILE: SL-AR-01.DWG PLOT SCALE: 1=1 DATE: 11/03/94 TIME: 3:22pm PATH: H:\SULLIVAN\



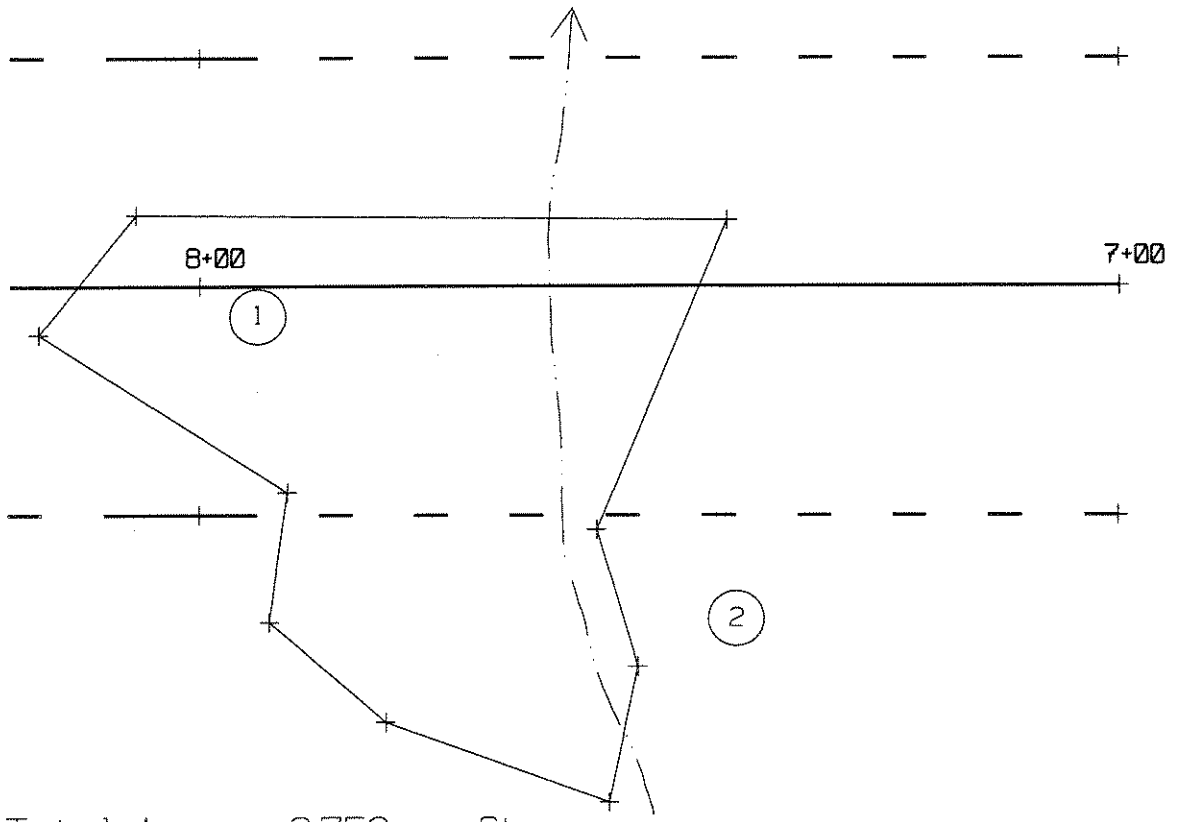

PUD No 1 of Pend Oreille County
Application For Amendment of License
Sullivan Creek Hydroelectric Project
FERC Project No 2225

Wetland W-3
Access Road AR 5+00-3+00

May 1996

Figure 7

Cascades Environmental Services, Inc.




Total Area = 2,753 sq ft
Impact Area = 1,353 sq ft

Seasonal Stream

Wetland Boundary

Clearing Limit

Center Line

1 Data Plot

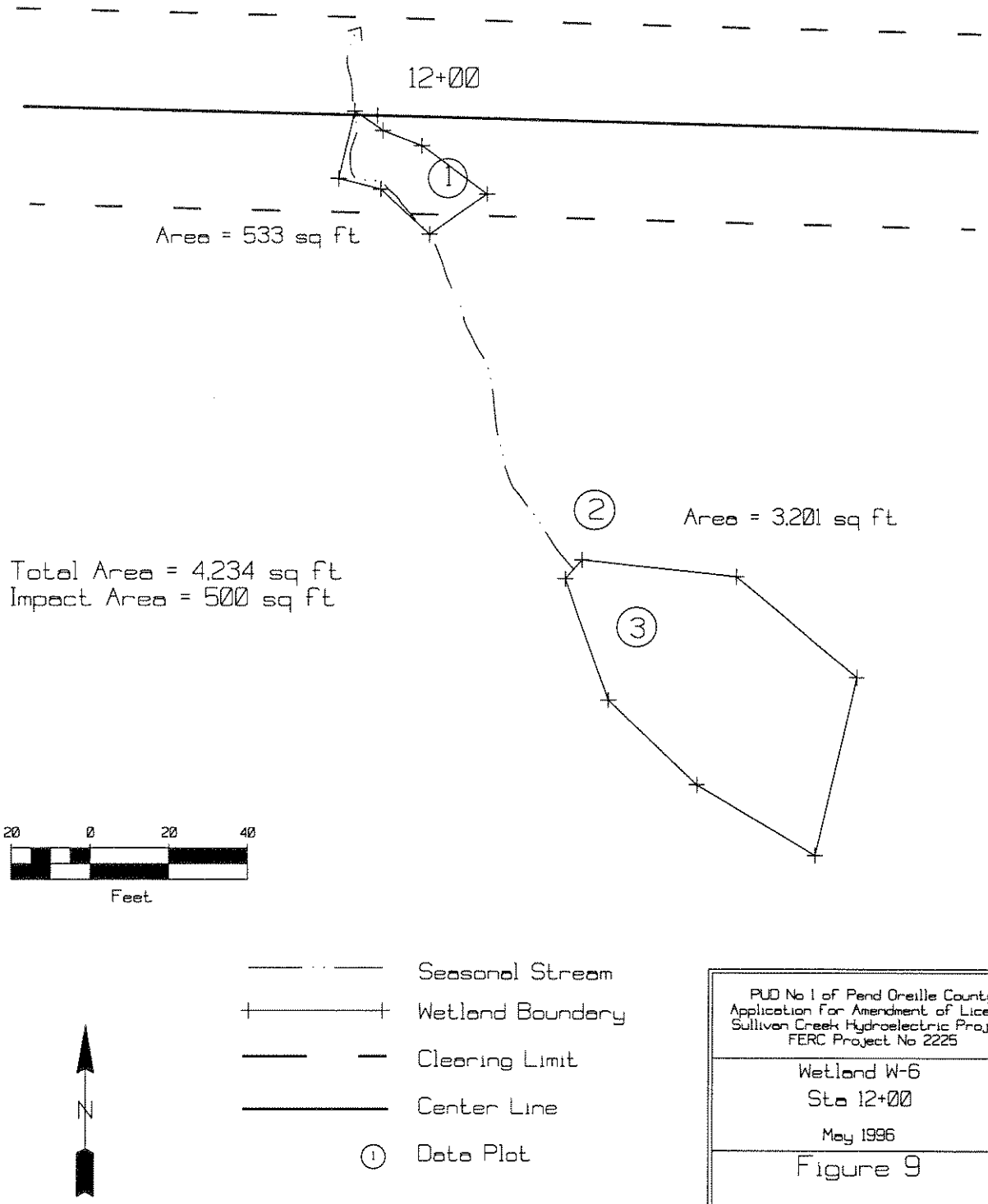
PUD No 1 of Pend Oreille County
Application for Amendment of License
Sullivan Creek Hydroelectric Project
FERC Project No 2225

Wetland W-5
Sta 7+00 to Sta 8+00

May 1996

Figure 8

Cascades Environmental Services, Inc.



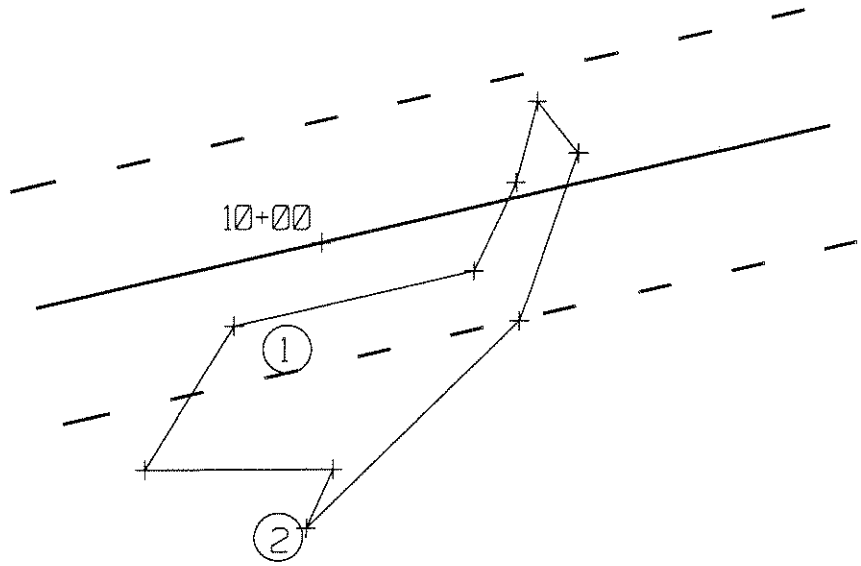

PUD No 1 of Pend Oreille County
Application for Amendment of License
Sullivan Creek Hydroelectric Project
FERC Project No 2225

Wetland W-6
Sta 12+00

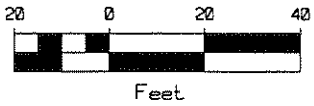
May 1996

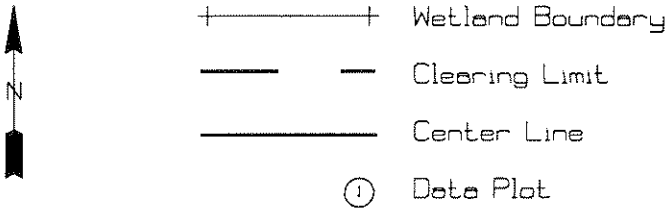
Figure 9

Cascades Environmental Services, Inc.




Total Area = 2,390 sq ft
Impact Area = 1,154 sq ft



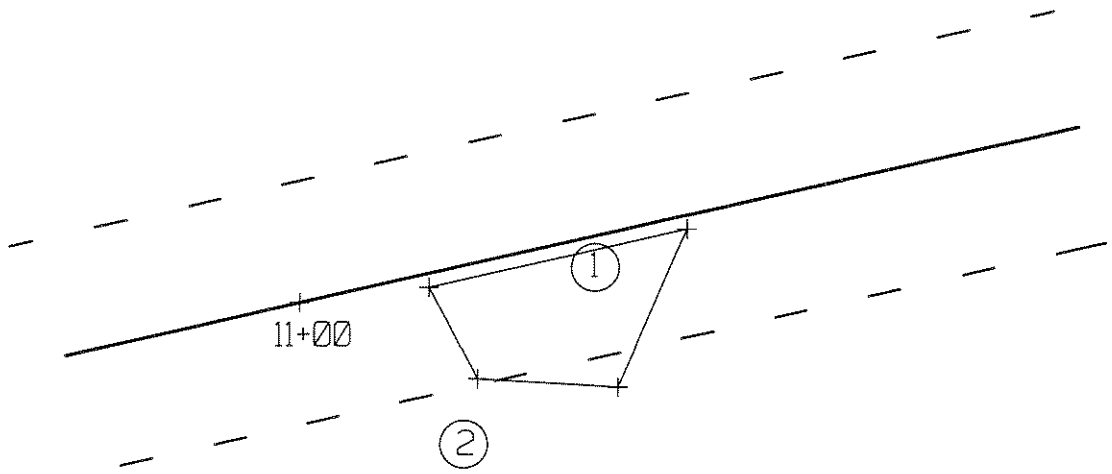

PUD No 1 of Pend Oreille County
Application for Amendment of License
Sullivan Creek Hydroelectric Project
FERC Project No 2225

Wetland W-9
Sta 10+00

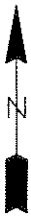
May 1996

Figure 10

Cascades Environmental Services, Inc.




Total Area = 1,070 sq ft
Impact Area = 970 sq ft




Wetland Boundary

Clearing Limit

Center Line

(1) Data Plot

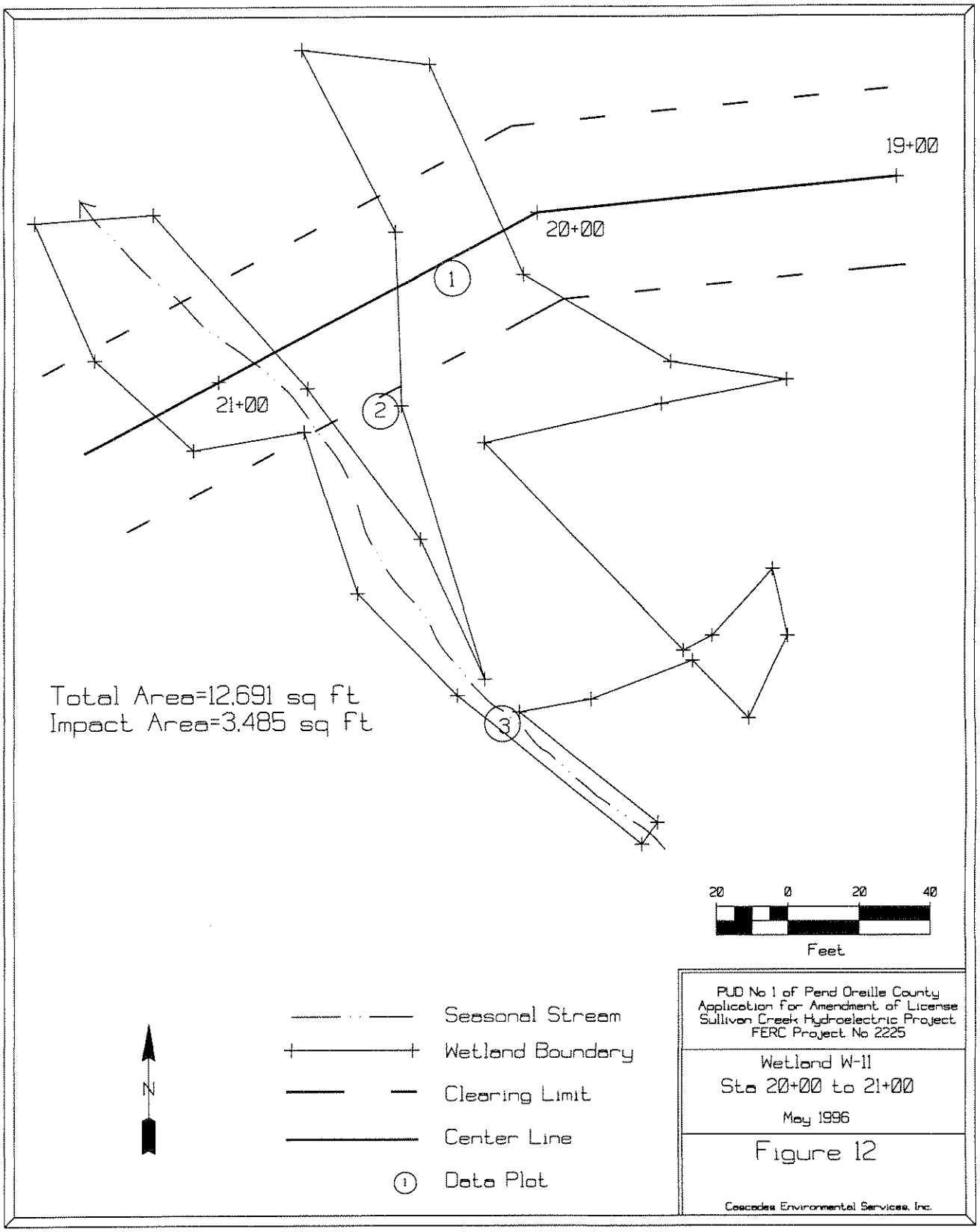
PUD No 1 of Pend Oreille County
Application for Amendment of License
Sullivan Creek Hydroelectric Project
FERC Project No 2225

Wetland W-10
Sta 11+00

May 1996

Figure 11

Cascades Environmental Services, Inc.


19+00
20+00
21+00
1
2
3
Total Area=12,691 sq ft
Impact Area=3,485 sq ft
20 0 20 40
Feet
N
Seasonal Stream
Wetland Boundary
Clearing Limit
Center Line
Data Plot
PUD No 1 of Pend Oreille County
Application for Amendment of License
Sullivan Creek Hydroelectric Project
FERC Project No 2225
Wetland W-11
Sta 20+00 to 21+00
May 1996
Figure 12
Cascades Environmental Services, Inc.

# APPENDIX 3
# GUIDELINES FOR PREPARING, HANDLING, AND PLANTING CUTTINGS

# APPENDIX 3
# GUIDELINES FOR PREPARING, HANDLING, AND PLANTING CUTTINGS

## Stake Planting Methods

In addition to the way stakes are prepared and stored, the way they are set in the ground is crucial for success. The following guidelines should be observed.

1. Plant the cuttings right side up (i.e. with the butt ends in the ground). It is not always easy to tell the top from the butt of a leafless cutting. A good rule is to have the butt end of all stakes painted or marked immediately by the cutting crew at the time of harvest. Alternatively, the tops of bundles of cuttings may be painted with a water-soluble latex paint. The paint also seals the ends and reduces desiccation of the cuttings.

2. Set the cutting as deep as possible. Most of the sprig length should be planted in the ground. It is preferable that at least 80% of the sprig length be in the ground. Deep plantings minimize water loss by transpiration and reduces root breakage.

3. Avoid stripping the bark or needless bruising of the stakes when transporting and setting them in the ground.

4. Tamp the soil around each cutting. The cutting must be firm in the ground so that it cannot be readily pulled out.

5. Fence or blockade commonly used footpaths through vegetated areas while materials are becoming established.

## Guidelines for Preparing and Handling Cuttings

1. Select healthy, reasonably straight wood from plant species that root easily and are native to the planting site.

2. Make clear cuts with unsplit ends.

3. Trim branches from cuttings as close as possible.

4. Diameter: The minimum diameter is 1/4 inch, but cuttings greater than 1 inch diameter are desirable. The maximum average diameter of individual cuttings is 1.5 inches.

5. Length: Cuttings should be 18 to 24 inches long. However, where water tables are low or receding, 3 to 5 foot whips at least one inch in diameter should be used to improve survival.

6. Location of buds and bud scars: Cuttings put out their greatest concentrations of shoots and strongest shoots below an annual ring (formed from a terminal bud scar). Cuttings should be

cut so that a terminal bud scar is within 1 to 4 inches of the tip. At least two buds and/or bud scars should be above the ground after planting.

7. Handling of stakes between cutting and planting: Cuttings must not be allowed to dry out. They must be kept covered and moist during transport, storage, and during the planting operation. Cuttings should be wrapped in moist burlap or stored in plastic wrapping with moisture retaining materials. Cuttings may also be kept submerged in water for one to several days after harvesting. Cuttings should be kept out of direct sunlight and at no time should cutting butt ends be left exposed to the air or they may desiccate prior to planting.

The following species specific procedures should be employed.

| | |
|---|---|
| Red-osier Dogwood (*Cornus stolonifera*) | Cuttings. Cuttings of 1 year old wood collected and planted before buds start to open; cuttings should be about 18 inches long and 3/4 inch diameter). Propagation by seeds requires cold stratification (storage at 35-41 F for 30-60 days after removal of pulp). Sow seeds in ordinary loam to start. |
| Sitka Alder (*Alnus sinuata*) | Can be transplanted from donor sites as pull-ups collected in the late winter and early spring before buds break. Uproot plants 2-4 feet tall, transport them to the restoration site with roots covered and moist. Plant immediately. |
| Willows (*Salix* spp.) | Cuttings. Does well in almost any soil but best in lowlands along streams. Three foot lengths planted on three foot centers. |

**Timing for Planting**

Stakes should be cut and planted when willows or other suitable species are dormant. This period extends from the time the leaves start to turn yellow in autumn until the time growth starts in the spring. McCluskey et al. (1984) indicated that early spring planting prior to the breaking of dormancy is probably the best. In moist soils, willow stakes can sometimes be planted successfully during the summer season, but usually this should not be attempted. If summer planted must be attempted, the cuttings should be defoliated. Additional soaking of cuttings prior to planting may also be required for late planting.

# APPLICATION FOR SURRENDER OF LICENSE
# SULLIVAN CREEK PROJECT
# FERC NO. 2225

## APPENDIX E.6-2
### PEND OREILLE COUNTY WEED BOARD 2009 LIST OF NOXIOUS WEEDS

Pend Oreille County
NOXIOUS WEED CONTROL BOARD
Sharon L. Sorby, Coordinator
Phone: (509) 447-2402
FAX: (509) 447-6477
E-mail: ssorby@coopext.cahe.wsu.edu
Courthouse / Post Office Box 5085 / Newport, Washington 99156-5085

# 2009 PEND OREILLE COUNTY NOXIOUS WEED LIST

I. Noxious weeds currently found growing in Pend Oreille County:

| Common Name | Scientific Name | Class | Toxicity |
|---|---|---|---|
| BIGHEAD KNAPWEED | *Centaurea macrocephala* | A | N |
| BUFFALOBUR | *Solanum rostratum* | A | Y -cattle, sheep & horses |
| CLARY SAGE | *Salvia sclarea* | A | N |
| VOCHIN KNAPWEED | *Centaurea nigrescens* | A | N |
| ANNUAL BUGLOSS | *Anchusa arvensis* | B-designate | N |
| BUTTERFLY BUSH | *Buddleja davidii* | B-designate | N |
| COMMON BUGLOSS | *Anchusa officianalis* | B-designate | N |
| COMMON CATSEAR | *Hypochaeris radicata* | B-designate | Y - to horses |
| COMMON REED | *Phragmites australis* | B-designate | N |
| EURASIAN WATERMILFOIL | *Myriophyllum spicatum* | B-designate in lakes | N |
| GIANT, JAPANESE & BOHEMIAN | *Polygonum sachalinense, P. cuspidatum* | B-designate | N |
| KNOTWEEDS | *& P. bohemicum* | B-designate | N |
| HERB ROBERT | *Geranium robertianum* | B-designate | N |
| KOCHIA | *Kochia scoparia* | B-designate | Y - Nitrate concentrator |
| LEAFY SPURGE | *Euphorbia esula* | B-designate | Y - dermal |
| LEPRODICLIS | *Lepyrodiclis holosteoides* | B-designate | N |
| MEADOW KNAPWEED | *Centaurea jacea x nigra* | B-designate | N |
| MUSK THISTLE | *Carduus nutans* | B-designate | N |
| PERENNIAL PEPPERWEED | *Lepidium latifolium* | B-designate | N |
| PLUMELESS THISTLE | *Carduus acanthoides* | B-designate | N |
| POLICEMAN'S HELMET | *Impatiens glandulifera* | B-designate | N |
| PURPLE & WAND LOOSESTRIFE | *Lythrum salicaria, L. virgatum* | B-designate | N |
| RUSH SKELETONWEED | *Chondrilla juncea* | B-designate | N |
| SALTCEDAR | *Tamarix ramossisma* | B-designate | N |
| SCOTCH BROOM | *Cytisus scoparius* | B-designate | N |
| SCOTCH THISTLE | *Onopordum acanthium* | B-designate | N |
| SPURGE LAUREL | *Daphne laureola* | B-designate | N |
| TANSY RAGWORT | *Senecio jacobaea* | B-designate | Y - destroys liver |
| VIPER'S BUGLOSS | *Echium vulgare* | B-designate | N |
| YELLOW STARTHISTLE | *Centaurea solstitialis* | B-designate | Y - to horses |
| DALMATIAN TOADFLAX | *Linaria dalmatica* ssp. *dalmatica* | B | N |
| DIFFUSE & SPOTTED KNAPWEED | *Centaurea diffusa,C. biebersteinii* | B | N |
| EURASIAN WATERMILFOIL | *Myriophyllum spicatum* | B - in PO River | N |
| HOARY ALYSSUM | *Bertero incana* | B | N |
| HOUNDSTONGUE | *Cynoglossum officianale* | B | Y - liver toxin |
| MEADOW, ORANGE & QUEEN-DEVIL | *Hieracium caespitosum, H. aurantiacum* | B | Y - dermal |
| HAWKWEEDS | *H. glomeratum* | B | Y - dermal |
| OXEYE DAISY | *Leucanthemum vulgare* | B | N |
| SULFUR CINQUEFOIL | *Potentilla recta* | B | N |
| WILD CARROT (QUEEN ANNE'S LACE) | *Daucus carota* | B | N |
| BABYSBREATH | *Gypsophila paniculata* | C | N |
| BLACK HENBANE (Shoofly) | *Hyoscyamus niger* | C | Y - neural |

| | | | |
|---|---|---|---|
| CANADA THISTLE | *Cirsium arvense* | C | N |
| COMMON TANSY | *Tanecetum vulgare* | C | Y - dermal allergen |
| CURLY-LEAF PONDWEED | *Potamogeton crispus* | C | N |
| ENGLISH IVY (4 cultivars) | *Hedera helix, H. hibernica* | C | N |
| FRAGRANT WATER LILY | *Nymphaea odorata* | C | N |
| MYRTLE SPURGE | *Euphorbia myrsinities* | C | Y - dermal |
| NON-NATIVE HAWKWEEDS, no ID | *Hieracium spp* | C | N |
| REED CANARYGRASS | *Phalaris arundinacea* | C | N |
| ST. JOHNSWORT | *Hypericum perforatum* | C | Y - causes photosensitivity |
| YELLOW FLAG IRIS | *Iris psuedocorus* | C | Y – dermal & glycosides |

**CLASS A AND B-DESIGNATE:** Weeds in these classes occur at a few sites within the county, are considered an economic threat, and the landowner will control them annually to prevent seed production until eradication is secured.

**CLASS B AND C:** These classes are mostly common in the county and will be controlled on right-of-ways and other areas where requested with the overall goal of containment and reducing the negative impact to an acceptable level.

II. Noxious weeds **NOT** currently found growing in Pend Oreille County, but will be monitored and controlled if discovered:

## Class A:

| Common Name | Scientific Name | Common Name | Scientific Name |
|---|---|---|---|
| bean caper, Syrian | *Zygophyllum fabago* | Johnsongrass | *Sorghum halepense* |
| blueweed, Texas | *Helianthus ciliaris* | kudzu | *Pueraria montana, lobata* |
| broom, Spanish | *Spartium junceum* | nightshade, silverleaf | *Solanum elaeagnifolium* |
| clary, meadow | *Salvia pratensis* | reed sweetgrass | *Glyceria maxima* |
| cordgrass, common | *Spartina anglica* | ricefield bullrush | *Schoenoplectus mucronatus* |
| cordgrass, dense flower | *Spartina densiflora* | sage, Mediterranean | *Salvia aethiopis* |
| cordgrass, salt meadow | *Spartina patens* | spurge, eggleaf | *Euphorbia oblongata* |
| crupina, common | *Crupina vulgare* | spurge flax | *Thymelaea passerina* |
| floating primrose-willow | *Ludwigia peploides* | starthistle, purple | *Centaurea calcitrapa* |
| four o'clock, wild | *Mirabilis nyctaginea* | thistle, Italian | *Carduus pynocephalus* |
| garlic mustard | *Alliaria petiolata* | thistle, milk | *Silybum marianum* |
| goatsrue | *Galega officinalis* | thistle, slenderflower | *Carduus tenuiflorus* |
| hawkweed, European | *Hieracium sabaudum* | variable-leaf milfoil | *Myriophyllum heterophyllum* |
| hawkweed, yellow devil | *Hieracium floribundum* | velvetleaf | *Abutilon theophrasti* |
| hogweed, giant | *Heracleum mantegazzianum* | woad, dyer's | *Isatis tinctoria* |
| hydrilla | *hydrilla verticillata* | | |

## Class B-DESIGNATE:

| Common Name | Scientific Name | Common Name | Scientific Name |
|---|---|---|---|
| blackgrass | *Alopecurus myosuroides* | knapweed, brown | *Centaurea jacea* |
| brony, white | *Bryonia alba* | knapweed, Russian | *Acroptilon repens* |
| camelthorn | *Alhagi maurorum* | knotweed, Himalayan | *Polyganum polystachyum* |
| cordgrass, smooth | *Spartina alterniflora* | lawnweed | *Soliva sessilis* |
| elodea, Brazilian | *Egeria densa* | loosestrife, garden | *Lysimachia vulgaris* |
| fanwort | *Cabomba caroliniana* | nutsedge, yellow | *Cyperus esculentes* |
| fennel, common | *Foeniculum vulgare* | oxtongue hawkweed | *Picris hieracioides* |
| fieldcress, Austrian | *Rorippa austiaca* | parrotfeather | *Myriophyllum aquaticum* |
| floating yellow heart | *Nymphoides pelata* | poison hemlock | *Conium maculatum* |
| gorse | *Ulex europaeus* | puncturevine | *Tribulus terrestris* |
| grass-leaved arrowhead | *Sagittaria graminea* | sandbur, longspine | *Cenchrus longispinus* |
| hawkweed, mousear | *Hieracium pilosella* | sowthistle, perennial | *Sonchus arvensis arvensis* |
| hawkweed, polar | *Hieracium atratum* | Swainsonpea | *Sphaerophysa salsula* |
| hawkweed, smooth | *Hieracium laevigatum* | water primrose | *Ludwigia hexapetala* |
| indigobush | *Amorpha fruiticosa* | wild chervil | *Anthriscus sylvestris* |
| knapweed, black | *Centaurea nigra* | | |

Public Utility District No.1 of Pend Oreille County

# APPLICATION FOR SURRENDER OF LICENSE
# SULLIVAN CREEK PROJECT
# FERC NO. 2225

## APPENDIX E.7-1

### 1994 HRA CULTURAL RESOURCES ASSESSMENT REPORT
### (PRIVILEGED DOCUMENTS- FILED SEPARATELY)

# APPLICATION FOR SURRENDER OF LICENSE
# SULLIVAN CREEK PROJECT
# FERC NO. 2225

## APPENDIX E.8-1
### 2005 PEND OREILLE VALLEY
### TOURISM MARKETING AND DEVELOPMENT ASSESSMENT

Dean Runyan Associates

# Pend Oreille Valley

*Tourism Marketing and Development Assessment*

March 2005

*Prepared for the*

Tri-County Economic Development District,
Newport, Washington

# Pend Oreille Valley
## Tourism Marketing and Development Assessment

March 2005

*prepared for the*

Tri-County Economic Development District
Newport, Washington

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Many individuals, organizations, and businesses provided guidance and information throughout the course of this project. Without their assistance, this project would not have been possible. Tri-County Economic Development District staff and volunteers provided very valuable guidance, suggestions, and feedback throughout the project as did staff and volunteers of USDA Forest Service. Special thanks goes to Washington Department of Community, Trade, and Economic Development for supporting the intercept portion of the survey research.

We also want to acknowledge the cooperation and support of the many businesses and organizations that offered information and recommendations as part of the project and provided locations for the survey research including:

- Newport/Oldtown Chamber of Commerce
- Metaline Chamber of Commerce
- Pend Oreille County Historical Society Museum
- The Cutter Theatre
- Pend Oreille Public Utility District
- Seattle City Light
- 49° North Mountain Resort
- Tiger Historical Center
- Kettle Range Conservation Group
- Newport Ranger District – USDA Forest Service
- Sullivan Lake Ranger District – USDA Forest Servie

# 1. Introduction

The travel industry has become a primary and rapidly growing segment of the economy in northeast Washington, providing business opportunities, employment, and tax revenue for many local communities. The many local businesses and government entities involved in this industry need good quality, current information to help guide their decisions regarding marketing and product development.

This report provides an analysis of the tourism industry in Pend Oreille County (hereafter referred to as the Pend Oreille Valley), and makes recommendations for additional product development and marketing. The study is intended to provide the Tri-County Economic Development District (EDD), as well as other interested government agencies and businesses, with current information in order to document the importance of the industry and to enhance its future health.

The long-range prospects of tourism development in Pend Oreille Valley are positive; the U.S. travel market shows a growing interest in nature-based tourism and outdoor recreation activities, and Pend Oreille Valley has a wealth of natural assets, including abundant opportunities for wildlife viewing, numerous opportunities for outdoor recreation, striking scenic views, and a geological treasure. In addition, the area also offers interesting historic sites and unique cultural events.

## Objectives

The primary purpose of this project is to develop the information necessary to guide and support a comprehensive marketing and planning effort for the Pend Oreille Valley and, as future partnerships develop, other government and private entities in the Tri-County EDD (represents Pend Oreille, Stevens, and Ferry counties). This report presents current, reliable information, helps to identify target markets, and recommends priorities for product development and marketing programs. Specific objectives include:

- Provide a high quality visitor database for marketing, strategic planning, and product development purposes.
- Analyze Pend Oreille Valley's primary visitor markets, focusing in particular on identifying target markets and effective marketing approaches.
- Recommend product development and marketing program priorities and strategies
- Identify opportunities for cooperative efforts for marketing and other visitor industry development
- Prepare a clearly written report for the Tri-County EDD's use, as well as for use by other agencies, elected officials and representatives of the visitor industry.

## Data Collection and Sample

A supporting component of our study was a Visitor Profile ("Black Box") Study, in partnership with the Washington State Business and Tourism Office. Approximately 6-10 survey instruments (called "black boxes") were placed at a variety of visitor attractions and major events in Pend Oreille Valley. These survey instruments lead the visitor through a series of predetermined questions, with regard to visitor origin, length of stay, type of accommodation, and other important travel behaviors.

Another component of our analysis was a telephone survey of Spokane Area residents, initially identified as the primary target market, who travel regionally within a 2-3 hours drive of Spokane. The survey was designed to help determine interest areas, recreation activities, awareness of Pend Oreille Valley, and perceptions of the Valley, as compared to other popular regional destinations.

Each research element, in addition to internal consultation and discussion, contributed important facts and insights. The results and analysis of our findings are culminated in this full report and strategic assessment.

## Report Contents

Following this introductory chapter, Chapter 2 provides an overview of travel trends and market factors, as well as a profile of the primary visitor attractions within the Pend Oreille Valley. Chapter 3 describes the primary travel market for the Pend Oreille Valley specifically, and includes the results from the intercept "black box" survey conducted during the summer of 2004. Chapter 4 presents the findings for the Spokane Metro Area survey, which also includes discussion and interpretation of specific survey results.

The final section of the report, Chapter 5 presents recommendations for Pend Oreille Valley tourism marketing and product development. Included, as well, is a discussion of criteria for success and program implementation ideas.

## Geographic Focus of Study

Figure 1-1 on the following page shows a regional map of the area of focus. Throughout this report, *Pend Oreille Valley* refers to the visitor destination area representing the political boundary of Pend Orielle County, bordered on the north side by Canada, the east by the State of Idaho, the south by Spokane County, and the west by Stevens County (see Figure 1-1). Since visitors will tend not to associate a destination with county boundaries, neighboring counties or portions thereof may be related, connected, or associated with *Pend Oreille Valley* and discussed in this Tourism Development and Marketing Assessment.

Figure 1-1
**Pend Oreille and Adjacent Counties**

# 2. Trends and Market Factors

This section reviews national market conditions, as well as local factors pertaining directly to Pend Oreille Valley. Although many of these factors operate regionally and nationally, at least to some degree, they affect travel and tourism markets for Pend Oreille Valley. Understanding these trends can help identify the highest priority target markets and messages, and the best opportunities for new or enhanced travel and recreation products.

## National Market Conditions

There are important demographic, travel, and other trends in North America that influence travel to and through the Pend Oreille Valley, and which should be considered carefully when considering any tourism development and marketing priorities. The following is a brief review of these factors, followed by a summary of implications for the Pend Oreille Valley.

### *Demographics*

| | |
|---|---|
| American population is aging | The primary growth is currently in the 45-55 age range. These are more likely to be empty nesters at this point; relatively few are retired yet. The retired population will increase significantly after 2010. |
| More dual-earner households | With more than one worker it is more difficult to schedule travel, which often means shorter trips, more frequently. Shorter trips tend to be more single-purposed—focused on one or a few activities. |
| Increasing incomes for some Americans | Incomes of professional, educated households have been increasing, producing a segment of the population with adequate resources for travel and recreation. However, much of the population is sharing in this income growth only to a limited degree, and will continue to travel on a more limited basis and be very value-oriented. |
| Educated population | The American population is becoming increasingly educated, with nearly a quarter of American adults currently holding a bachelor or advanced degree. Educated travelers are particularly interested in information-rich displays and programs. |

***Travel Trends***

| | |
|---|---|
| Shorter vacations, more frequently | North American households are more likely to take long weekend and other relatively short trips; the incidence of extended, multi-destination long-distance travel is decreasing. More vacations are close to home, 2-4 days, within 150 miles, often on weekends. |
| Children travel more often with parents or relatives | More travel includes children, and accordingly is more oriented to educational and recreational experiences. Children also require higher service levels (more bathrooms, child-oriented food service), and are not associated with "night life." |
| Organized group travel increasing | Organized group travel -- by motorcoach, cruise ship or using air transportation -- is increasing and is related to the aging of the North American population and increasing incomes here and abroad. Much of this travel is during Summer and is very value-oriented. |
| Seasonality | The preferred leisure travel season is April through October. Family travel, in particular, is oriented to summer months. Spring and Fall travel is popular among empty nesters to avoid crowds and take advantage of travel specials. Meetings/convention travel is more oriented to Spring and Fall. |
| Travelers want educational, packaged experience | More travelers are focused on educational experiences, (particularly if children are involved), such as visits to natural or historic sites, interpretive facilities and programs, and activities oriented to wildlife and natural resources. Some of the strongest growth for the past decade has been in highly packaged recreation and entertainment, such as theme parks, cruises and gaming. |
| Business and leisure travel are combined more | Travelers sometimes extend business trips to include leisure activities and provide a good market for destinations adjacent to major metro areas. Business trips are also more likely to include spouses and children than in the past (although most do not). |
| Entertainment increasingly important | Entertainment is an increasingly important component of travel and recreation, and of education as well; travelers and facility users expect very good presentation, interactivity and visual appeal; competitive sports and gaming are very popular. |
| Travel parties and grandparents | Travel parties including grandparents are increasing. These trips may have an educational focus and would not tend to include strenuous activity. |

| | |
|---|---|
| Membership programs increasing | Travel associated with membership programs is increasing: RV clubs, senior citizen organizations, membership reward programs (e.g., frequent fliers). Family reunions are a popular reason for travel. |
| International travel increasing in Washington State | Canadians represent about 14% of all out-of state travel to Washington State, and the majority of them are from British Columbia. Over half of overseas arrivals to Washington originate from four countries/regions – Japan, the United Kingdom, Scandinavia (Denmark, Finland, Norway, Sweden), and Germany – amounting to 57% of all overseas travelers to Washington. These travelers are particularly interested in things that are historic, unique and memorable. Overall, international travel is strongly affected by exchange rates. |

***Primary Qualities Visitors Want***

Research on travel and tourism behavior indicates some trends in what travelers want from their trips. These qualities are important to keep in mind when considering tourism development and marketing options.

| | |
|---|---|
| Convenience | Easy access, clear directions, as little congestion as possible: make it easy. Some localized congestion may be acceptable, particularly if it seems to represent the appeal of a very good location. |
| Safety | A primary concern, particularly with older travelers. The perception of diminished safety in many urban areas leads people to want to get away from these concerns to the extent possible: smaller communities in the Pend Oreille Valley can capitalize on this concern. |
| Cleanliness | Particularly important with most travelers – especially those that are well off. Buildings, interiors and grounds must be as clean, neat and orderly as possible. |
| Good service | Attentive, careful and friendly service stands out in travelers' minds. Travelers can cope with some inattentive and even rude service, but it is one of the most undesirable aspects of travel for many. |
| Escape | The complexity of many lives today means travelers want to get away, avoid stress, and relax. Younger travelers like to include some focused activity as part of trips, such as biking, hiking or sports. For older travelers, a trip may well involve some active recreation, but it is most often low key, such as golf or fishing. Education can serve as |

| | |
|---|---|
| | an important motivation, particularly when combined with recreation experiences. |
| Heritage and cultural sites | History remains one of the most common interests among travelers. This interest can be easily combined with natural resource topics. |
| Wildlife | The presence of wild animals is an important indicator of quality; to some, having wild animals around means that you have "escaped." But what constitutes "wild animals," and what represents good quality viewing and other related experiences varies widely. To some, this is a very casual activity, what others would call simply sightseeing. |
| Good weather | Most vacation travel takes place during summer months and is more oriented to locations with "good" (sunny and warm) weather. Winter travel is primarily oriented to either winter recreation locations or to locations with warm weather (Mexico, Caribbean). The seasonal factor will always be a challenge for travel in Pend Oreille County despite some opportunities to enhance winter recreation. |
| Parking | Parking is a big concern for many travelers who drive. Poor parking is very inconvenient, and good parking is a draw. Good parking is also safe and clean. |
| Water / shoreline | Proximity to water, and water access, are among the most consistent draws for people who travel. Travelers gravitate to lakefront and riverside locations and find visitor services located in the area appealing. |

## Demographic and Market Conditions

Market conditions in the Spokane area are strong, and projections suggest that demand will continue to grow. Population in Spokane County has grown from about 340,000 in 1980 to 430,000 in 2004, an average growth rate of 1 percent per year. Population growth in the Spokane area, accompanied by increased urbanization, has generated increasing demand for outdoor recreation and leisure activities throughout the region.

### *Population Growth*

Projections for Spokane and other counties in the region indicate that, over the next decade, the population will continue to grow at a similar pace, although the growth rate will depend to some degree on economic conditions. Projected growth estimates for the Spokane and selected counties appear below in Table 2-1.

Table 2-1
**Population Projections, 2000 - 2015**
Selected Counties

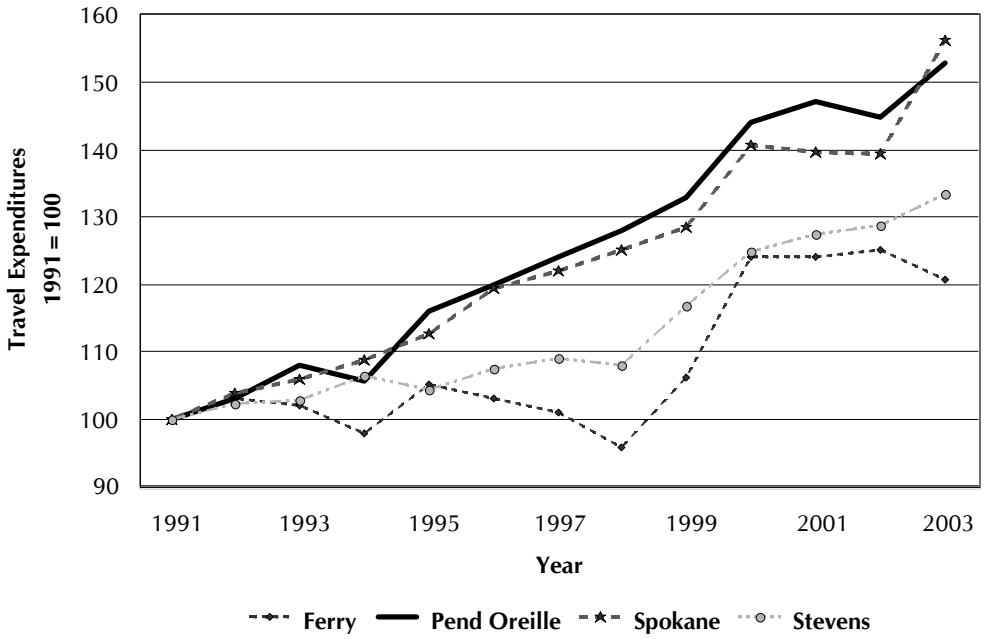
| *County* | 2000 | 2015 | Avg. Annual Change |
|---|---|---|---|
| Ferry | 7,280 | 9,120 | 1.5% |
| Pend Oreille | 11,760 | 14,830 | 1.6% |
| Spokane | 418,480 | 482,880 | 1.0% |
| Stevens | 40,240 | 52,880 | 1.8% |
| Total | 477,760 | 559,710 | 1.1% |

Source: NPA Data Services, Inc.

## Travel Industry Market Conditions

Travel expenditures in Pend Oreille County grew by 3.6% per year from 1991 to 2003. This rate of growth was similar to that of Spokane County (3.8% per year) over the same time period. As compared to both Ferry and Stevens counties, Pend Oreille has increased its relative share of the region's substantial travel industry growth. See Figure 2-1.

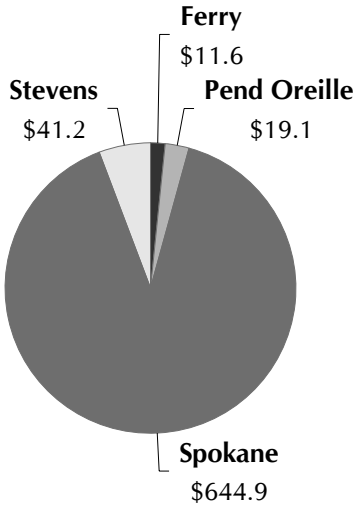
Figure 2-1
**Change in Travel Expenditures, 2003**
Selected Counties




Source: Dean Runyan Associates Regional Travel Impact Model

Figure 2-2 shows the distribution of travel spending in Pend Oreille County and surrounding counties during 2003. Supported by a relatively high concentration of lodging properties, transportation services (includes Spokane International Airport), and attractions, Spokane County receives the bulk of the region's travel expenditures. Due, in part, to the proximity to Spokane and appeal as a travel destination for Spokane area residents, Pend Oreille County, as well as Ferry and Stevens counties, receives an important share of the region's travel. As shown in Table 2-2, the travel industry generates a significantly higher proportion of local economic activity for each of these less populated counties.

Figure 2-2
**Total Travel Spending by County, 2003**
($ Millions)




Source: Dean Runyan Associates Regional Travel Impact Model

Table 2-2
**Travel Industry Share of Economic Activity, 2003**
Selected Counties

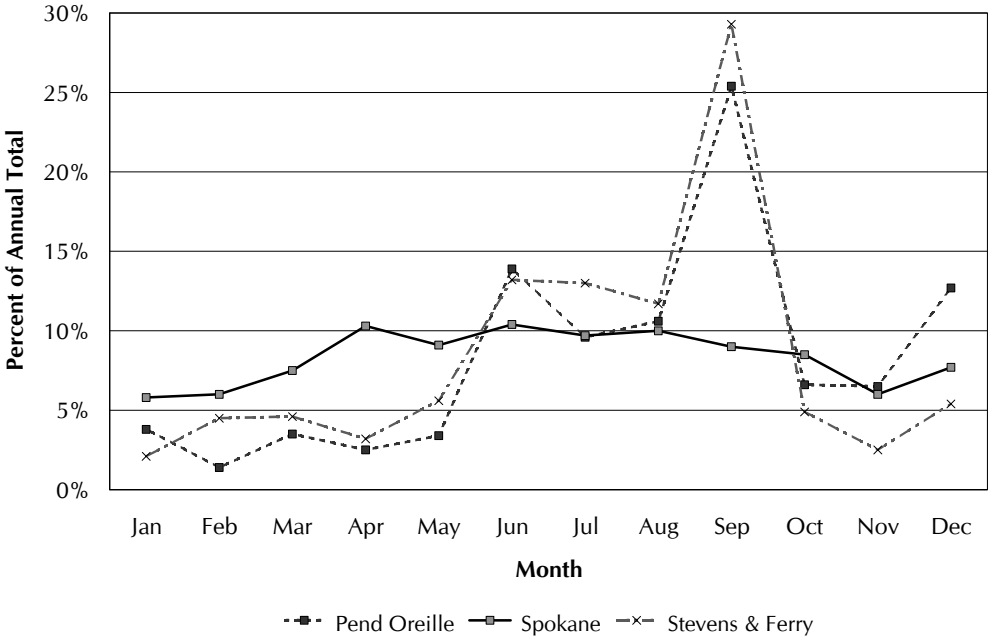
| *County* | Travel Industry Employment as pct. of Total | Travel-Generated Earnings as pct. of Total Earnings | Travel related taxable sales as pct. of Total Taxable Sales |
|---|---|---|---|
| Ferry | 9.0% | 4.3% | 30.0% |
| Pend Oreille | 7.5% | 3.7% | 23.8% |
| Stevens | 5.6% | 2.8% | 11.3% |
| Spokane | 3.5% | 2.5% | 7.1% |

Source: Dean Runyan Associates Regional Travel Impact Model; Washington State Dept. of Reven
Washington State Employment Security Dept.; Washington State Office of Financial Management

## Seasonal Travel Patterns

The seasonal pattern of room sales is similar within Pend Oreille, Stevens, and Ferry counties, with peak activity occurring in the late summer and early fall—an indication of the importance of the outdoor recreation, particularly, the hunting season. For Spokane County, the pattern of room sales is much more evenly distributed throughout the year, although with significantly less activity during the winter months.

Figure 2-3
**Room Sales by Month, 2003**
Selected Counties



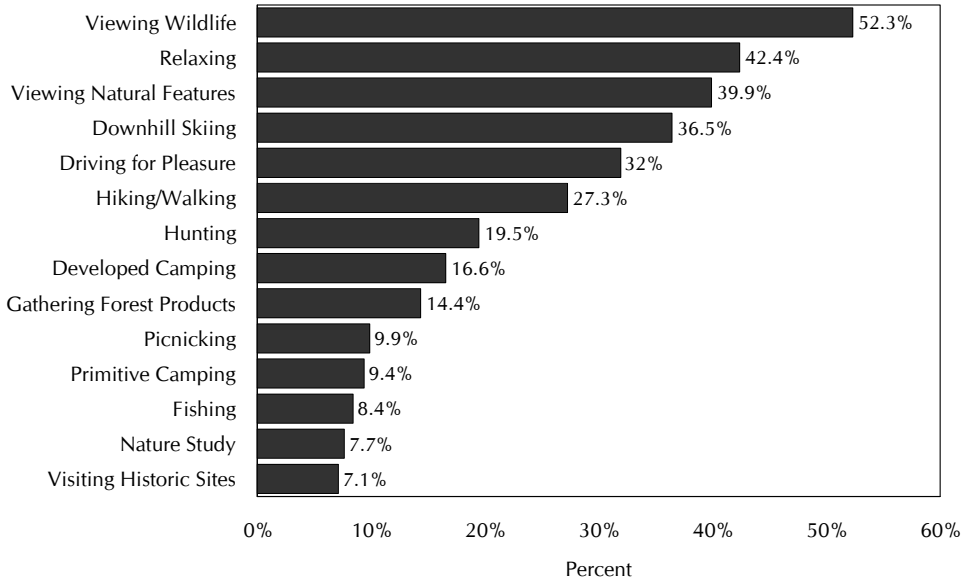

Source: Dean Runyan Associates & Washington State Department of Revenue

## Colville National Forest Visitation and Facility Use

The Colville National Forest participated in the National Visitor Use Monitoring project from October 2002 through September 2003. The information collected included participation in various recreation activities, as well as visitor use of facilities and special designated areas on Colville National Forest.

During their visit to the forest, the top five recreation activities of the visitors were wildlife viewing, relaxing, viewing natural features, downhill skiing, and driving for pleasure.

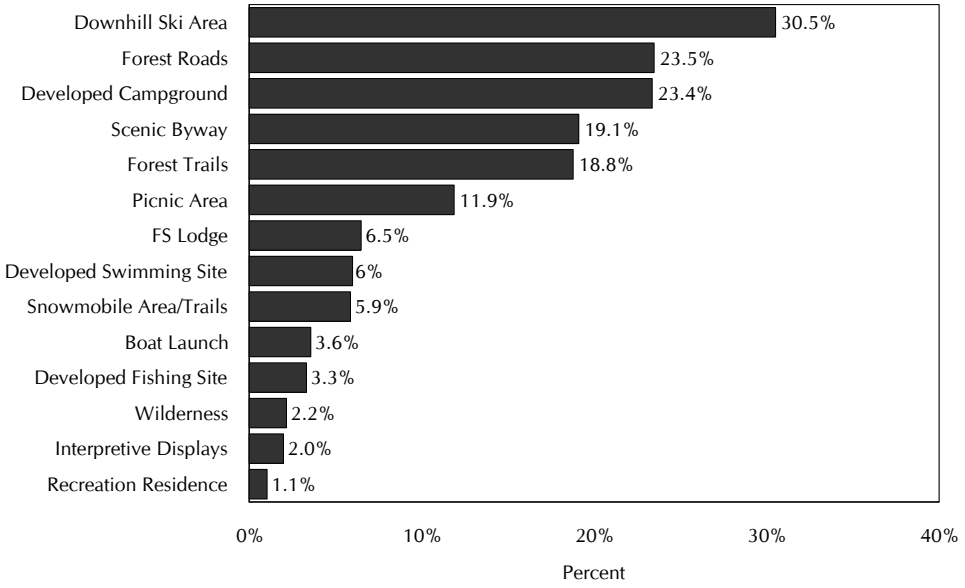
Figure 2-4
**Colville National Forest Activity Participation, 2002-03**




Source: National Visitor Use Monitoring Results, Colville National Forest, 2004
Note: Multiple Response; Percentages sum to more than 100%

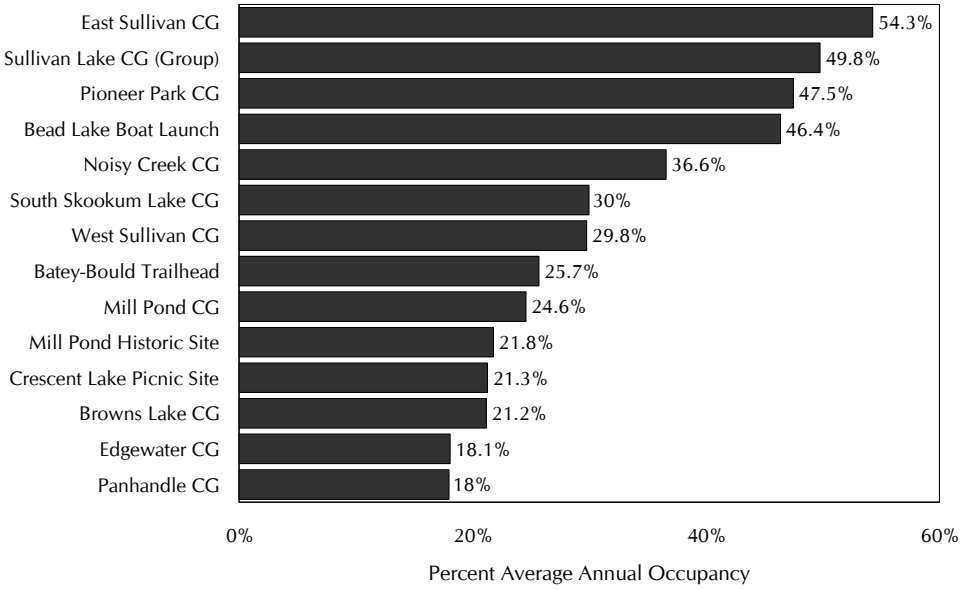
While visiting the Colville National Forest, visitors made use of a variety of constructed facilities and special designated areas. Among the facilities/areas most used were: downhill ski area, forest roads, developed campground, scenic byway, and forest trails. Figure 2-5 provides a summary of visitor use reported for developed facilities and designated areas. As shown in Figure 2-6, among a selection of Colville National Forest developed facilities in the Pend Oreille Valley, developed campgrounds -- in particular those located at Sullivan Lake, Pioneer Park, Noisy Creek, and South Skookum Lake – as well as the Bead Lake Boat Launch, currently receive a relatively high level of visitor use.

Figure 2-5
**Colville NF Visitor Use**
**Developed Facilities and Designated Areas, 2002-03**




Source: National Visitor Use Monitoring Results, Colville National Forest, 2004
Note: Multiple Response; Percentages sum to more than 100%

Figure 2-6
**Average Annual Occupancy for Selected Colville NF Facilities, 2002-03**



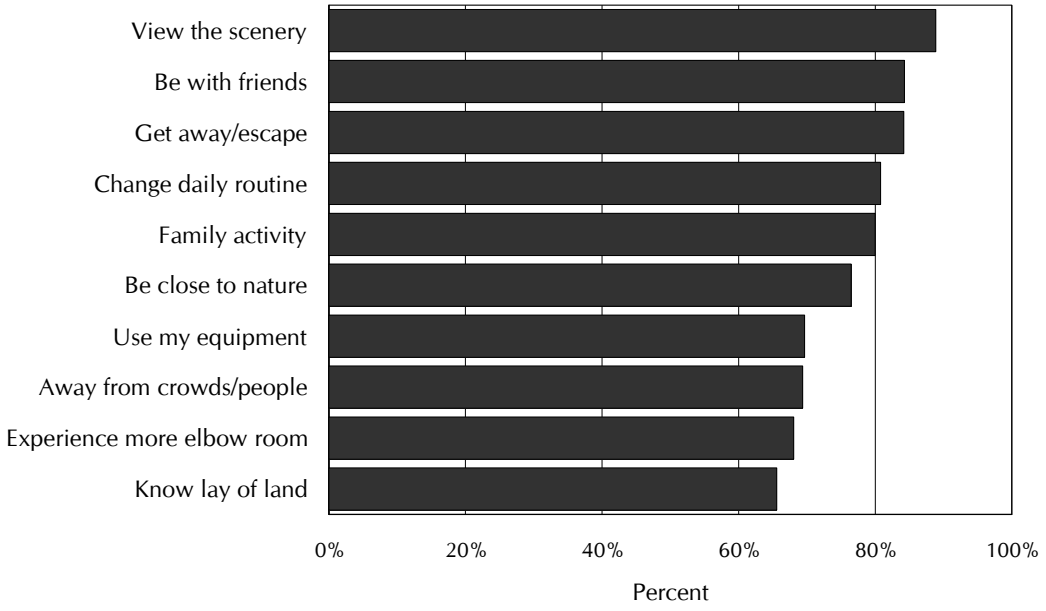

Source: USDA Forest Service, Colville National Forest

## Winter Recreation

Snowmobiling is an important winter recreation activity in Pend Oreille Valley. Understanding the characteristics and motivations of snowmobilers can help to better manage and promote this winter recreation activity in the area. Research findings based on a sample of registered snowmobile owners in the state of Wyoming (snowmobiling is among the most popular winter recreation activity in Wyoming) can help provide an indication of the perceptions and attitudes of those who participate in this winter recreation activity.

Figure 2-7 summarizes the top reasons why snowmobilers took their most recent trip. The top five reasons were to view the scenery, be with friends, to get away from the usual demands of life, to have a change from their daily routine, and to do something with their family. Among those snowmobilers best described as "nature lovers who want to be with family and friends", nearly one in five (19.4%) was retired, drove an average of 91 miles, and spent about $100 on their last trip. On average, these snowmobilers made approximately 11 trips resulting in nearly 25 snowmobiling days per year.

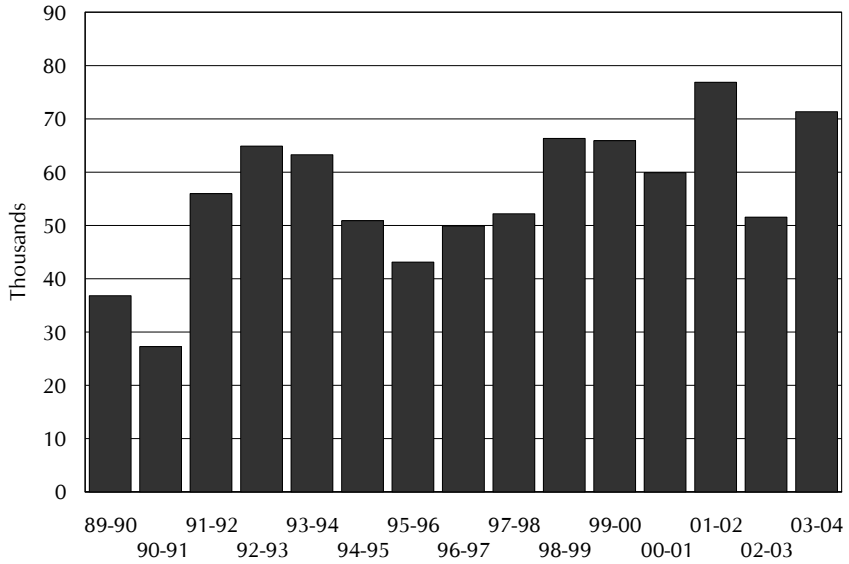
Figure 2-7
**Top Reasons for Most Recent Snowmobiling Trip**
**Survey of Registered Snowmobile Owners in Wyoming**




Note: Percent of respondents indicating reason listed is either extremely important or important.
Source: Journal of Travel Research, Vol. 39, February 2001, 292-299

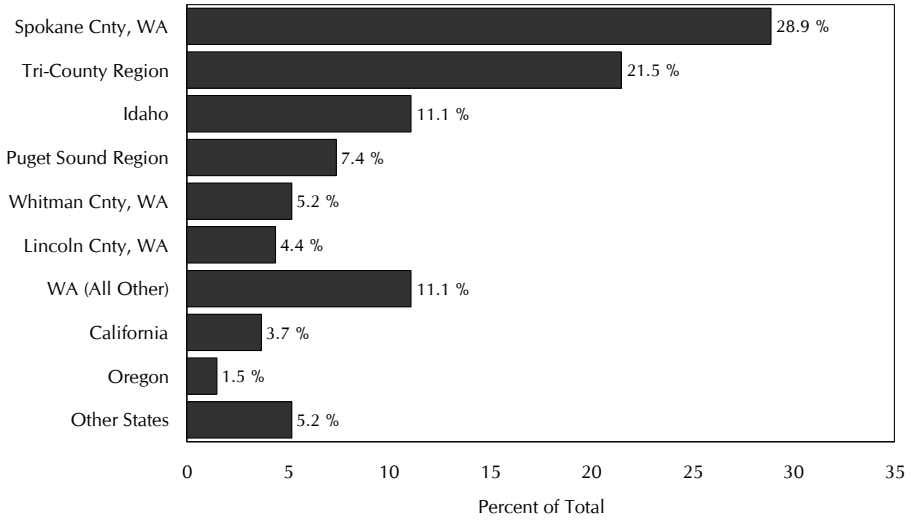
Located in the Newport Ranger District, of the Colville National Forest, 49° North Mountain Resort provides a good measure of the demand and source of winter recreation in Pend Oreille Valley.

Figure 2-8
**49° North Ski Area**
**Annual Visitation, 1990-2004**




Source: "49" North Mountain Resort

Figure 2-9
**49° North Ski Area**
**Source of Season Pass Buyers, 2004-05**




Source: "49" North Mountain Resort
Note: Tri-County Region represents Stevens, Pend Oreille and Ferry Counties.

## Overview of Assets as a Visitor Destination

The Pend Oreille Valley (also known as the "Forgotten Corner") has a number of assets as a visitor destination, many of which can contribute to expanding the tourism market. Establishing a basic understanding of the tourism product is an important step that sets the stage for a discussion of opportunities to develop new products and market the Pend Oreille Valley. Although the focus of this study is on the Pend Oreille Valley, it is important to recognize that from a visitor's perspective the destination may be visited in conjunction with other areas in northeastern Washington, northern Idaho, and southeastern British Columbia.

While this overview intends to describe the primary tourism product for the Pend Oreille Valley, it does not intend to list or describe every specific attraction or facility, or identify every possible visitor activity. More extensive listings of sites and recreation activities can be found on a variety of websites including:

| | |
|---|---|
| Colville National Forest | www.fs.fed.us/r6/colville |
| The International Selkirk Loop | www.selkirkloop.org |
| Washington State Tourism | www.tourism.wa.gov/ttd_regionactivity_R6_T24 |
| Pend Oreille Valley Network | www.povn.com |
| The Kalispel Tribe | www.kalispeltoday.com |
| Newport-Oldtown Chamber | www.newportoldtownchamber.org/ |

### *Outdoor Recreation*

The Pend Oreille Valley offers a rich variety of scenic natural features, public lands, and opportunities for good quality outdoor recreation. Examples include:

- Forest Service road access to mountain peaks with views extending into Canada, Idaho, and mountains of Montana, as well as overlooking the Pend Oreille River and several lakes -- the highest of these mountain peaks is Calispel Peak, with an elevation of 6,905 feet.
- Several large water bodies, including the Pend Oreille River and Sullivan Lake, offering extensive opportunities for boating, fishing, swimming, and other water sports, as well as numerous smaller lakes and streams throughout the Colville National Forest.
- A wide variety of developed and primitive camping opportunities, both private and public, particularly along lakefronts and riversides.
- Extensive hiking opportunities, and a network of roads and trails for biking and equestrian activities, particularly throughout the Colville National Forest.

### *Wildlife Viewing*

The Selkirk Range mountains, forestlands, high meadows, rivers, and lakes of northeast Washington provide extensive habitat for numerous species, some of which are unique to Washington, including grizzly bear, woodland caribou, lynx, and wolves. In particular, the forests and high meadows surrounding *Flume Creek Mountain Goat Viewing Area* (north of Metaline) offer one of the most reliable places to view mountain goats, big horn sheep, moose, woodland caribou, and white-tailed and mule deer (site won the U.S. Forest Service "Eyes on Wildlife" award in 1992).

The forested mountain lake and wetlands of *Big Meadow Lak*e (west of Ione) are a natural habitat for many waterfowl and birds, including osprey and eagles, goldeneyes, buffleheads, and many other migratory ducks – hiking trails lead around the lake and to an observation tower with excellent views of wildlife habitat.

Further south, *Little Pend Oreille National Wildlife Refuge* (40,000 acres) provides refuge for over 200 migratory bird species, including numerous songbirds, waterfowl, and birds of prey, among mixed-conifer forestlands, streams, and wetlands. The U.S. Forest Service maintains a Watchable Wildlife loop with gravel roads open most of the year, with numerous picnic and bird watching opportunities.

### *Historical Attractions*

The City of Newport offers a newly revitalized downtown district, designed to preserve the town's historical character and landmarks. At the south end of town, Centennial Plaza is home to historically significant structures such as the Idaho Washington Northern Railway Depot (1909) which now houses the Pend Oreille County Historical Museum; the Great Northern Depot (1911) which now houses the offices of Stimpson Lumber Co.; Kelly's Tavern (1894) -- which contains the original bar that sailed around South America to San Francisco and then was transported by wagon train to Newport -- and "The Big Wheel," a steam sawmill engine which formally powered the town's sawmill. Designed as a pedestrian friendly city, these and many other historic buildings are listed on the "Walking Tour" which is available at the Newport Chamber and Visitors Center.

To the north, three historic small towns – Ione, Metaline and Metaline Falls – offer a number of historically significant structures: house museums, art galleries, shops, and other businesses. Among those most notable, the Cutter Theatre (a nationally recognized Center of the Arts, circa 1912), Washington Hotel (1906), and Old Miner's Hotel (1929).

Located in Colville, the Keller Heritage Center is 7-acre complex that features a museum depicting the development through the years of Northeast Washington. Displays

include: geology, Native Americans (with artifacts depicting The Kettle Falls), fur trade, missions, agriculture, schools, mining, timber and lumbering, a well stocked pioneer general store, and military Fort Colville. More modern activities are included such as The Print Shop (equipment donated by Statesman Examiner), telephone switchboard, a pharmacy (donations by individuals, Mt. Carmel Hospital and Medical Clinic), World War I and II memorabilia. In addition, the Keller House, on the National Register of Historic Places, provides an example of a turn-of-the-century home furnished with original Gustav-Stickley furniture, Tiffany light fixtures, and Art Nouveau windows and wallpaper.

***The Cutter Theatre***

Built in 1912, this historic school is now a community and performing arts center housing the Cutter Theatre and its support spaces, an art gallery, a rural schools exhibit, and other areas for other public and private use. The 166-seat Theatre is on the State and National Registers of Historic Places. Events include amateur plays and musicals, professional musicians and dancers, a lecture series, school plays and concerts, and an arts festival.

***Lions Club Train Ride***

The historic North Pend Oreille Valley Lions Train (operated by the North Pend Oreille Lions Club) travels along the Pend Oreille River beginning from the Town of Ione's railway depot to Metaline Falls (during Labor Day weekend rides begin in Metaline Falls as a part of the "Affair on Mainstreet" Festival). The two-hour excursion offers visitors an opportunity to travel in the mode of the early 19$^{th}$ century through the scenic river canyon. The train stops on an historic trestle spanning the Pend Oreille River, giving passengers a view of the Pend Oreille River and Box-Canyon Dam. The train returns to Ione, also the location of historically significant structures, including Congregational Church (1910), Ione Bank (1909), and Tiger Museum (1912).

***Recreational Boating and Fishing***

Power boating, kayaking, canoeing, and fishing are popular activities, and the Pend Oreille Valley has some valuable attributes in this regard. In particular, the Pend Oreille River (2nd largest river in the state of Washington), is ideal for a variety of boating activities including kayaking, canoeing, rafting (seasonal white-water), water skiing, fishing, or leisurely relaxation. Between Box Canyon Dam and Boundary Dam, the scenery offers soaring cliffs and magnificent water falls. Other prime waterbodies for recreational boating and fishing include: Sullivan Lake, Diamond Lake, Sacheen Lake, Bead Lake, Marshall Lake, and Davis Lake.

### *International Selkirk Loop*

The International Selkirk Loop is a 280-mile scenic drive through the heart of the Pend Oreille Valley, as well as the neighboring regions of northern Idaho and southeastern British Columbia. Within the Pend Oreille Valley, the scenic drive includes the towns of Metaline, Metaline Falls, Ione, Tiger, Usk, Cusick, and Newport. Other communities with notable recreational, cultural, and historic activities and attractions include Priest River, Sandpoint, and Bonners Ferry in Idaho; and Creston, Balfour, and Nelson in British Columbia. Each of these, as well as other towns along the Loop, offers a variety of accommodations, dining, shopping, entertainment, and events.

Along the Selkirk International Loop lie three nationally and internationally recognized wildlife viewing preserves:

- Kootenai National Wildlife Refuge (Bonners Ferry, Idaho)
- Little Pend Oreille National Wildlife Refuge (Colville, Washington)
- Creston Valley Wildlife Management Area (Creston, British Columbia)

### *Gardner Cave*

Located in Crawford State Park 11 miles north of Metaline, Gardner Cave is the second longest limestone cave in Washington State -- over one-fourth mile long. Cave lights, stairways and walkways have been installed to provide safety for the visitor and protection for the natural resource. A few picnic tables and a comfort station are near the parking lot. During the summer months, park staff provides guided tours through the caves.

### *Box Canyon and Boundary Dam Tours*

Free, guided tours of Box Canyon (offered by Pend Oreille Public Utility District) and Boundary Dams (offered by Seattle City Light) are available from Memorial Day weekend through Labor Day, by reservation. Visitors can view large turbines and electrical generating facilities that produce clean, renewable energy. At Boundary Dam, a Visitors' Gallery is located deep inside a massive limestone cavern, and visitors can view the expansive views at the Vista House and observation deck. The grounds behind the dam feature a pleasant picnic area, a boat launch, a few campsites, and a turn-of-the-century settler's cabin.

### *Golf*

The Pend Oreille Valley includes four golf courses offering good access to both residents and visitors (see below). Golf is increasingly popular and should be seen as an important opportunity for drawing visitors to the area as population in the Spokane MSA – and the associated recreation demands – increase in the years ahead.

- Metaline Falls Golf Course (Sullivan Lake District)
- Serendipity Golf Club (Ione)
- The Ranch Club (Priest River, ID)
- Stoneridge Golf Club (Blanchard, ID)

***Performing Arts***

Performing arts and facilities are valuable assets for communities seeking to enhance tourism. Performing arts appeal to many travelers – especially to those with families, as well as those seeking a quick getaway in the form of a special performance or event. Pend Oreille Valley features the following performing arts venues:

- Located in Metaline Falls (recognized as one of the nation's best small towns for arts), *The Cutter Theatre*, a historical 1912 schoolhouse renovated into a visual and performing arts center, features live community theater performances with an average of 22 different events per year.

- In the town of Newport, the *CREATE Place* serves as a multi-arts organization providing a venue for community theatre, performances by local and regional musicians, open microphone nights, art classes and exhibits, poetry readings, lectures, and more.

- In south Pend Oreille County near Sacheen Lake, the *Circle Moon Theatre* owned by Northwoods Performing Arts features choral shows and Broadway musicals performed by local artists.

***Festivals and Events***

There are a large number of festivals and events that occur each year throughout Pend Oreille County and the Tri-County Region. The Pend Oreille County visitors guide events calendar lists a total of over 20 events throughout the year including:

- Newport PWRA Rodeo
- Lavender Festival (Cusick)
- Down River Days (Ione)
- Kalispel Tribe Pow Wow (Usk)
- Pend Oreille County Fair (Cusick)
- Affair on Main Street (Metaline Falls)
- Christmas Celebration (Newport)
- Deck the Falls (Metaline Falls)

In addition to these key events, each Saturday (mid-May through mid-October) the town of Newport hosts Earth Market, and Lions Train Rides feature Autumn Colors tours

(various weekends, Sept.-Oct.). Properly managed and marketed, special events can help draw both new and repeat visitors who seek one-day activities and/or entertaining weekend trips.

***49$^{O}$ North Mountain Resort***

Located in Chewelah, Washington immediately to the west of Pend Oreille County, lies 49$^{O}$ North Mountain Resort, the most active site for skiing in the area – with an average of 120 inches of annual snow fall, 4 chair lifts and night skiing. Recently, (May, 2004), the Colville National Forest approved a proposed master plan to expand and improve ski area slopes and infrastructure including chair lift extensions, lodge expansion, and a state-of-the art cross country ski area.

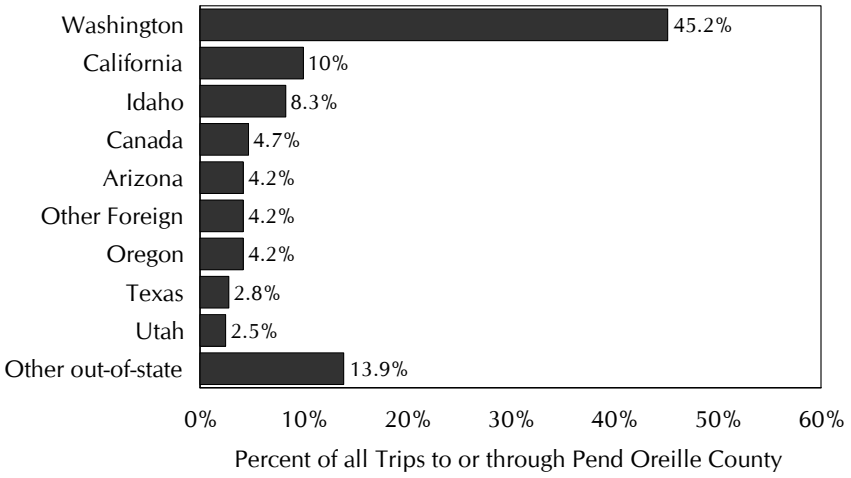
# 3. Visitor Profile

This section profiles visitors to the *Pend Oreille Valley* from an intercept "black box" survey conducted at various sites throughout Pend Oreille County during the summer of 2004. The topics covered include the origin of visitors, demographic characteristics, purpose of travel, activities, use of trip planning information, and visitor satisfaction. The survey results are presented in both graphical and tabular form. Additional survey results can be found in the Appendix C to this report.

## Origin of Visitors to Pend Oreille Valley

Of all visitors to Pend Oreille Valley, four out of ten (45%) reside in Washington State. Other primary sources of visitors include California, Idaho, and Canada (primarily those who originate from British Columbia).

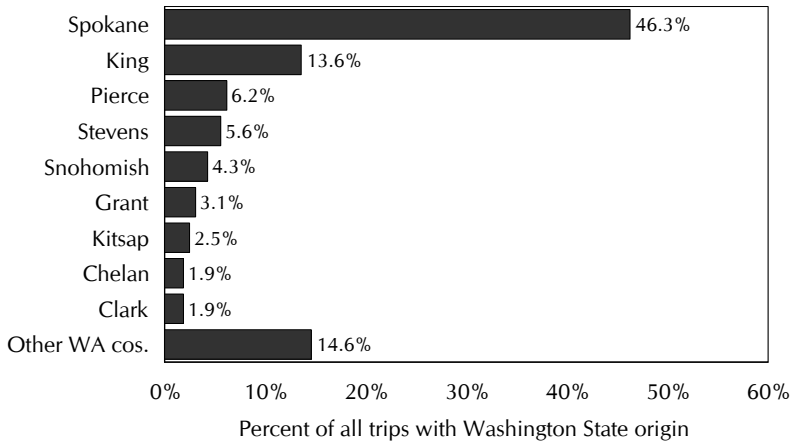
Figure 3-1
**Origin of All Visitors to Pend Oreille County, 2004**




Source: RRC Associates

Nearly one-half (46%) of all Pend Oreille Valley visitors from Washington State reside in Spokane County. This illustrates the importance of the Spokane Metro Area as the primary source of travelers to the Pend Oreille Valley. Another primary source of Washington state visitors originated from the Puget Sound (King, Pierce, and Snohomish counties, representing 24%).

Figure 3-2
**Origin of Washington State Visitors to Pend Oreille County, 2004**

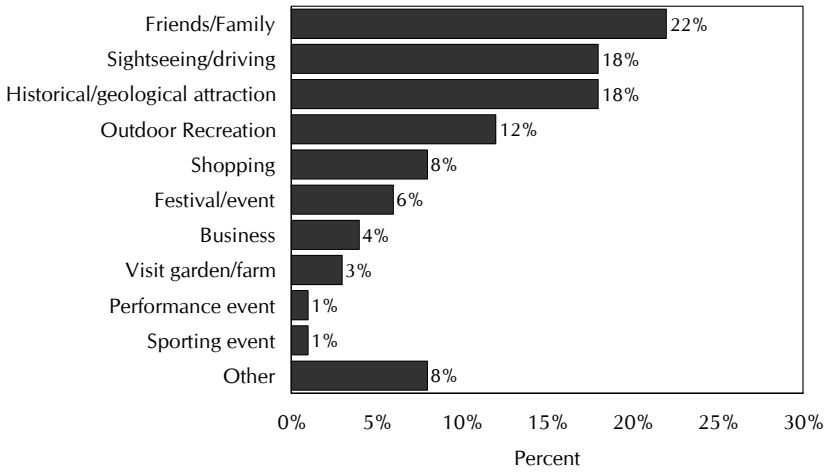



Source: RRC Associates

## Primary Purpose of Travel

Visiting friends and family (22%), sightseeing/driving (18%), historical/geological attractions (18%), and outdoor recreation (12%) were the most important types of trip purposes for visitors to the Pend Oreille Valley.

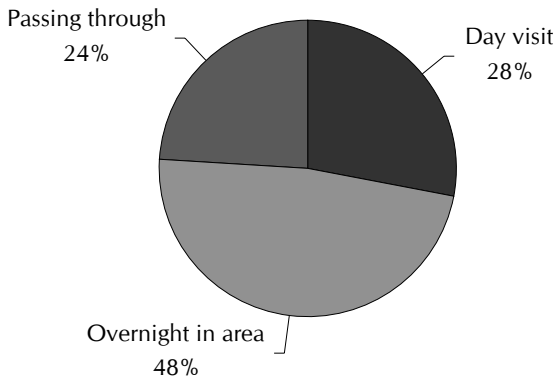
Figure 3-3
**Primary Purpose of Travel**




Source: RRC Associates

As shown in Figure 3-4, about one-half (48%) of all visitors to Pend Oreille Valley spent at least one night in the area. The remaining half of visitors either visited for the day (28%), or were passing through Pend Oreille Valley either on route to another destination or were traveling on an extended vacation (24%). For those visitors who were passing through, Pend Oreille Valley is not functioning as a primary destination, although particular locations or features of the area may have been appealing enough to merit a visit.

Figure 3-4
**Day and Overnight Visitors to Pend Oreille County**

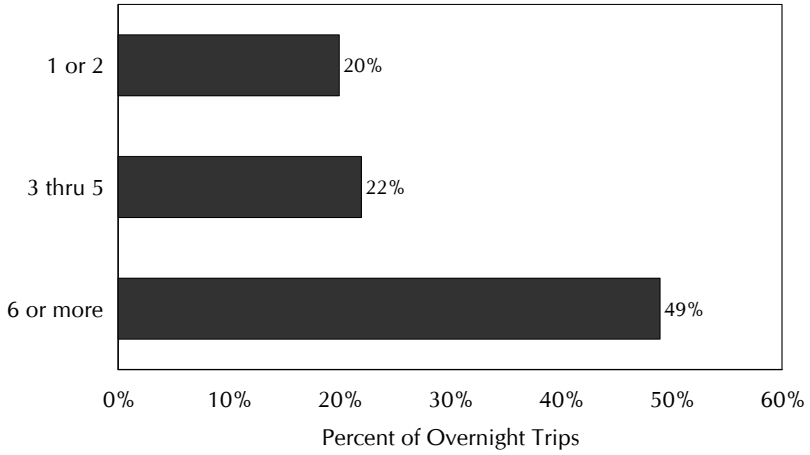



Source: RRC Associates

## Overnight Trip Length

Among all *overnight travelers* to Pend Oreille Valley, one-half (49%) were on trips that lasted six or more nights away from home (an average of 6.4 nights) – an indication that many of these visitors are traveling on extended vacations. The relatively long trip length is also related to the high proportion of stays at private homes with friends and relatives, which tend to be associated with longer length of stays.

Figure 3-5
**Overnight Length of Trip**
Overnight Visitors to Pend Oreille Valley

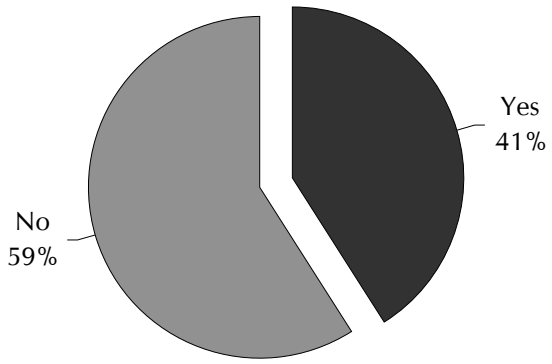



Source: RRC Associates

## Repeat Visitation

Repeat visitors were common to Pend Oreille Valley, with more than one-half (59%) of all visitors having made a previous trip to the region.

Figure 3-6
**First Time Visit to Pend Oreille County**

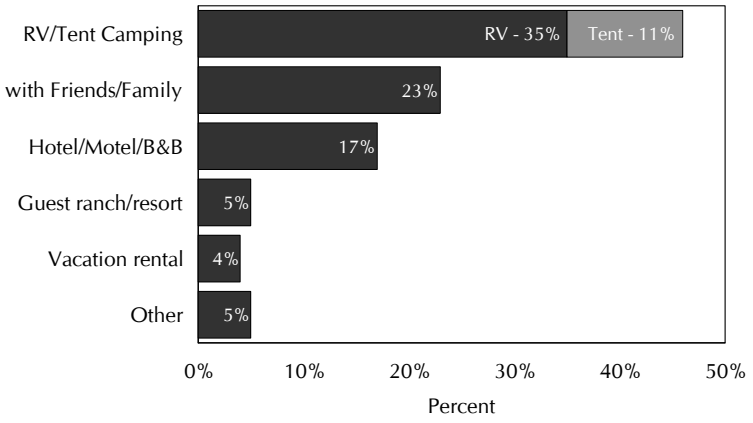



Source: RRC Associates

## Type of Accommodation and Overnight Destination

Overnight visitors to Pend Oreille Valley are very oriented to camping, with nearly one-half (46%) of travel parties camping either with recreation vehicles or tents. Private home stays were the next highest, with nearly one-quarter (23%) having stayed with friends or family. Other overnight visitors stayed at a hotel/motel/B&B (17%), guest ranch/resort (5%), or rented a vacation home (4%).

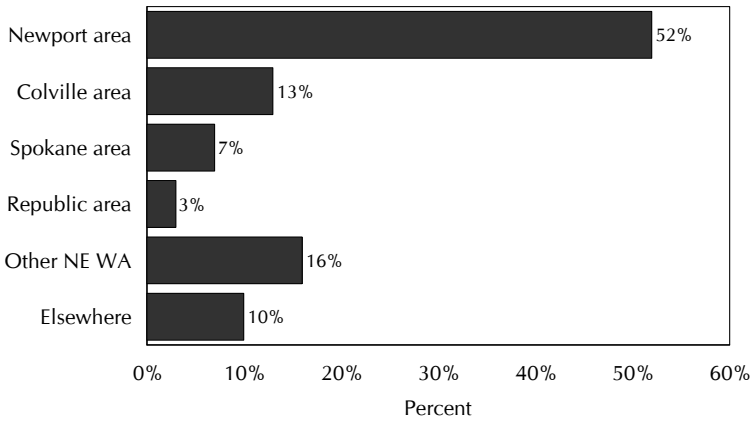
Figure 3-7
**Type of Accommodation**
Overnight Visitors to Pend Oreille County




Source: RRC Associates

Among overnight visitors to Pend Oreille Valley, the Newport area was, by far, the most common overnight destination – the choice for more than one-half (52%) of Pend Oreille Valley visitors planning to spend the night.

Figure 3-8
**Overnight Destinations of Pend Oreille Valley Visitors**
Visitors Planning to Spend the Night

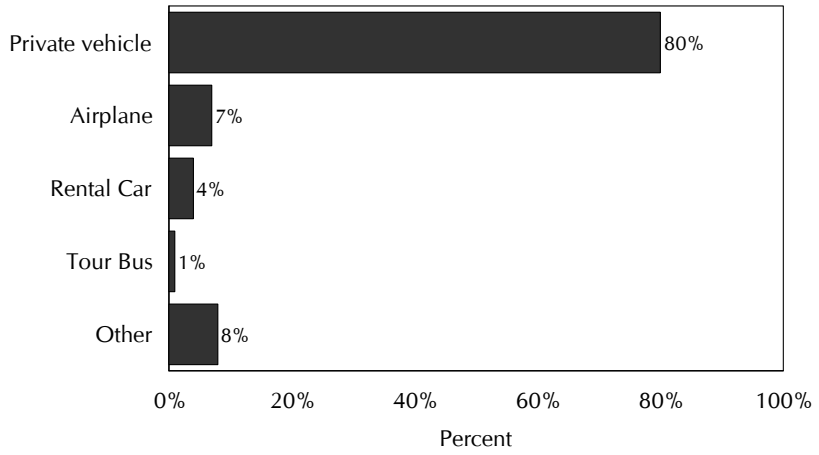



Source: RRC Associates

## Primary Mode of Transportation

Pend Oreille Valley is largely a motor vehicle destination, with more than three-fourths (80%) of all visitors to the area traveling primarily by private motor vehicle. This high proportion of private motor vehicle travelers illustrates the importance and value of encouraging these travelers to spend as much time in the area as possible.

Figure 3-9
**Primary Mode of Transportation**

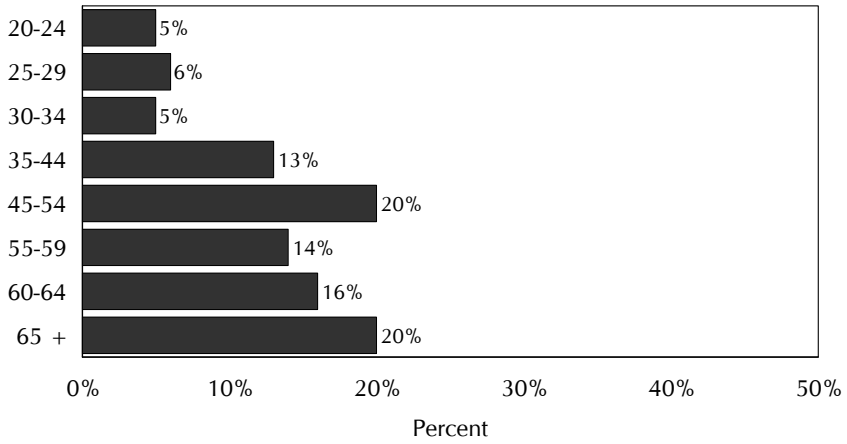



Source: RRC Associates

## Demographic Characteristics

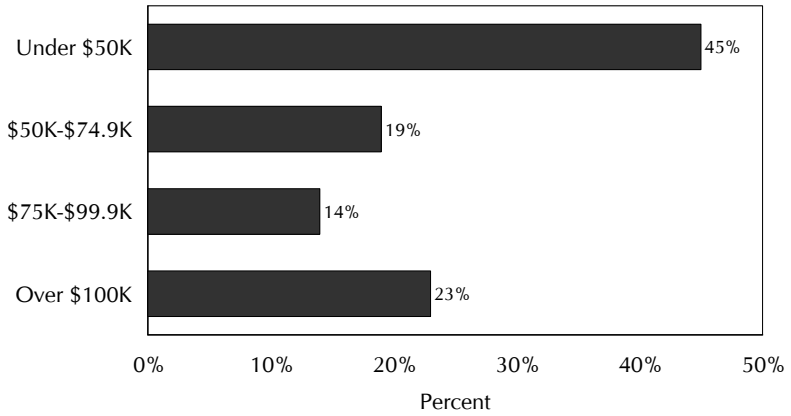
Figures 3-10 and 3-11 describe the age range and household income characteristics of Pend Oreille Valley visitors. The average age of visitors (respondents under 20 years were excluded) was 52 years. Over one-half (55%) had annual household incomes of $50,000 per year and above, with an average of nearly $72,000.

Figure 3-10
**Age of Respondent**




Source: RRC Associates
Note: Average 52.3

Figure 3-11
**Household Income**



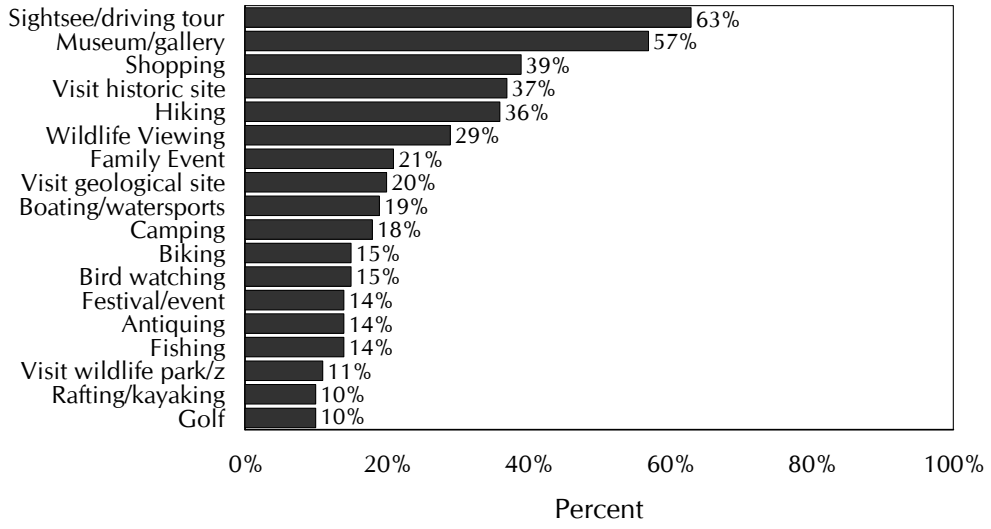

Source: RRC Associates, 2004
Note: Average $71,967

## Activities of Visitors to Pend Oreille Valley

Almost two-thirds (63%) of all Pend Oreille Valley visitors reported sightseeing/driving tour as an activity. Other leading activities include a visit to a museum/gallery (57%), shopping (39%), visit to a historic site (37%), hiking (36%), and wildlife viewing (29%). To some extent, the reported activities reflect the intercept sites chosen to interview visitors (intercept sites included Tiger Museum and Newport Historical Society and

Museum). However, the variety of reported activities also reflects the degree of visitor participation, in that respondents typically reported multiple activities.

Figure 3-12
**Top Activities of All Visitors to Pend Oreille Valley**



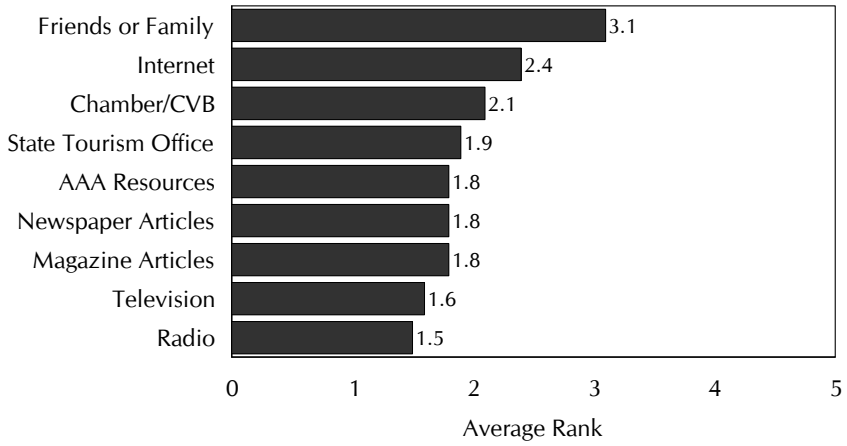

Source: RRC Associates
Note: Multiple Response, percentages sum to more than 100%

## Sources of Information about Travel

Figures 3-13 and 3-14 summarize the degree of importance with regard to sources of trip planning information. Figure 3-13 shows the degree of importance among trip planning sources in terms of setting an itinerary. Friends and relatives were the most important source of trip planning information, which reflects the importance of this primary trip purpose for visitors to Pend Oreille Valley. Among formal sources of trip planning information, the most important were the Internet, Chamber/CVB, State Tourism Office, and AAA Resources.

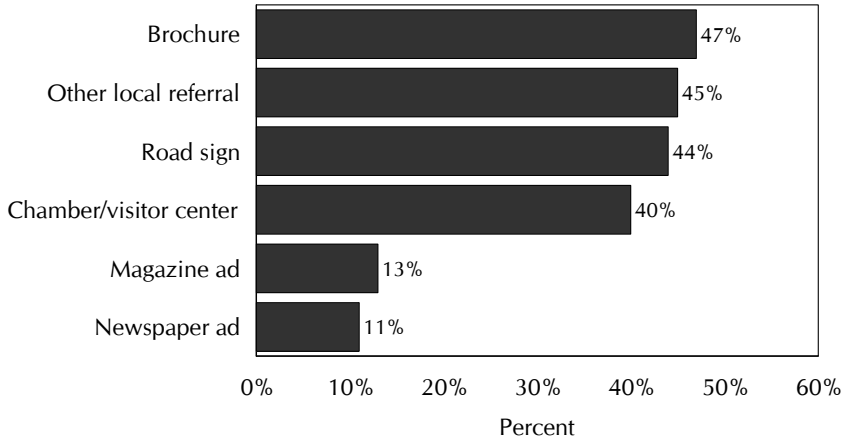
Figure 3-14 shows the frequency of use among common information sources after leaving home while traveling. The most common include: brochures, local referrals, road signs, and local area chambers/CVB's.

Figure 3-13
**Top Sources of Trip Planning Information**
Degree of Importance in Setting Itinerary




Source: RRC Associates
Note: 1 = Not a factor, 5 = Very important

Figure 3-14
**Top Sources of Trip Planning Information**
After leaving home and "hitting the road"

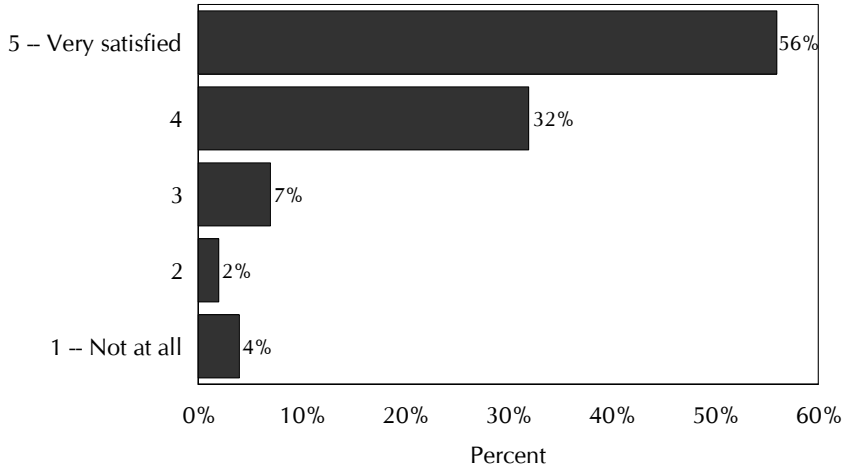



Source: RRC Associates
Note: Multiple Response; Percentages sum to more than 100%

## Satisfaction Rating and Likelihood to Return to Pend Oreille Valley

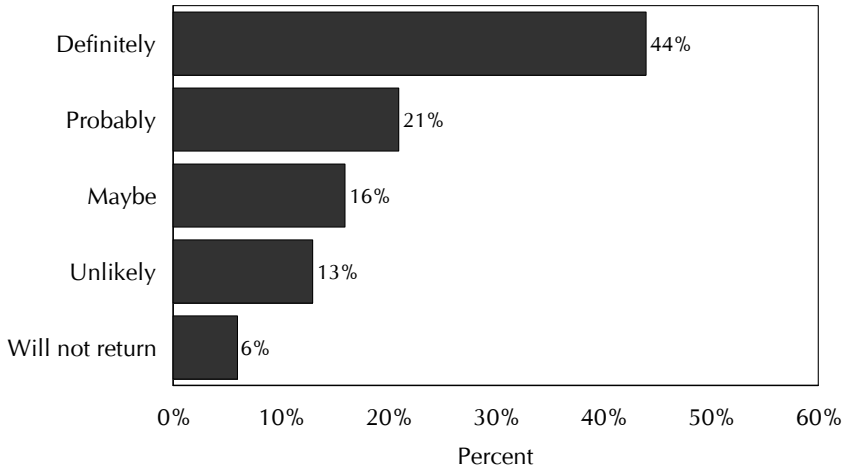
Visitors were also asked to rate their satisfaction with their current travel experience and likelihood of returning in the next year. Figure 3-15 shows most visitors (88%) were either satisfied or very satisfied. Figure 3-16 shows that about two-thirds of visitors (65%) will probably or definitely return to the Pend Oreille Valley next year.

Figure 3-15
**Degree of Satisfaction with Travel Experience**




Source: RRC Associates

Figure 3-16
**Likelihood of Returning in the Next Year**




Source: RRC Associates

# 4. Spokane Resident Travelers Profile

## Introduction

The population of Spokane provides the Pend Oreille Valley with a concentrated market of potential travelers, and the prospect of higher repeat visits. While the previous section focused on the characteristics of current visitors to Pend Oreille Valley (summer 2004), the findings presented in this section examine the potential opportunities to further penetrate the market of travelers from the Spokane Metropolitan Statistical Area (MSA). This is an important distinction and primary purpose to learn more about the trip activities and preferences of travelers from the Spokane MSA. Previously unknown factors may help to identify potential opportunities for more effective marketing and product development strategies.

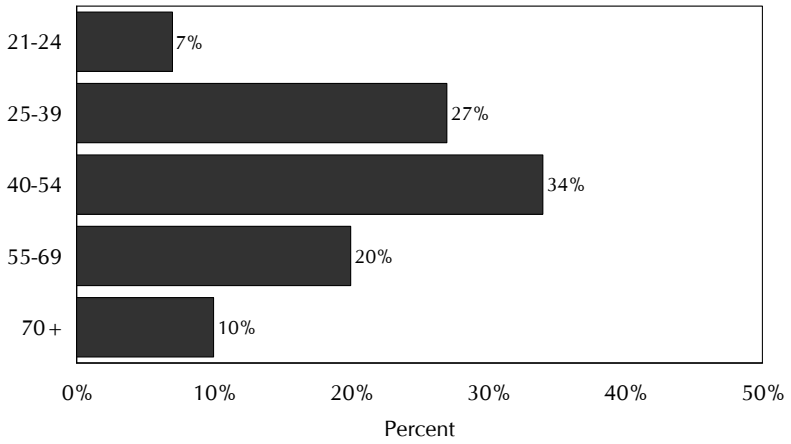
## Purpose and Method

The overall purpose of the Spokane Travelers Profile is to better understand the current travel patterns and attitudes of Spokane residents who travel regionally. The survey focused on the respondent's perceptions and attitudes with regard to regional travel, or more specifically, travel within a two or three hour drive of Spokane, including locations in Pend Oreille Valley (referred to in survey as *Pend Oreille River Area*). Topics covered include locations visited, primary purpose of travel, motivation for travel, trip activities, the evaluation of the Pend Oreille River Area by visitors, and demographic characteristics. All survey data is presented in graphical and tabular form. Additional survey detail can be found in Appendix A.

Four hundred telephone interviews were conducted from GMA Research headquarters located in Bellevue, Washington between July 7, 2004 and July 19, 2004. The interviews were approximately 14 minutes in length. The sample design targeted individuals who were most likely to travel within the region. Therefore, all respondents have taken at least one overnight or day pleasure trip, by highway, within a two or three hour drive of Spokane during the past two years. Respondents were drawn from a random selection of residents of the Spokane MSA. A copy of the telephone questionnaire is attached as Appendix B to this report.

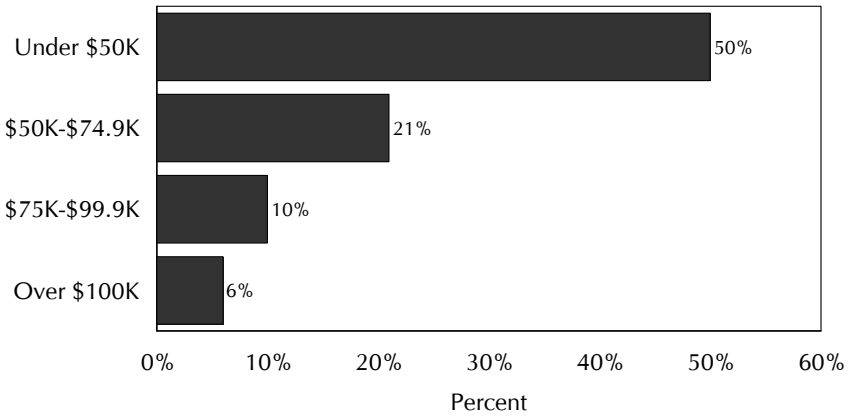
The most important factors that indicate an ability to travel are age, income, and the presence of children (lower numbers of children indicate greater discretionary income available for travel). The median age of survey respondents is 46 years. Figure 4-1 summarizes the age distribution of Spokane resident travelers. Figure 4-2 illustrates each income category and respondent percentages. The mean household income of all respondents is $51,300. Figure 4-3 illustrates the number of children (under age 18) living in the household of each respondent. More than half (55%) have no children present.

Figure 4-1
**Age of Survey Respondent**



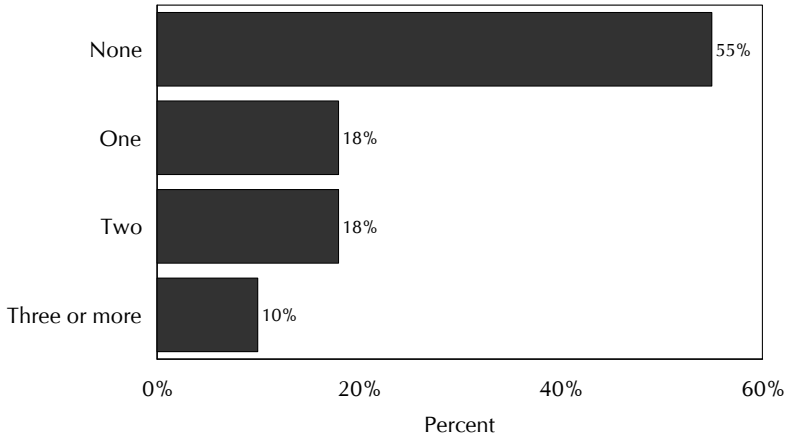

**Source: Dean Runyan Associates**

Figure 4-2
**Household Income of Survey Respondent, 2004**




Source: Dean Runyan Associates, 2004
Note: Percentages in graph sum to 87%. Remainder of respondents answered "don't know" or refused.

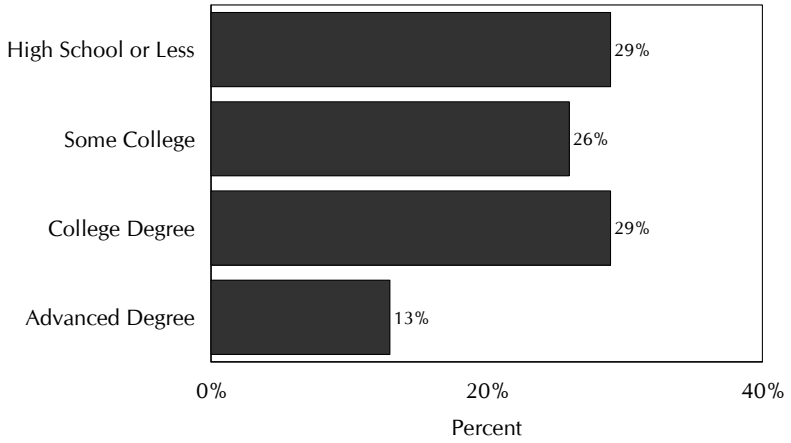
Figure 4-3
**Number of Children in Household of Survey Respondent, 2004**




Source: Dean Runyan Associates, 2004

With regard to educational attainment, the survey results, as illustrated in Figure 4-4, showed: High school or less 29%, Some college 26%, College Degree 29%, Advanced Degree 13% and Refused 3%.

Figure 4-4
**Educational Attainment of Survey Respondent, 2004**



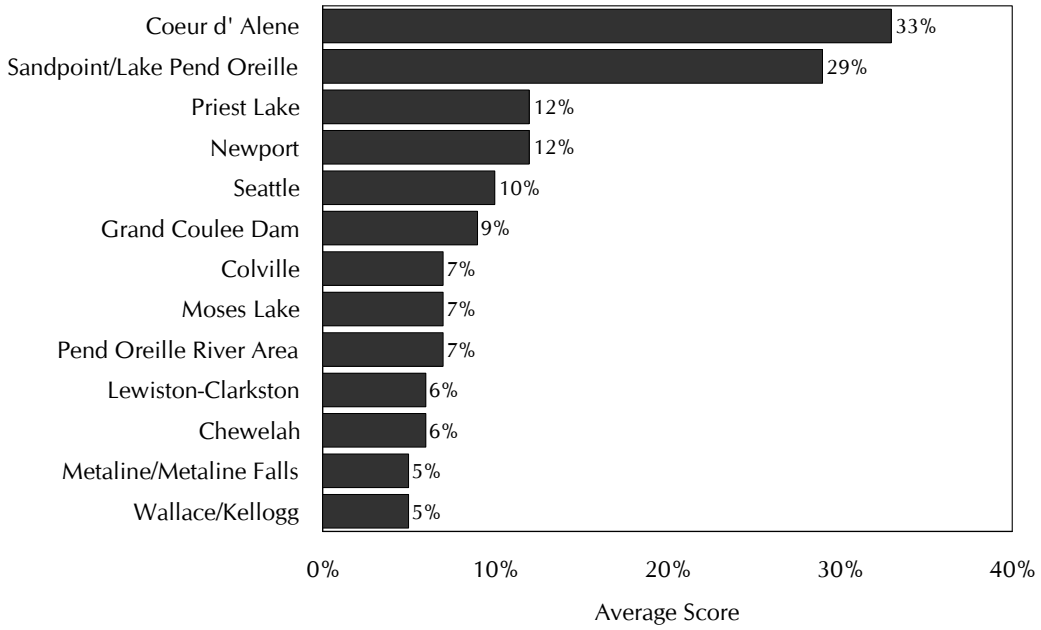

**Source: Dean Runyan Associates, 2004**

## Regional Travel Preferences

*Regional Destinations Visited*

Within a two to three hour drive of Spokane, respondents visited a variety of destinations, most of which were in northeastern Washington and northern Idaho. The most frequently visited destinations in the last two years included: Coeur D'Alene (one-third of all respondents), Sand Point/Lake Pend Oreille (29%), Priest Lake (12%), and Newport (12%). A summary of these findings is found below in Figure 4-5.

Figure 4-5
**Unaided Recall of Towns or Points of Interest**
**Trips Taken During the Past Two Years**




Source: Dean Runyan Associates, 2004
Note: Destinations where respondent percentage 5% or more.

*Frequency and Season of Travel*

Spokane resident travelers were more likely to visit the Pend Oreille River Area for the day as compared to an overnight trip. One-third of Spokane resident travelers made at least one overnight trip to the Pend Oreille River Area, whereas slightly less than one-half made at least one day trip during the past two years. See Table 4-1 below.

Overall, Spokane resident travelers reported the mean number of pleasure trips taken during the past two years was 8.2 for overnight trips and 9.7 for day trips.

Table 4-1

**Frequency of Regional Travel**

on pleasure trips taken during the past two years

| | Overnight Trips | | Day Trips | |
|---|---|---|---|---|
| pleasure trips taken | All Locations | Pend Oreille River Area | All Locations | Pend Oreille River Area |
| none | 7% | 64% | 11% | 51% |
| 1 to 2 | 20% | 19% | 14% | 22% |
| 3 to 4 | 23% | 15% | 19% | 26% |
| 5 to 9 | 26% | 0% | 22% | 0% |
| 10 or more | 25% | 0% | 35% | 0% |

Source: Dean Runyan Associates

Spokane resident travelers most often take pleasure trips during the summer months of the year, with less frequent travel during the spring and fall. Travel during the winter occurs much more infrequently, with more than two-thirds of respondents reporting that they seldom or never travel for pleasure regionally during this time of year, as shown below in Table 4-2.

Table 4-2

**Season of Travel**

on pleasure trips taken during the past two years

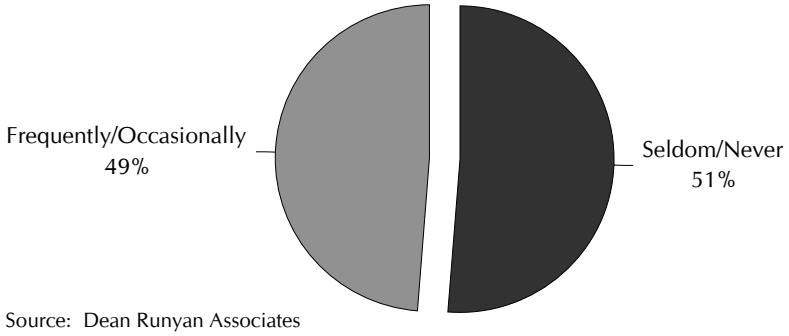
| | Season of Visit | | | |
|---|---|---|---|---|
| | Summer | Fall | Winter | Spring |
| Frequently | **44%** | 19% | 13% | 24% |
| Occasionally | **36%** | **39%** | 20% | **45%** |
| Seldom | 17% | 33% | **37%** | 23% |
| Never | 4% | 9% | 30% | 8% |

Source: Dean Runyan Associates

*Travel with Children*

Nearly one-half of all Spokane resident travelers frequently or occasionally travel with children under the age of 18.

Figure 4-6
**Frequency of Regional Travel with Children**
on pleasure trips taken during the past two years

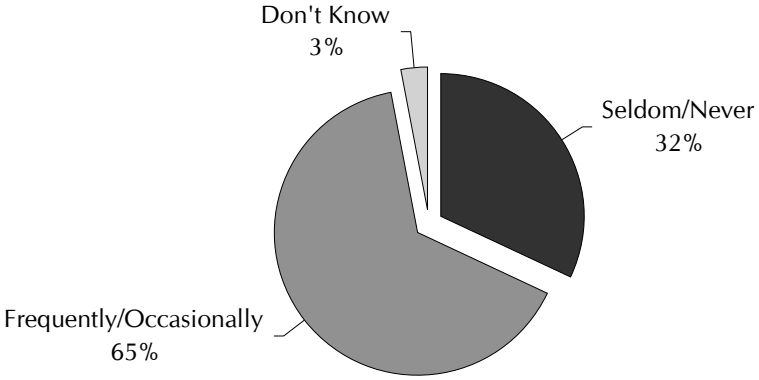



Source: Dean Runyan Associates

*Recreation on Public Lands*

Nearly two-thirds of Spokane resident travelers frequently or occasionally visit or take part in recreation on public lands. This finding suggests a very prominent position for preserving and enhancing recreation opportunities on public land as a magnet to attract Spokane resident travelers.

Figure 4-7
**Frequency of Visits or Recreation on Public Lands**
on pleasure trips taken during the past two years



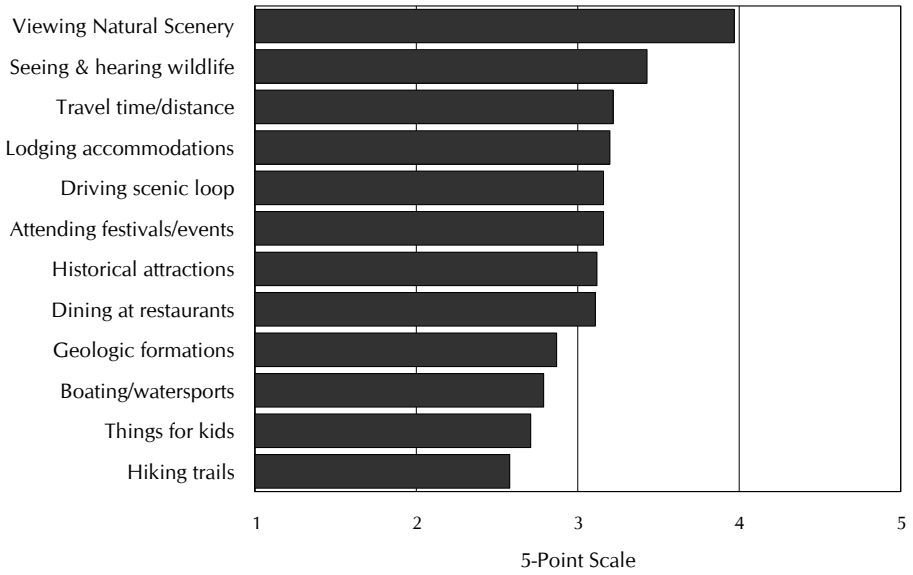

Source: Dean Runyan Associates

*Motivation for Travel*

Respondents were asked to rate the importance in motivating pleasure travel within a two or three hour drive of Spokane on a number of recreation and tourism opportunities. The ratings respondents could select ranged from 1 to 5, where 1 means "not at all important to you in motivating you to travel," and 5 means "extremely important in motivating you to travel." While the categories are quite general, the results help provide key insight into visitors' motivation for travel, as well as potential opportunities regarding the Pend Oreille River Area as a travel destination.

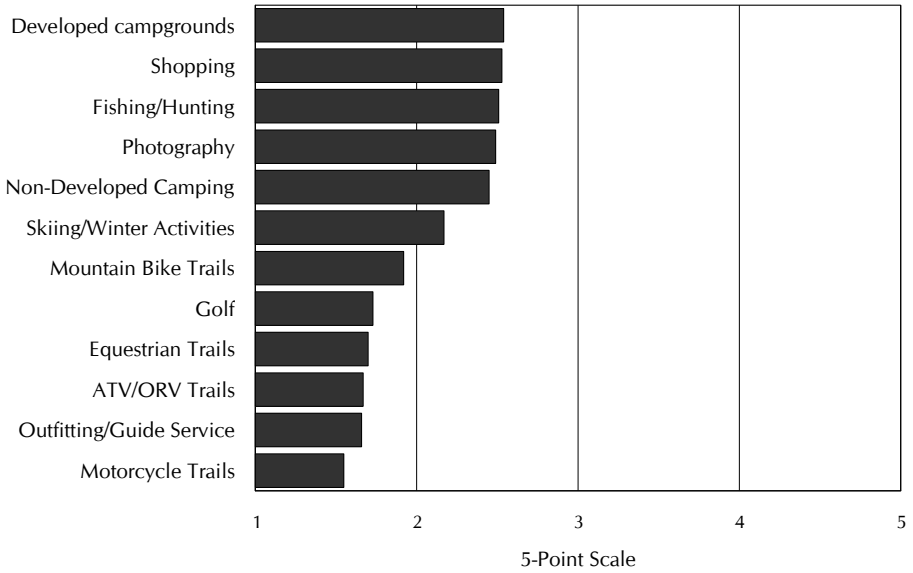
Among the attributes rated by Spokane resident travelers, the two most important for motivating pleasure travel were viewing natural scenery and seeing & hearing wildlife. This finding underscores the value of the Pend Oreille River Area's scenery and wildlife as a marketing asset, and also the importance of preserving and enhancing the appeal of these important assets. Other attributes receiving high "importance" scores include: travel time/distance, lodging accommodations, scenic loops, festivals/events, historical attractions, and restaurants. See figures 4-8 and 4-9 below.

Figure 4-8
**Attributes Most Important in Motivating Spokane Resident Travelers**
average based on 5-point scale
1 = not at all important, 5 = extremely important




Source: Dean Runyan Associates

Figure 4-9
**Attributes Least Important in Motivating Spokane Resident Travelers**
average based on 5-point scale
1 = not at all important, 5 = extremely important

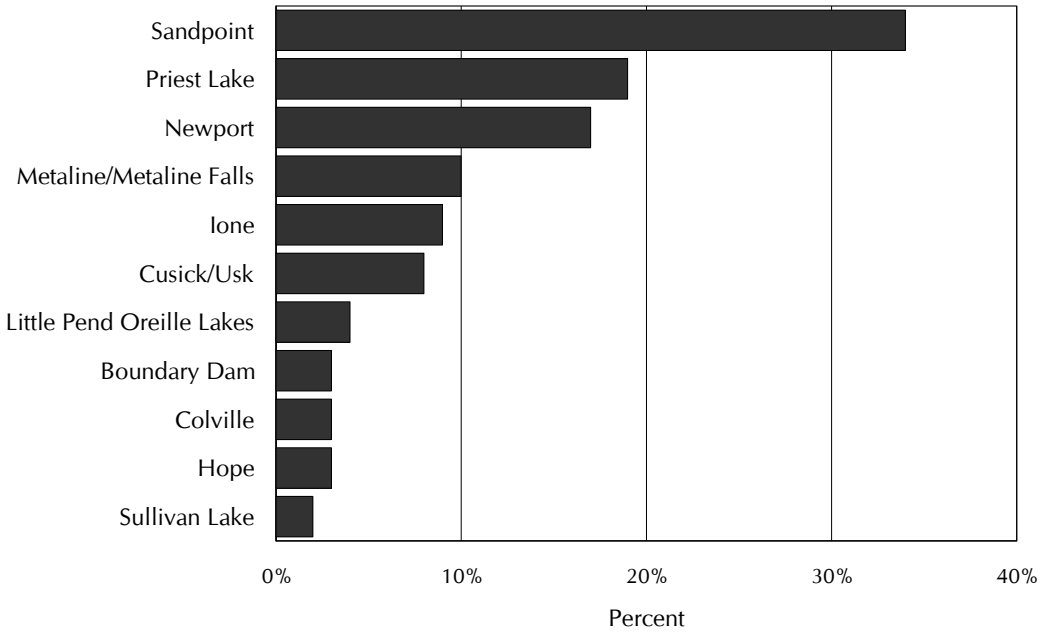



Source: Dean Runyan Associates

*Specific Destination Recall*

Unaided recall is one way of measuring the "top of mind" awareness of a visitor destination. Since most communication messages try to keep the name, if not the nature of the experience on the consumer's mind, recall is important. Many of the survey respondents could successfully recall, unaided, several destinations in the Pend Oreille River Area; however, two of the most common responses were Sandpoint (34%) and Priest Lake (19%), neither of which is in the Pend Oreille River Area. As shown in Figure 4-10, these findings indicate that the Pend Oreille River Area has the challenge of more clearly distinguishing itself in the mind of Spokane resident travelers, particularly with regard to Sandpoint, Idaho (most often associated with Lake Pend Oreille).

Figure 4-10
**Unaided Recall of Towns or Points of Interest In the Pend Oreille River Area**

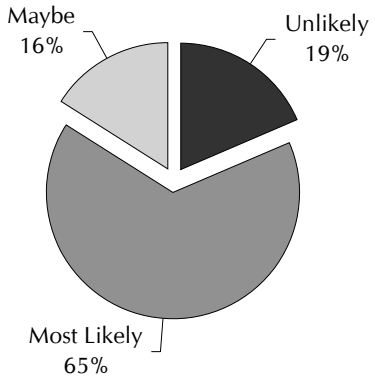



Source: Dean Runyan Associates

*Likelihood of Visit to Pend Oreille River Area*

Respondents were asked how likely they are to either visit or return to the Pend Oreille River Area. Nearly two-thirds (65%) indicate that they definitely or probably will visit the area within the next year or two. It is important to note that a large proportion of respondents (53%) associate Sandpoint and Priest Lake with the Pend Oreille River Area.

Figure 4-11
**Likelihood of Visit or Return Trip to Pend Oreille River Area**
within the next year or two




Source: Dean Runyan Associates

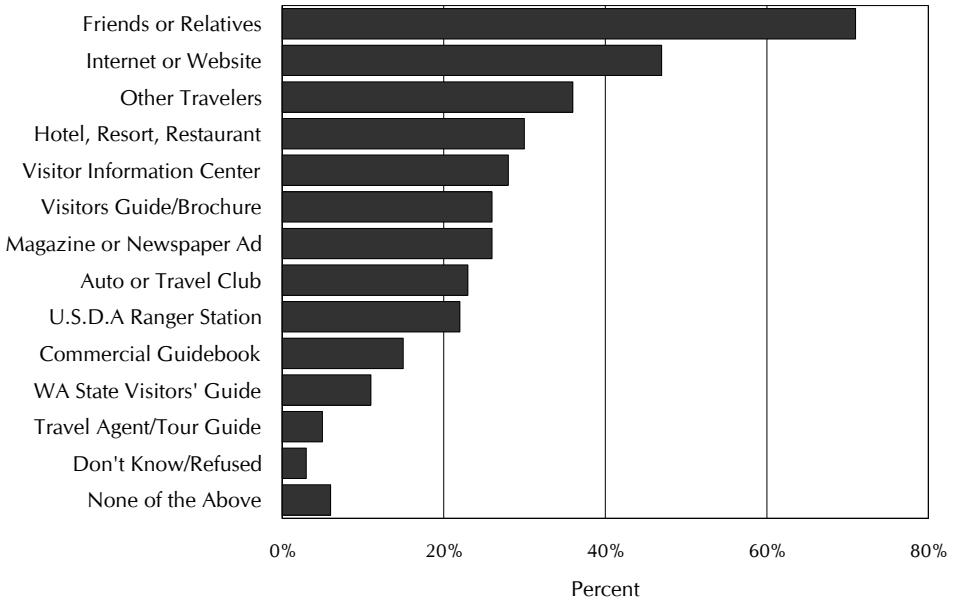
*Sources of Trip Planning Information*

Travelers use a wide variety of information sources for planning their trips. Knowing about these sources helps in making decisions regarding advertising and other marketing efforts. Respondents were asked to indicate as many sources as they used.

While Friends or Relatives (often the most common information source) are the most frequent source for Spokane resident travelers (71%), the second most used source of information for regional travel is the Internet (47%). These findings suggest that an Internet-based marketing communications strategy can reach the primary Spokane market efficiently and with sufficient coverage, as well as provide an avenue of inquiry by more distant markets. Spokane resident travelers also reported making use of a variety of other information sources for planning regional trips, as shown in Figure 4-12.

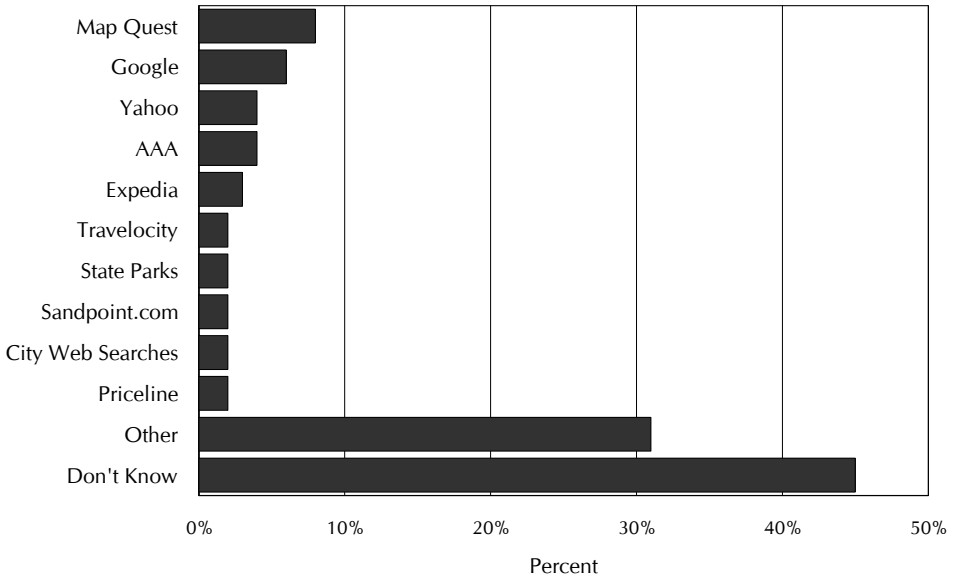
Among respondents who used Internet or websites as a source of information to plan for trips regionally, Map Quest, Google, Yahoo, AAA, Expedia, and Travelocity were the most common websites reported. See Figure 4-13. However, it is important to note that nearly one-half of respondents could not recall any of the specific websites they had used.

Figure 4-12
**Sources of Information Used In the Past Year For Trip Planning in Washington, Idaho, or British Columbia**




Source: Dean Runyan Associates

Figure 4-13
**Unaided Recall of Internet Web Sites Used for Trip Planning**




Base: Respondents who used Internet web sites to plan for trips
Source: Dean Runyan Associates

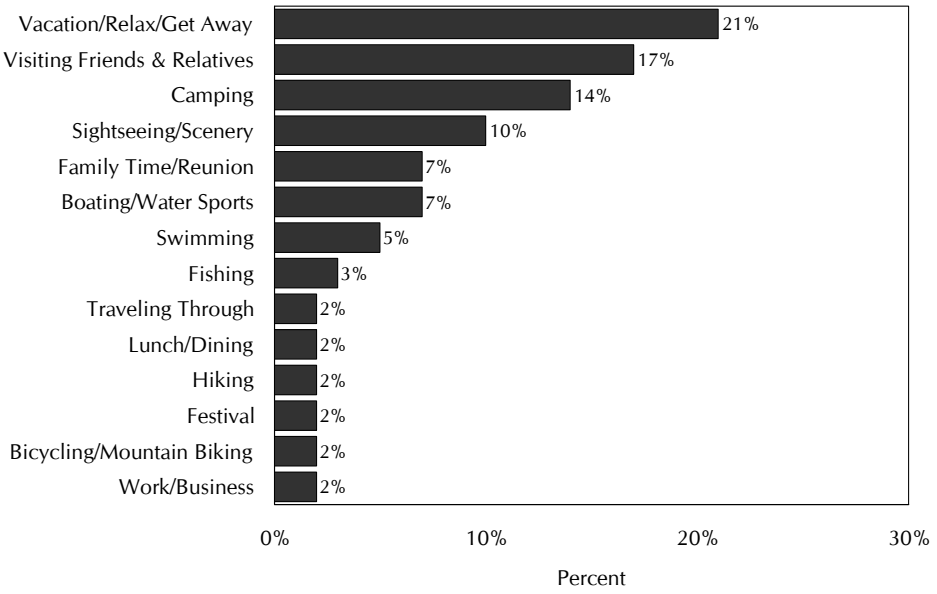
## Segment of Travelers to Pend Oreille River Area

Spokane resident travelers who indicated that they had taken a pleasure trip (day or overnight) to the Pend Oreille River Area during the past two years were asked to provide additional insight with regard to primary reason for travel (on most recent trip), how specific attributes of the Pend Oreille River Area compared to other similar areas they may have visited, and what they found most and least appealing about the Pend Oreille River Area. While the categories are quite general, the results help determine overall perceptions and experiences of those who recently visited the Pend Oreille River Area.

*Primary Reason for Travel*

Vacation, relaxation, or "get away" trips were the primary purpose of travel for two-in-ten (21%) of all visitors. Visiting with friends & relatives (17%) was the next most frequently reported purpose of travel. Other common primary reasons for travel include: camping, sightseeing, swimming, boating, and fishing. See Figure 4-14.

Figure 4-14
**Primary Reason for Travel to Pend Oreille River Area**
reported for most recent trip



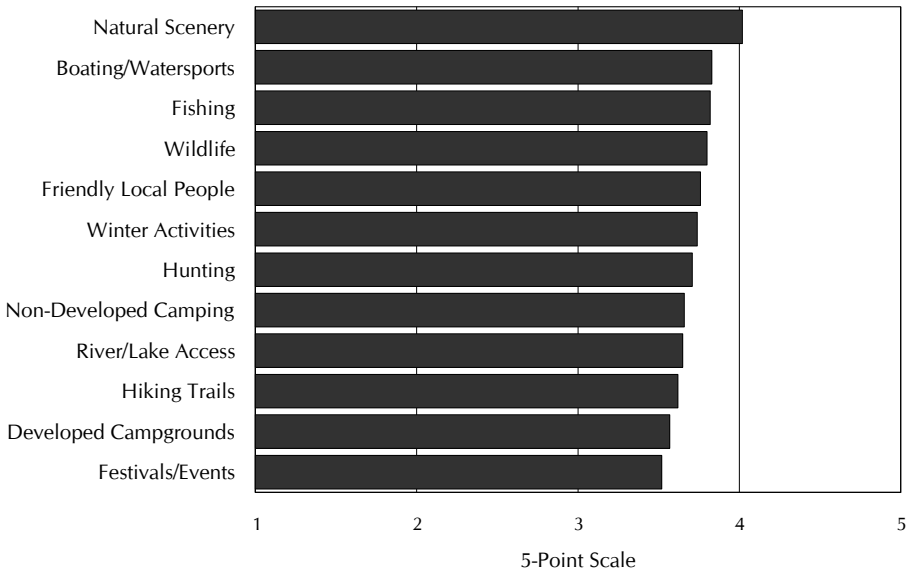

Source: Dean Runyan Associates, 2004

*Attitudes and Satisfaction with the Pend Oreille River Area*

Those survey respondents who indicated that they had taken a pleasure trip (day or overnight) to the Pend Oreille River Area during the past two years were asked to rate the attributes of the Pend Oreille River Area relative to other regional destinations they may have visited such as Coeur d' Alene, Sandpoint, Priest Lake, and Grand Coulee Dam. As compared to these other destinations, respondents rated the Pend Oreille River Area for a variety of attributes on a 5-point scale (1 = *much worse* to 5 = *much better*).

Spokane resident travelers rated the Pend Oreille River Area relatively high as compared to other similar destinations in terms of a number of attributes. Among these attributes are: natural scenery, boating/watersports, opportunities for fishing, seeing & hearing wildlife, friendly local people, winter activities, opportunities for hunting, non-developed camping, and river/lake access. See Figure 4-15.

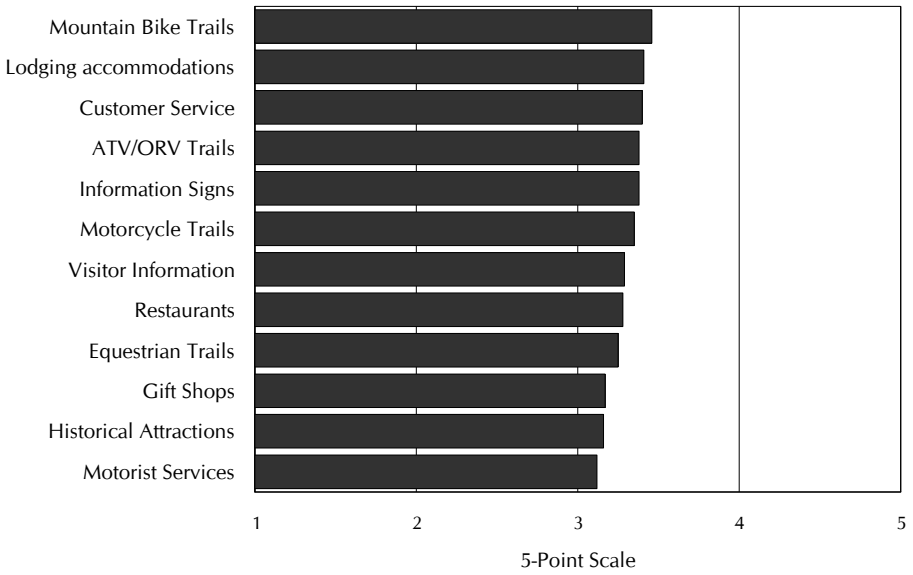
Figure 4-15
**Attributes of Relative Strength for Pend Oreille River Area**
average based on 5-point scale
1 = much worse, 5 = much better




Source: Dean Runyan Associates

Spokane resident travelers rated the Pend Oreille River Area relatively low as compared to other similar destinations in terms of a number of attributes. Among these attributes are: motorist services, historical attractions, gift/souvenir shops, equestrian trails, restaurants, visitor information, motorcycle trails, traveler information signs, and ATV/ORV trails. See Figure 4-16.

Figure 4-16
**Attributes of Relative Weakness for Pend Oreille River Area**
average based on 5-point scale
1 = much worse, 5 = much better




Source: Dean Runyan Associates

*Most/Least Appealing Aspects of Pend Oreille River Area*

Those respondents who visited the Pend Oreille River Area were asked two open-ended questions with regard to what they found most and least appealing about the area. Nearly one-half of respondents recalled scenery/beauty as most appealing about the area. While only a small proportion identified any least appealing attributes, those that did were generally concerned with crowds, road construction, traffic, and weather conditions.

Table 4-17
**Unaided Recall of Pend Oreille River Area**

| Most Appealing Attributes | Percent of Respondents |
|---|---|
| Scenery/Beauty | 49% |
| Wildlife | 8% |
| Natural/Undeveloped | 8% |
| River/River Access | 7% |
| Quiet/Peaceful | 5% |
| Convenient/Close | 5% |
| Lake/Big Lake | 4% |
| Camping/Camp Areas | 4% |
| Water | 4% |
| Not Crowded/Private | 4% |
| Fishing | 4% |
| Nothing/Don't Know | 4% |
| Friendly People | 3% |
| Clean | 3% |
| Hiking Trails | 2% |
| Mountains | 2% |
| Outdoors/Open Space | 2% |
| Boating | 2% |
| Hunting | 2% |
| Eating/Restaurants | 2% |
| Eagles/Osprey | 2% |
| Other | 22% |

Source: Dean Runyan Associates

Table 4-18
**Unaided Recall of Pend Oreille River Area**

| Least Appealing Attributes | Percent of Respondents |
|---|---|
| Nothing/Don't Know | 50% |
| Crowded/Crowds | 5% |
| Roads/Bad Construction | 4% |
| Growth/Population | 3% |
| The Drive | 3% |
| Traffic | 2% |
| Limited Campsites | 2% |
| Weather/Rainy | 2% |
| Bugs/Mosquitoes | 1% |
| Other | 30% |

Source: Dean Runyan Associates

# 5. Marketing and Product Development Recommendations

This final section of the report reviews a set of recommendations based on this market analysis, the research findings, and an assessment of Pend Oreille Valley's competitive strengths as a travel destination. The focus is both on marketing (which tends to be relatively short-term but also should be seen with a long-term, developmental perspective) and on product development, which is primarily a long-term concern. In some cases, the programs we recommend are currently operating to some degree or are under development, in which case the recommendation should be seen as encouragement to continue and/or enhance the existing effort.

## Marketing Recommendations

Primary Recommendation

*Establish a Pend Oreille Valley Tourism Advisory Task Force*

The proposed Pend Oreille Valley Tourism Advisory Task Force would guide, monitor, and evaluate travel and tourism promotion strategies. Task Force members would receive input from the public, and particularly from local officials, chambers of commerce, and visitor-oriented businesses. As a condition for success, the Task Force needs to function independently from a local government or area chamber of commerce. An independent Task Force will be more fully supported by the local communities, and will facilitate an environment that encourages the members to promote Pend Oreille Valley in the most effective and efficient manner.

The Task Force should work to build support among various organizations within Pend Oreille Valley. In order to ensure the success of the proposed Task Force, local government and businesses will need to support and, to some degree, participate financially in the overall program.

We suggest that the Task Force would consist of an odd-number of members, with a minimum of five, including a representative of Tri-County EDD, who would serve as chair, at least for an introductory period of six months. The Task Force would meet on a regular basis, either monthly or quarterly. Meeting minutes should be widely distributed to encourage public input and comments. The Task Force should include representatives from among the following organizations, as well as representatives of individual businesses with an interest in tourism development and marketing:

- Newport-Oldtown Chamber of Commerce
- The Kalispel Tribe of Indians
- Metalines Chamber of Commerce
- Selkirk Business Association
- CREATE

- North Pend Oreille Valley Lions Club
- The Cutter Theatre
- $49^0$ North
- Chewelah Peak Learning Center

Eventually, the Task Force will want to hire a Tourism Coordinator who will develop and manage the specific marketing and product development tasks. Specific duties would include developing tourism promotion projects, forming teams to help achieve objectives, working closely with business and community leaders, developing an annual budget, and meeting monthly or quarterly with the Task Force. Excellent public relations, marketing, business, and communications skills would be essential qualifications for the position. In addition, the Tourism Coordinator should be very familiar with the local area and connected with the visitor industry.

Primary Recommendation

*Coordinate and enhance joint marketing efforts with Washington State Tourism as well as visitor organizations that promote northern Idaho and southeastern British Columbia.*

Washington State Tourism, Department of Community, Trade, and Economic Development is key to assisting Pend Oreille Valley promote the area as a destination. Pend Oreille Valley has a product that appeals to key market segments such as mature travelers, families, rural tourism, cultural and heritage tourism, and outdoor recreation. Targeting each of these specific markets is a very expensive process. The best way for Pend Oreille Valley to effectively reach each of these, along with other market segments that are interested in travel to the area, is by leveraging partnerships with Washington State Tourism and other marketing organizations.

From a visitor's perspective, regional coordination of products is very important. A primary asset of Pend Oreille Valley's visitor product is the connection and association with the International Selkirk Loop (a 280-mile scenic drive through Northeastern Washington, Northern Idaho, and Southeastern British Columbia). In particular, Pend Oreille Valley should work with Washington State Tourism and other regional partners in Northern Idaho and Southeastern British Columbia to promote the *International Selkirk Loop* in conjunction with the *North Pend Oreille Scenic Byway*. Visitors who travel along any segment of the International Selkirk Loop are good candidates for day travel to Pend Oreille Valley, and perhaps an overnight stay for reasons related to the quality and value of accommodations, extending their length of stay, or varying their trip itinerary. A more targeted marketing effort to promote this shared resource would help spur additional cooperation to the mutual benefit of many communities along this internationally recognized scenic drive.

Primary Recommendation

*Promote Pend Oreille Valley as a national and international viewing wildlife and natural scenery destination.*

Pend Oreille Valley offers visitors numerous opportunities to view widespread and diverse populations of wildlife, along with vast awe-inspiring natural scenery. This region remains home to an abundance of wildlife – some of which is unique to the lower United States, including grizzly bear, woodland caribou, lynx, and wolves. Forested mountain lakes, rivers and wetlands are a natural habitat for many migratory birds and waterfowl. This is a sign of both the relative isolation and the relatively pristine condition of the natural landscape. Opportunities for wildlife viewing, scenic beauty, and sightseeing – attributes that survey respondents noted among the most important in motivating travel – offer very clear advantages in order to attract visitors to Pend Oreille Valley.

In 2003, the Washington State Legislature passed SB 5011 requesting that the departments of Fish and Wildlife (WDFW) and Community, Trade and Economic Development (CTED) develop and adopt a strategic plan to promote wildlife-viewing tourism in Washington. The Legislature also requested that steps to implement the plan be developed. Pend Oreille Valley should offer support for the recommendations put forth in the Washington Wildlife Viewing Plan, particularly the following marketing activities:

- Develop a watchable wildlife site database
- Develop an interactive Web map
- Expand advertising exposure in key metro markets
- Conduct a media blitz involving community wildlife viewing representatives

Recommendation

*Generate popular support for tourism development among local communities.*

Success of tourism in Pend Oreille Valley will require support from the local communities. In addition to generating business opportunities and jobs, visitors seek many of the same qualities and attributes that also have strong appeal to residents who live in the area (i.e., scenic beauty, wildlife viewing, events, outdoor recreation, etc.). Local residents and interest groups will be encouraged to lend their support for additional tourism development and marketing once they understand how such efforts will enhance the area as a place to live.

Direct communication with local residents and businesses will provide insights regarding local issues and concerns. In addition, close community ties can facilitate the development of volunteer networks, and help to establish a clear identity for the Pend Oreille Valley among local visitor-oriented businesses. Such cooperation with local

businesses and residents will foster good community relations, as well as a positive image of the area to visitors.

A PowerPoint presentation/slide show that features the Tourism Development and Marketing Assessment would be a great and inexpensive public relations component for the previously recommended Tourism Advisory Task Force. The presentation could be made to elected officials and their staff, community leaders, local businesses, and residents of Pend Oreille Valley.

Recommendation

*Work jointly with Spokane CVB to promote repeat visitation and to encourage more diverse itineraries and longer lengths of stay.*

It is important to take every opportunity to present Pend Oreille Valley as a regional destination to Spokane area visitors and residents. Visitor profile findings show that repeat visitation to Pend Oreille Valley is substantial, and many visitors originate from the Spokane area. Existing visitors are current customers, which, like for many businesses, represent the best business opportunities. These visitors should be provided with the best information possible regarding additional activities, locations, etc., for future trips to the Valley, formatted in a form that will encourage them to keep it. Including a good map as a trip planning resource encourages visitors to hold on to the materials for use when planning or making future trips. Scenic drive tours should be included on such maps.

Encourage cross-selling or cooperative marketing between local communities and events throughout the region. Information guides and displays should include a good map and associated information regarding regional attractions, recreation opportunities, and events.

Recommendation

*Develop a Pend Oreille Valley "fam" trip to familiarize visitor information center personnel, front line employees, and interested residents.*

As shown in the recent visitor profile, Pend Oreille Valley is oriented to travel by those staying with friends and relatives. These residents make choices regarding the activities and expenditures of their guests, and should be carefully nurtured in terms of information about interesting attractions, events/activities, and recreation opportunities. In addition, residents of the area will tend to serve as excellent community ambassadors. A "fam" trip would also increase the level of knowledge of and enthusiasm for all the various attractions in the Valley, and would increase opportunities for inter-regional cross selling by inviting information center staff from outside the area.

Recommendation

*Promote the North Pend Oreille Scenic Byway as a fall color driving tour and event location.*

Viewing fall color has become an increasingly popular day visit activity, and can be part of an overnight stay for many travelers. Pend Oreille Valley should prepare a guide for this activity and use it to test the fall travel market. The appeal will probably be strongest for older travelers: empty nest or retired people, particularly those who are willing to drive from the Puget Sound area. Since there are closer locations for fall color, other associated attractions within the Valley should also be emphasized, such as historic Metaline Falls, wildlife viewing opportunities, and special events, such as a fall festival, community crafts market, or cultural activities. Bus tours could be organized for the fall color season; discount accommodations and dining programs could also be offered.

Recommendation

*Develop an integrated regional strategy to promote heritage tourism.*

Pend Oreille Valley contains a wide variety of sites and properties of significant historical and cultural value; however, the "heritage product" is not well promoted and geographically scattered throughout the area. A coordinated strategy with the International Selkirk Loop could help integrate the heritage product through region-wide heritage tours. As a first step in such an effort, heritage resources should be evaluated to assess the existing condition and tourism value of the area's historical attractions. This could be accomplished with participation from museum staff, historical societies, and interested citizens in conjunction with the proposed Tourism Advisory Task Force.

In addition, Pend Oreille Valley should continue to enhance the area's historic attractions with an emphasis on the following:

- Continue developing tourism focus of the historic sites in the area. Historic Metaline Falls and downtown Newport are well-positioned as visitor attractions, because of their convenient highway access and nostalgic, small town appeal.
- Continue to promote the North Pend Oreille Scenic Byway as a visitor attraction with emphasis on sites of historical significance to the area.
- Support and build upon success of festivals and special events held in the area.

Recommendation

*Encourage overnight visitation.*

Lodging establishments with an historic theme represent a segment of the accommodations industry that can be expanded and packaged with historic and cultural

events and attractions. Pend Oreille Valley should assure that potential visitors interested in staying overnight can easily utilize the area's website to learn about available lodging facilities. Members of the Tourism Advisory Task Force should interview lodging operators to ascertain their specific ideas to encourage repeat travel and/or extended lengths of stay, and support these efforts as much as possible.

Recommendation

*Increase efforts to promote winter recreation activities.*

Downhill skiing should be promoted at the 49$^{O}$ North Mountain Resort in conjunction with lodging establishments, restaurants, and other activities in Pend Oreille Valley. The towns of Metaline – Metaline Falls lie within a one-hour drive of the Resort, and offer visitor attractions and services (such as theater plays and events, lodging, restaurants etc.), which could be promoted, and as demand increases, expanded during the winter months.

Snowmobile promotion should be included in summer promotion in order to cross-sell seasons. The area's website should link to the state's snowmobile web site, as well as to sites that promote winter recreation activities in northern Idaho. In general, promotion efforts should emphasize the social and family-oriented aspects of the experience, in combination with the natural scenery attributes of the area.

Additional winter activities should be promoted in order to highlight the extent of opportunities available throughout the region's vast public lands. Activities could include snowshoeing and cross-country skiing promoted together with wildlife and natural scenery viewing – the region usually has snow cover during the winter, so wildlife viewing can include identification of animal tracks. Educational tours may be organized for groups of different ages to learn more about local wildlife and unique opportunities to view during the winter. Winter can be a great time to fish. Ice fishing opportunities should be investigated and promoted where it is most appropriate.

## Product Development

Recommendation

*Work jointly with the North Pend Oreille Valley Lions Club to further develop the potential for the excursion train rides.*

Among the greatest potential opportunities to strengthen Pend Oreille Valley's marketable image as a destination is the development and promotion of the Lions Excursion Train Ride. The historic train ride offers a unique visitor experience that can be used to leverage the visitor potential for the entire Pend Oreille Valley. There are few historic train rides in the West today, and yet much of the region's history is tied to this development. Vintage train rides can serve as a significant cultural icon in many

communities, and can help make them a more desirable place to visit. A form of transportation from the past provides not only a reason for visitors seeking cultural heritage attractions to visit, but also nostalgic memories for the area's residents.

As an amusement, riding for the sake of experiencing a vintage train ride is an activity not likely to be repeated. However, if the train ride is also a means to getting to a tourism-oriented destination (i.e., special events, restaurants, shopping, theatre, or hotels), the train ride can develop a regular clientele. The transportation function of the train ride must not be overlooked. Supporters of the North Pend Oreille Lions Club train rides tours should find ways to promote and expand the number of tours to offer visitors more opportunities, particularly during the summer months. Eventually, paid staff will need to be hired. Admission prices for the rides should be structured in such a way that the operation becomes sustainable over the long-term.

Recommendation

*Support efforts to achieve National Scenic Byway status for the International Selkirk Loop and continue efforts to develop the North Pend Oreille Scenic Byway.*

The National Scenic Byways program supported through the U.S. Department of Transportation, Federal Highway Division recognizes certain roads as National Scenic Byways based on one or more archeological, cultural, historic, natural, recreational, and scenic qualities. National Scenic Byway designation of the International Selkirk Loop would promote the region as among the most distinct and diverse in the nation, as well as allow eligibility for additional highway funding support.

As part of the International Selkirk Loop, the North Pend Oreille Scenic Byway connects the Pend Oreille Valley to an historical and culturally rich visitor region. Each of the byway sites will have extensive interpretive signs depicting the area's extensive history in logging, mining, railroading and riverboats. Proposed byway sites in Pend Oreille Valley include:

- Tiger Historical Center
- Ione River Front Park
- Box Canyon Viewpoint
- Eagles Nest Pullout
- Sweet Creek Falls
- Metaline Waterfont Park
- Metaline Falls Overlook
- Hooknose Mountain Viewpoint
- Crescent Lake

Recommendation

*Support established or proposed plans for downtown redevelopment, community enhancement, or other projects that will enhance and support heritage tourism.*

A number of communities in Pend Oreille Valley have proposed plans for downtown redevelopment and projects that will encourage and support additional tourism. Realization of these projects will enhance the area's communities, and stimulate economic development to the benefit of both visitors and residents. Tri-County EDD could help to facilitate the development of these plans by building common ground with community stakeholders, and ensuring promotional support to encourage visitation. Tri-County EDD should encourage and support the Newport Comprehensive Plan.

Recommendation

*Coordinate and lead efforts to enhance wildlife viewing areas.*

Work jointly with the Washington Department of Fish and Wildlife, State of Washington Department of Community, Trade and Economic Development, Washington State Parks, and Colville National Forest (U.S. Department of Agriculture) to improve and develop wildlife-viewing areas in the Pend Oreille Valley. To the extent possible, wildlife-viewing areas should be identified and developed as part of a network of showcase or "must see" attractions in the state and region. Such attractions are particularly important for gaining the attention of first-time visitors to the area.

Recommendation

*Extend development of existing bike trails connecting Sandpoint with Metaline Falls.*

Consistent with the Newport Comprehensive Plan, develop a bike path that extends from Rotary Park (via LaClair Creek Road) around Sullivan Lake to Metaline Falls. This 45-mile extension would connect with an existing bike path from Rotary Park extending to Sandpoint and south to Coeur d'Alene.

Recommendation

*Encourage and support maintenance and development of recreation trails.*

Trail maintenance and development serves as an important component of Pend Oreille Valley's tourism product. Properly maintained trails support numerous outdoor recreation activities, which serve to enhance the visitor product. There is potential to strengthen the Valley's attractiveness as a visitor destination by further developing recreation trails, designed to accommodate activates such as hiking, mountain biking, horseback riding in conjunction with viewing natural scenery and wildlife.

Recreation trails permitting motorized vehicle (ORV) also support an important segment of Pend Oreille Valley's tourism market. Additional ORV trails should be designed and built according to the intended use. Maps and clearly posted rules at all trailheads will help promote the intended trail use, which will enhance the quality of experience for all motorized and non-motorized recreation trail use.

Recommendation

*Investigate ways to enhance water-oriented attractions and activities.*

The Pend Oreille Valley has a rich history as a commercial and pleasure boating location, which could be enhanced more. Travelers of all types – and in particular Spokane resident travelers – see water-based recreation as primary strengths for the area. Although at present, other water-oriented destinations also standout, such as Sandpoint and Priest Lake. Pend Oreille Valley should investigate ways by which water-based recreation could be made more accessible and/or shorelines developed further so as to serve as a stronger destination for visitors. Examples might be: better signing, additional access for boating, swimming, picnics, and equipment rentals.

With regard to long-term product development, examples include additional water-based events and activities, watershed development support for jet-boat excursions and canoeing/kayaking tours, and operation of a large-scale riverboat for group sightseeing cruises.

Recommendation

*Assure that highway signs function to the best possible advantage.*

Highway signs are important for guiding visitors to locations where additional attraction and activity information is available. These signs are particularly important to first-time visitors and those traveling through the area as part of a longer trip. Attention should be paid to road signs and visitor information signs, plus signs designating nature and significant attractions – such as scenery and wildlife viewing, outdoor recreation and historic sites. To the extent possible, the signage design should be used as consistently as possible so as to become a recognizable feature of the area. Public support should be sought for the following:

- Conduct a Pend Oreille Valley evaluation of all visitor-related signage.
- Establish priorities to add new signage.
- Identify potential opportunities to relocate and/or design current signage.

# Appendix A

Table A-1
**Destinations Visited by Spokane Resident Travelers**
Numbers in percentages

| | Type of Visitor-trip | | | |
|---|---|---|---|---|
| | Day | Overnight | Don't Know | Total (400) |
| Coeur d' Alene | 68 | 32 | 10 | 33 |
| Sandpoint/Lake Pend Oreille | 62 | 47 | 5 | 29 |
| Priest Lake | 39 | 67 | 6 | 12 |
| Newport | 79 | 36 | 0 | 12 |
| Seattle | 0 | 100 | 0 | 10 |
| Grand Coulee/Lake Roosevelt | 54 | 31 | 23 | 9 |
| Colville | 34 | 69 | 7 | 7 |
| Moses Lake | 67 | 37 | 7 | 7 |
| Pend Oreille River Area | 62 | 58 | 0 | 7 |
| Lewiston-Clarkstone (Snake River Area) | 40 | 52 | 8 | 6 |
| Chewelah | 79 | 38 | 0 | 6 |
| Metaline/Metaline Falls | 62 | 48 | 0 | 5 |
| Wallace/Kellogg | 67 | 38 | 5 | 5 |
| Ione | 47 | 47 | 13 | 4 |
| Kettle Falls | 60 | 47 | 0 | 4 |
| Tri-Cities | 0 | 100 | 0 | 4 |
| Yakima | 0 | 100 | 0 | 3 |
| Cusick/Usk | 45 | 45 | 9 | 3 |
| Nelson, B.C. | 20 | 80 | 0 | 3 |
| Colville Indian Reservation | 100 | 17 | 0 | 2 |
| Idaho (unspecified) | 0 | 100 | 0 | 2 |
| Odessa | 80 | 40 | 0 | 1 |
| Gardner Caves/Crawford SP | 75 | 25 | 0 | 1 |
| Republic/Stone Rose IC | 25 | 50 | 25 | 1 |
| Sullivan Lake | 50 | 50 | 25 | 1 |
| All Other Locations | | | | 44 |
| Don't Know/Refused | | | | 13 |

Source: Dean Runyan Associates

Note: Multiple Response; percentages reported may sum to more than 100%

Table A-2

**Attributes in Motivating Travel for Spokane Resident Travelers**

| | | Numbers in percentages | | | | |
|---|---|---|---|---|---|---|
| | Mean | 1 (Not at all important) | 2 | 3 | 4 | 5 (Extremely important) |
| Viewing Natural Scenery | 3.97 | 3 | 6 | 23 | 28 | 40 |
| Seeing and Hearing Wildlife | 3.43 | 12 | 10 | 28 | 23 | 27 |
| Travel Time/Distance | 3.22 | 17 | 10 | 29 | 21 | 23 |
| Logging Accommodations | 3.20 | 19 | 10 | 26 | 21 | 23 |
| Driving Scenic Loop Tours/Byways | 3.16 | 14 | 16 | 28 | 24 | 18 |
| Attending Festivals/Special Events | 3.16 | 15 | 15 | 28 | 24 | 19 |
| Historical Attractions/Museums/Art Galleries | 3.12 | 15 | 16 | 30 | 23 | 17 |
| Dining at Restaurants/Bars | 3.11 | 16 | 15 | 29 | 23 | 18 |
| Visiting Geological Formations/Caves | 2.87 | 23 | 14 | 29 | 19 | 15 |
| Boating/Watersport Activities | 2.79 | 30 | 14 | 21 | 15 | 20 |
| Things for Kids to Do | 2.71 | 42 | 6 | 13 | 15 | 23 |
| Hiking Trails | 2.58 | 35 | 13 | 25 | 16 | 12 |
| Developed Campgrounds by Sites | 2.54 | 39 | 15 | 16 | 15 | 15 |
| Shopping | 2.53 | 32 | 22 | 20 | 13 | 13 |
| Fishing/Hunting Opportunities | 2.51 | 44 | 11 | 13 | 12 | 19 |
| Photography | 2.49 | 36 | 16 | 24 | 10 | 14 |
| Opportunities for Non-Developed Camping | 2.45 | 43 | 11 | 16 | 16 | 14 |
| Skiing/Other Winter Activities | 2.17 | 55 | 10 | 13 | 8 | 14 |
| Mountain Bike Trails | 1.92 | 59 | 13 | 11 | 10 | 7 |
| Golf | 1.73 | 70 | 7 | 9 | 6 | 8 |
| Equestrian Trails | 1.70 | 67 | 12 | 9 | 7 | 5 |
| ATV/ORV trails | 1.67 | 70 | 9 | 8 | 4 | 7 |
| Outfitting and Guide Services | 1.66 | 64 | 14 | 13 | 6 | 3 |
| Motorcycle Trails | 1.55 | 76 | 7 | 7 | 3 | 7 |

Source: Dean Runyan Associates

Note: Due to no opinion or response; percentages reported may sum to less than 100%

# Appendix B

## Spokane Area Travel Market Survey
### Telephone Questionnaire

**INTRODUCTION:** Hello. My name is Mr./Ms._____ with GMA Research. We are conducting a study of regional travel for residents of the Spokane Area, and would like to include the attitudes and opinions of your household. This information will be kept confidential and will not be given to any solicitors. It is strictly for purposes of understanding factors that influence travel in the region. I need to speak to the resident of this household who is over 21 years of age and makes or shares in the decision regarding where to go for vacation. Would that be you? **(WHEN CORRECT PERSON IS REACHED, REINTRODUCE YOURSELF IF NECESSARY AND CONTINUE)**

**S1** In the past two years, have you taken at least one day or overnight pleasure trip within a two or three hour drive of Spokane?

1 Yes
2 No

(MUST SAY "YES" TO S1 TO CONTINUE. ALL OTHERS TERMINATE)

**Q1** Using a scale of "frequently, occasionally, seldom, never", how would you describe your frequency of taking pleasure trips within a two or three hour drive of Spokane for pleasure during the following seasons? **(READ AND ROTATE LIST)**

1 Summer
2 Fall
3 Winter
4 Spring

**Q2** In the past two years, approximately how many total "overnight" pleasure trips within a two or three hour drive of Spokane would you say you took? **(RECORD EXACT NUMBER, ENTER "DK" FOR DON'T KNOW)**

_____

**Q3** Talking just about these overnight trips, how many of those trips, if any, were to the Pend Oreille (pronounced "Pond O' Ray") River Area? **(RECORD EXACT NUMBER, IF "NONE" ENTER "0". ENTER "DK" FOR DON'T KNOW. DESCRIBE LOCATION, IF NECESSARY)**

_____

**Q4** In the past two years, approximately how many total "day" pleasure trips within a two or three hour drive of Spokane would you say you took? **(RECORD EXACT NUMBER, ENTER "DK" FOR DON'T KNOW)**

_____

**Q5** Talking just about these day trips, how many of those trips, if any, were to the Pend Oreille (pronounced "Pond O' Ray") River Area? **(RECORD EXACT NUMBER, IF "NONE" ENTER "0". ENTER "DK" FOR DON'T KNOW. DESCRIBE LOCATION, IF NECESSARY)**

_____

**Q6** Using a scale of "frequently, occasionally, seldom, never", do you typically travel with any children or youth on these regional trips?

_____

**Q7** Please name for me any towns or points of interest that you visited while traveling on any of these day or overnight trips? **(DO NOT READ LIST. PRODE WITH "ANY OTHERS" UNTIL RESPONDENT SAYS, "THAT'S ALL")**

***For each named location ask if this was a "day" or "overnight" trip.***

1 Chewelah
2 Coeur D'Alene
3 Colville
4 Colville Indian Reservation
5 Cusick/Usk
6 Gardner Caves/Crawford State Park
7 Grand Coulee Dam/Lake Roosevelt
8 Ione
9 Kettle Falls
10 Lewiston-Clarkston (Snake River Area)
11 Metaline/Metaline Falls
12 Moses Lake
13 Nelson, B.C.
14 Newport
15 Odessa
16 Pend Oreille River Area
17 Priest Lake
18 Republic/Stone Rose Interpretive Center
19 Sandpoint/Lake Pend Oreille
20 Sullivan Lake
21 Wallace/Kellogg
22 Other (Specify all)
23 Don't Know
24 Refused

**Q8** Please tell me how important each of the following recreation and tourism opportunities are to you in motivating you to travel within a 2-3 hour drive of Spokane. Please use a 1 to 5 scale, where 1 means "not at all important to you in motivating you to travel," and 5 means "extremely important in motivating you to travel"? **(READ AND ROTATE LIST, ENTER "NO" FOR NO OPINION.)**

1 Viewing natural scenery
2 Driving scenic loop tours/byways
3 Historical attractions/museums/art galleries
4 Seeing and hearing wildlife
5 Attending festivals/special events
6 Shopping
7 Dining at restaurants/bars
8 Lodging accommodations
9 Fishing/hunting opportunities
10 Skiing/other winter activities
11 Developed campgrounds/RV sites
12 Opportunities for non-developed camping
13 Motorcycle trails
14 ATV/ORV trails
15 Equestrian trails
16 Hiking trails
17 Mountain bike trails
18 Outfitting and guide services
19 Boating/watersports activities
20 Golf
21 Visiting geologic formations/caves
22 Things for kids to do
23 Photography
24 Travel time/distance

**Q9** Using a scale of "frequently, occasionally, seldom, never", on these trips, how often do you visit or take part in recreation on public lands?

_____

**(WITH REFERENCE TO BOTH QUESTIONS 3 AND 5 – REGARDING TRIPS TO THE PEND OREILLE RIVER AREA -- FOR THOSE WHO ANSWERED "1" OR MORE CONTINUE. ALL OTHERS BRANCH TO Q14)**

**READ:** These next questions apply specifically to your most recent trip to the Pend Oreille River Area.

**Q10** On your most recent trip to the Pend Oreille River Area, what was your primary reason for travel? **(RECORD ALL ANSWERS. IF MORE THAN ONE ANSWER, ASK FOR *MOST IMPORTANT* PRIMARY)**

**Q11** I would like to know how your travel and recreation experiences in the Pend Oreille River Area compare to your experiences or perceptions of other similar areas you may have visited. Using a scale of "Much better, better, about the same, worse or much worse," please tell me how Pend Oreille River Area compares in each of the following recreation and tourism opportunities. **(READ AND ROTATE LIST, ENTER "NO" FOR NO OPINION.)**

1 Natural Scenery
2 Friendly local people
3 Customer service
4 Opportunities to see/hear wildlife
5 Motorcycle trails
6 ATV/ORV trails
7 Equestrian trails
8 Hiking trails
9 Mountain bike trails
10 Festivals/special events
11 Historical attractions/museums/art galleries
12 Opportunities for fishing
13 Opportunities for hunting
14 Boating/watersports activities
15 River/Lake access sites
16 Winter activities
17 Restaurants
18 Lodging accommodations
19 Developed campgrounds/RV facilities
20 Opportunities for non-developed camping
21 Gift/Souvenir shops
22 Motorist Services
23 Visitor Information Centers
24 Traveler Information Directional Signs

**Q12** What did you find most appealing about the Pend Oreille River Area?
**(OPENED ENDED QUESTION – RECORD ANSWER)**

**Q13** What did you find least appealing about the Pend Oreille River Area?
**(OPENED ENDED QUESTION – RECORD ANSWER)**

**Q14** Please name for me any towns or points of interest you can think of in the Pend Oreille River Area. **(DO NOT READ LIST. PROBE WITH "ANY OTHERS" UNTIL RESPONDENT SAYS, "THAT'S ALL")**

1 49 Degrees North Ski Resort
2 Bear Paw Camp
3 Boundary Dam Recreation Area
4 Box Canyon Dam
5 Camp Cowles (Boy Scout Camp)
6 Camp Spalding
7 Colville
8 Colville National Forest
9 Cusick/Usk
10 Cutter Theatre
11 Gardner Caves/Crawford State Park
12 Ione
13 Kalispel Indian Reservation
14 Lion Train Rides
15 Little Pend Oreille Lakes
16 Metaline/Metaline Falls
17 Naco West/Little Diamond
18 Newport
19 Priest Lake
20 Salmo-Priest Wilderness
21 Sandpoint
22 Sullivan Lake
23 Z Canyon
24 Other (Specify and record all other)
25 Don Know
26 Refused

**Q15** How likely are you to *either visit or return* to the Pend Oreille River Area within the next year or two? Would you say you…..

1 Definitely will
2 Probably will
3 Maybe or may not
4 Probably will not
5 Definitely will not
6 Don't know
7 Refused

**Q16** Which, if any, of the following sources of information did you use during the last year for planning trips regionally in Washington, Idaho or British Columbia? **(READ AND ROTATE LIST)**

1 Commercial guidebook
2 Local area visitors guide/brochure
3 Auto or travel club brochure
4 Printed ad in a magazine or newspaper
5 Travel Agent or Tour operator
6 Washington State Visitors' Guide
7 Friends and Relatives
8 Other Travelers
9 Information at Hotel/Resort/Restaurant
10 Internet/Web sites
11 Visitor Information Center at the destination
12 U.S. Forest Service Ranger Station
13 **(DON'T READ)** None of the above
14 **(DON'T READ)** Don't know
15 **(DON'T READ)** Refused
**16**

(WITH REFERENCE TO PREVIOUS QUESTION, CONTINUE FOR THOSE WHO ANSWERED, "YES" TO "INTERNET/WEB SITE". ALL OTHERS BRANCH TO Q18.)

**Q17** Please name for me any of the web sites you recall using to plan for these regional trips. **(PROBE WITH "ANY OTHERS" UNTIL RESPONDENT SAYS, "THAT'S ALL")**

**Demographics**

*This information is for research purposes only and will be kept strictly confidential.*

**Q18** How many children under age 18 currently live in your home? _____

**Q19** What is your age?

**Q20** What was the last grade in school you had the opportunity to complete? **(DO NOT READ LIST)**

1 High school or less (grade 12 or under)
2 Some college/business or technical school
3 College degree
4 Advanced degree
5 Don't know
6 Refused

**Q21** What is your approximate annual household income?

Less than $50,000
$50,000 to less than $75,000
$75,000 to less than $100,000
$100,000 or more

**Q22** **(NOT A QUESTION)** Record Gender

1 Male
2 Female

# Appendix C

## Northeast Washington Visitors Survey 2004
### Results for Pend Oreille County

## NORTHEAST WASHINGTON VISITORS SURVEY 2004
## Preliminary Results - Pend Oreille County

| | | Overall Pend Oreille | BOX LOCATION | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Newport Ranger District | Box Canyon Dam | Tiger Store | Historical Society | Cutter Theater | Sullivan Lake Road | Intercept |
| GENDER | Male | 48% | 40% | 42% | 43% | 54% | 40% | 44% | 48% |
| | Female | 52% | 60% | 58% | 57% | 46% | 60% | 56% | 52% |
| TOTAL | | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| | n = | 394 | 42 | 19 | 74 | 182 | 20 | 32 | 25 |
| AGE | 20 - 24 | 5% | 5% | | 3% | 5% | 10% | 9% | |
| | 25 - 29 | 6% | 12% | 11% | 3% | 4% | 15% | 6% | 4% |
| | 30 - 34 | 5% | 2% | 5% | 5% | 5% | 5% | 13% | 4% |
| | 35 - 44 | 13% | 12% | 26% | 9% | 10% | 5% | 34% | 16% |
| | 45 - 54 | 20% | 24% | 26% | 28% | 14% | 20% | 16% | 36% |
| | 55 - 59 | 14% | 17% | 5% | 16% | 13% | 30% | 13% | 8% |
| | 60 - 64 | 16% | 17% | 16% | 20% | 18% | 5% | 6% | 16% |
| | 65 and over | 20% | 12% | 11% | 15% | 30% | 10% | 3% | 16% |
| TOTAL | | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| Average | | 52.3 | 50.1 | 48.6 | 53.5 | 54.8 | 47.4 | 42.7 | 52.6 |
| n = | | 394 | 42 | 19 | 74 | 182 | 20 | 32 | 25 |
| HOUSEHOLD INCOME | Under $20,000 | 11% | 14% | | 14% | 12% | 5% | 9% | 8% |
| | $20,000 - $24,999 | 6% | 7% | 5% | 4% | 6% | 20% | 6% | |
| | $25,000 - $34,999 | 12% | 17% | 26% | 11% | 9% | 15% | 16% | 16% |
| | $35,000 - $49,999 | 16% | 14% | 11% | 12% | 19% | 10% | 13% | 20% |
| | $50,000 - $74,999 | 19% | 19% | 11% | 15% | 20% | 15% | 19% | 28% |
| | $75,000 - $99,999 | 14% | 10% | 37% | 18% | 12% | 10% | 13% | 8% |
| | $100,000 - $124,999 | 9% | 5% | | 14% | 8% | 10% | 9% | 8% |
| | $125,000 - $149,999 | 4% | 5% | 5% | 1% | 4% | 5% | 3% | 4% |
| | $150,000 - $199,999 | 4% | 2% | | 3% | 4% | 5% | 6% | 8% |
| | $200,000 or more | 6% | 7% | 5% | 9% | 6% | 5% | 6% | |
| TOTAL | | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| Average | | $71,967 | $66,488 | $70,921 | $78,142 | $71,209 | $69,750 | $74,688 | $67,500 |
| n = | | 394 | 42 | 19 | 74 | 182 | 20 | 32 | 25 |

**24 Nov 04**
**Source: RRC Associates**

## NORTHEAST WASHINGTON VISITORS SURVEY 2004
### Preliminary Results - Pend Oreille County

| | | Overall Pend Oreille | BOX LOCATION | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Newport Ranger District | Box Canyon Dam | Tiger Store | Historical Society | Cutter Theater | Sullivan Lake Road | Intercept |
| MARITAL STATUS | Single, no children | 13% | 14% | 11% | 12% | 14% | 15% | 16% | 8% |
| | Couple, no children | 17% | 17% | 26% | 15% | 16% | 30% | 13% | 16% |
| | Single with children at home | 5% | 2% | 5% | 8% | 4% | 5% | 3% | 4% |
| | Couple with children at home | 21% | 19% | 21% | 20% | 19% | 5% | 41% | 24% |
| | Couple, empty-nester | 39% | 43% | 37% | 41% | 40% | 40% | 22% | 44% |
| | Single, empty-nester | 6% | 5% | | 4% | 8% | 5% | 6% | 4% |
| TOTAL | | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| | n = | 394 | 42 | 19 | 74 | 182 | 20 | 32 | 25 |
| DO YOU HAVE CHILDREN / GRANDCHILDREN (18 & UNDER) TRAVELING WITH YOU | Yes | 35% | 34% | 50% | 26% | 34% | 9% | 65% | 42% |
| | No | 65% | 66% | 50% | 74% | 66% | 91% | 35% | 58% |
| TOTAL | | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| | n = | 276 | 29 | 12 | 54 | 128 | 11 | 23 | 19 |
| DO THE CHILDREN FALL INTO ANY OF THESE AGE GROUPS | 0 - 5 years | 35% | 40% | 50% | 22% | 39% | 100% | 23% | 20% |
| | 6 - 12 years | 59% | 40% | 33% | 56% | 53% | 100% | 92% | 80% |
| | 13 - 18 years | 33% | 40% | 50% | 33% | 32% | | 31% | 20% |
| TOTAL | | 127% | 120% | 133% | 111% | 124% | 200% | 146% | 120% |
| | n = | 82 | 10 | 6 | 9 | 38 | 1 | 13 | 5 |
| HOW MANY PEOPLE ARE IN YOUR TRAVEL PARTY | 1 | 8% | 7% | 5% | 8% | 8% | 5% | 6% | 12% |
| | 2 | 52% | 55% | 32% | 65% | 55% | 45% | 22% | 52% |
| | 3 | 10% | 7% | 21% | 8% | 9% | 15% | 16% | 4% |
| | 4or more | 30% | 31% | 42% | 19% | 27% | 35% | 56% | 32% |
| TOTAL | | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| Average | | 2.8 | 2.8 | 3.2 | 2.5 | 2.7 | 3.0 | 3.5 | 2.7 |
| n = | | 394 | 42 | 19 | 74 | 182 | 20 | 32 | 25 |

24 Nov 04
Source: RRC Associates

## NORTHEAST WASHINGTON VISITORS SURVEY 2004
## Preliminary Results - Pend Oreille County

| | | Overall Pend Oreille | BOX LOCATION | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Newport Ranger District | Box Canyon Dam | Tiger Store | Historical Society | Cutter Theater | Sullivan Lake Road | Intercept |
| ARE YOU A RESIDENT OF THE USA | Yes | 92% | 98% | 89% | 88% | 94% | 80% | 88% | 96% |
| | No | 8% | 2% | 11% | 12% | 6% | 20% | 13% | 4% |
| TOTAL | | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| | n = | 394 | 42 | 19 | 74 | 182 | 20 | 32 | 25 |
| WHICH BEST DESCRIBES WHERE YOU LIVE | Australia/ Oceania | 3% | | | | 9% | | | |
| | Mexico | 6% | | | 11% | | | 25% | |
| | Europe | 3% | | | | 9% | | | |
| | Africa | 3% | | | | | | 25% | |
| | Central/ South America | 3% | | | | | | 25% | |
| | Canada | 53% | 100% | 100% | 89% | 27% | 25% | 25% | 100% |
| | Other | 28% | | | | 55% | 75% | | |
| TOTAL | | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| | n = | 32 | 1 | 2 | 9 | 11 | 4 | 4 | 1 |
| WHERE IN CANADA | Alberta | 29% | 100% | 50% | 25% | 33% | | | |
| | British Columbia | 71% | | 50% | 75% | 67% | 100% | 100% | 100% |
| TOTAL | | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| | n = | 17 | 1 | 2 | 8 | 3 | 1 | 1 | 1 |
| WHERE IN EUROPE | | 100% | | | | 100% | | | |
| TOTAL | | 100% | | | | 100% | | | |
| | n = | 1 | | | | 1 | | | |
| WHERE IN ASIA | | | | | | | | | |
| TOTAL | | | | | | | | | |
| | n = | | | | | | | | |

**24 Nov 04**
**Source: RRC Associates**

## NORTHEAST WASHINGTON VISITORS SURVEY 2004
## Preliminary Results - Pend Oreille County

| | | Overall Pend Oreille | BOX LOCATION | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Newport Ranger District | Box Canyon Dam | Tiger Store | Historical Society | Cutter Theater | Sullivan Lake Road | Intercept |
| DESCRIBE YOUR VISIT TO THIS LOCATION | Day visit from home | 28% | 29% | 11% | 25% | 29% | 32% | 22% | 52% |
| | Overnight in the region | 48% | 43% | 67% | 33% | 48% | 53% | 78% | 48% |
| | Passing through, overnighting elsewhere | 24% | 29% | 22% | 42% | 24% | 16% | | |
| TOTAL | | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| | n = | 390 | 42 | 18 | 73 | 181 | 19 | 32 | 25 |
| WILL YOU STAY TONIGHT IN OR NEAR | Colville area | 13% | 6% | | 38% | 1% | 10% | 46% | 8% |
| | Newport area | 52% | 56% | 58% | 8% | 74% | 50% | 17% | 42% |
| | Spokane area | 7% | 6% | 8% | 4% | 6% | 10% | 13% | 8% |
| | Republic area | 3% | | | 8% | 3% | | | |
| | Other Northeast WA area | 16% | 11% | 33% | 33% | 5% | 10% | 25% | 33% |
| | Elsewhere | 10% | 22% | | 8% | 10% | 20% | | 8% |
| TOTAL | | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| | n = | 186 | 18 | 12 | 24 | 86 | 10 | 24 | 12 |
| DESCRIBE YOUR ACCOMMODATIONS | Bed & Breakfast | 1% | | | | 1% | | | |
| | Hotel/ motel | 16% | | 8% | 23% | 21% | 38% | 4% | |
| | RV - camping | 35% | 31% | 42% | 23% | 40% | | 46% | 18% |
| | Tent camping | 11% | | 25% | 14% | 5% | 25% | 25% | 9% |
| | With friends/ family | 23% | 46% | 17% | 27% | 16% | 38% | 21% | 45% |
| | Vacation rental | 4% | 8% | | | 5% | | 4% | |
| | Guest ranch/resort | 5% | 8% | 8% | 9% | 5% | | | 9% |
| | Other | 5% | 8% | | 5% | 6% | | | 18% |
| TOTAL | | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| | n = | 167 | 13 | 12 | 22 | 77 | 8 | 24 | 11 |

24 Nov 04

Source: RRC Associates

## NORTHEAST WASHINGTON VISITORS SURVEY 2004
## Preliminary Results - Pend Oreille County

| | | Overall Pend Oreille | BOX LOCATION | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Newport Ranger District | Box Canyon Dam | Tiger Store | Historical Society | Cutter Theater | Sullivan Lake Road | Intercept |
| HOW MANY NIGHTS WILL YOU BE AWAY FROM HOME THIS TRIP | 1 night | 7% | | 8% | 14% | 6% | | | 18% |
| | 2 nights | 13% | 8% | 17% | 14% | 13% | 38% | | 18% |
| | 3 nights | 13% | 8% | 17% | 5% | 9% | | 38% | 9% |
| | 4 nights | 9% | 8% | 8% | 14% | 8% | 13% | 13% | |
| | 5 nights | 11% | 8% | 17% | 14% | 6% | | 29% | |
| | 6 or more nights | 49% | 69% | 33% | 41% | 57% | 50% | 21% | 55% |
| TOTAL | | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| Average | | 6.4 | 8.0 | 5.4 | 5.9 | 6.9 | 6.3 | 5.2 | 6.3 |
| n = | | 167 | 13 | 12 | 22 | 77 | 8 | 24 | 11 |
| HOW MANY OF THOSE NIGHTS WERE / WILL BE IN WASHINGTON STATE | 0 | 9% | 31% | | | 12% | | | 18% |
| | 1 night | 7% | | 17% | 10% | 6% | | | 27% |
| | 2 nights | 13% | | 17% | 24% | 12% | 38% | 8% | |
| | 3 nights | 14% | 8% | 8% | 10% | 13% | | 33% | 18% |
| | 4 nights | 10% | 8% | 17% | 10% | 10% | 13% | 13% | |
| | 5 nights | 8% | 8% | 17% | 14% | 4% | | 21% | |
| | 6 or more nights | 38% | 46% | 25% | 33% | 43% | 50% | 25% | 36% |
| TOTAL | | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| Average | | 5.4 | 5.5 | 4.8 | 5.3 | 5.6 | 6.3 | 5.2 | 4.5 |
| n = | | 166 | 13 | 12 | 21 | 77 | 8 | 24 | 11 |
| (VISITORS PASSING THROUGH, OVERNIGHTING ELSEWHERE) WILL YOU STAY TONIGHT IN | Washington state | 43% | 19% | 25% | 61% | 37% | 80% | | |
| | Idaho | 38% | 69% | 50% | 15% | 45% | | | 100% |
| | Montana | 8% | 6% | | 3% | 14% | | | |
| | Another state | 2% | 6% | | | 2% | | | |
| | Canada | 9% | | 25% | 21% | 2% | 20% | | |
| TOTAL | | 100% | 100% | 100% | 100% | 100% | 100% | | 100% |
| | n = | 110 | 16 | 4 | 33 | 51 | 5 | | 1 |

24 Nov 04
Source: RRC Associates

## NORTHEAST WASHINGTON VISITORS SURVEY 2004
## Preliminary Results - Pend Oreille County

| | | Overall Pend Oreille | BOX LOCATION | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Newport Ranger District | Box Canyon Dam | Tiger Store | Historical Society | Cutter Theater | Sullivan Lake Road | Intercept |
| PRIMARY REASON FOR THIS TRIP | Shopping | 8% | 10% | 6% | 6% | 9% | 16% | 10% | |
| | Visit historical / geological attraction | 18% | 21% | 24% | 17% | 22% | 11% | 6% | 4% |
| | Visit garden / farm | 3% | | | | 2% | | 3% | 24% |
| | Friends / family | 22% | 18% | 12% | 20% | 24% | 26% | 13% | 32% |
| | Festival / event | 6% | 3% | 6% | 3% | 3% | 16% | 3% | 32% |
| | Business | 4% | 8% | | 4% | 2% | 11% | 10% | |
| | Outdoor recreation | 12% | 15% | 24% | 10% | 6% | 5% | 55% | |
| | Sporting event | 1% | | | 1% | 1% | | | |
| | Performance event | 1% | | | | 1% | | | 4% |
| | Sightseeing / driving tour | 18% | 21% | 18% | 31% | 19% | 11% | | |
| | Other | 8% | 5% | 12% | 8% | 10% | 5% | | 4% |
| TOTAL | | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| | n = | 374 | 39 | 17 | 71 | 172 | 19 | 31 | 25 |

**24 Nov 04**
**Source: RRC Associates**

## NORTHEAST WASHINGTON VISITORS SURVEY 2004
## Preliminary Results - Pend Oreille County

| | | Overall Pend Oreille | BOX LOCATION | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Newport Ranger District | Box Canyon Dam | Tiger Store | Historical Society | Cutter Theater | Sullivan Lake Road | Intercept |
| ACTIVITIES THIS TRIP | Sightsee / driving tour | 63% | 71% | 75% | 66% | 64% | 65% | 42% | 56% |
| | Museum / gallery | 57% | 41% | 31% | 48% | 77% | 59% | 31% | 16% |
| | Shopping | 39% | 41% | 31% | 25% | 46% | 29% | 27% | 48% |
| | Visit historic site | 37% | 38% | 19% | 39% | 44% | 29% | 27% | 12% |
| | Hiking | 36% | 53% | 56% | 33% | 30% | 29% | 77% | 16% |
| | Wildlife viewing | 29% | 47% | 25% | 30% | 24% | 29% | 38% | 28% |
| | Family event | 21% | 29% | 25% | 7% | 23% | 24% | 19% | 28% |
| | Visit geological site | 20% | 12% | 25% | 33% | 16% | 24% | 27% | 8% |
| | Boating / watersports | 19% | 26% | 25% | 16% | 15% | 18% | 35% | 28% |
| | Camping | 18% | 15% | 38% | 16% | 16% | 24% | 35% | 8% |
| | Biking | 15% | 15% | 19% | 7% | 18% | 18% | 23% | 8% |
| | Bird watching | 15% | 26% | 13% | 19% | 12% | 18% | 12% | 16% |
| | Festival / event | 14% | 3% | 13% | 10% | 13% | 24% | 8% | 52% |
| | Antiquing | 14% | 9% | 6% | 18% | 16% | 24% | 8% | 8% |
| | Fishing | 14% | 18% | 31% | 9% | 11% | 35% | 27% | 4% |
| | Visit wildlife park / zoo | 11% | 12% | 19% | 12% | 10% | 24% | 4% | 4% |
| | Rafting / kayaking | 10% | 9% | 31% | 13% | 7% | 18% | 4% | 4% |
| | Golf | 10% | 9% | 13% | 7% | 12% | 6% | 12% | 4% |
| | Garden / farm visit | 9% | 12% | | 12% | 6% | 12% | 4% | 20% |
| | Train ride | 8% | 3% | 31% | 12% | 6% | 18% | 4% | |
| | Visit winery | 7% | 9% | 6% | 12% | 5% | 12% | 4% | 8% |
| | Off-road vehicle | 7% | 3% | 13% | 9% | 7% | 6% | 12% | 4% |
| | Performance arts / | 7% | 9% | 6% | 3% | 5% | 24% | | 20% |
| | Back-packing | 5% | 3% | 13% | 3% | 3% | 12% | 12% | 4% |
| | Horseback ride | 5% | 6% | 6% | 6% | 4% | 18% | | |
| | Casino | 4% | 6% | 6% | 4% | 5% | 6% | | |
| | Motorcycle touring | 3% | 6% | | 3% | 2% | 6% | 4% | |
| | Sports event | 3% | 3% | | 1% | 3% | 6% | 4% | 4% |
| | Rock climbing | 2% | 3% | | | 1% | 18% | | 4% |
| TOTAL | | 501% | 535% | 575% | 476% | 498% | 629% | 496% | 412% |
| | n = | 350 | 34 | 16 | 67 | 165 | 17 | 26 | 25 |

**24 Nov 04**
**Source: RRC Associates**

## NORTHEAST WASHINGTON VISITORS SURVEY 2004
## Preliminary Results - Pend Oreille County

| | | Overall Pend Oreille | BOX LOCATION | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Newport Ranger District | Box Canyon Dam | Tiger Store | Historical Society | Cutter Theater | Sullivan Lake Road | Intercept |
| MAIN MODE OF TRANSPORTATION THIS TRIP | Commercial / private air | 7% | 12% | | 9% | 6% | 17% | | 4% |
| | Private vehicle | 80% | 88% | 100% | 79% | 78% | 67% | 76% | 92% |
| | Tour bus | 1% | | | | 1% | 6% | | |
| | Train | 0% | | | | | | 3% | |
| | Rental Car | 4% | | | 5% | 4% | 6% | 3% | 4% |
| | Other | 8% | | | 8% | 11% | 6% | 17% | |
| TOTAL | | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| | n = | 348 | 34 | 14 | 66 | 162 | 18 | 29 | 25 |
| WHEN DID YOU BEGIN PLANNING THIS TRIP | A few days advance | 20% | 24% | 14% | 23% | 17% | 28% | 14% | 28% |
| | 1 - 3 weeks advance | 19% | 18% | 36% | 12% | 14% | 33% | 41% | 28% |
| | 1 month advance | 9% | | 14% | 8% | 11% | 22% | 10% | 4% |
| | More than a month | 35% | 44% | 29% | 41% | 37% | 17% | 21% | 36% |
| | No advance plan | 16% | 15% | 7% | 17% | 21% | | 14% | 4% |
| TOTAL | | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| | n = | 347 | 34 | 14 | 66 | 161 | 18 | 29 | 25 |
| IS THIS YOUR FIRST VISIT TO THE REGION | Yes | 41% | 47% | 57% | 50% | 43% | 56% | 7% | 24% |
| | No | 59% | 53% | 43% | 50% | 58% | 44% | 93% | 76% |
| TOTAL | | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| | n = | 346 | 34 | 14 | 66 | 160 | 18 | 29 | 25 |
| HOW MANY PREVIOUS VISITS HAVE YOU MADE HERE IN THE PAST YEAR | None | 19% | 6% | | 18% | 27% | 25% | 11% | 11% |
| | One | 15% | 22% | 33% | 21% | 13% | | 15% | 6% |
| | 2 - 4 visits | 32% | 28% | 33% | 24% | 36% | 25% | 33% | 33% |
| | 5 - 10 visits | 11% | 11% | | 12% | 11% | 13% | 11% | 17% |
| | More than 10 visits | 22% | 33% | 33% | 24% | 12% | 38% | 30% | 33% |
| TOTAL | | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| | n = | 201 | 18 | 6 | 33 | 91 | 8 | 27 | 18 |

**24 Nov 04**
**Source: RRC Associates**

## NORTHEAST WASHINGTON VISITORS SURVEY 2004
## Preliminary Results - Pend Oreille County

| | | Overall Pend Oreille | BOX LOCATION | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Newport Ranger District | Box Canyon Dam | Tiger Store | Historical Society | Cutter Theater | Sullivan Lake Road | Intercept |
| OVERALL HOW SATISFIED ARE YOU WITH YOUR TRAVEL EXPERIENCE | 1 - Not at all | 4% | 6% | | 5% | 3% | | 3% | 8% |
| | 2 | 2% | 3% | | 2% | 1% | | 7% | 4% |
| | 3 | 7% | 6% | 7% | 8% | 8% | 6% | 3% | |
| | 4 | 32% | 29% | 36% | 35% | 34% | 33% | 28% | 17% |
| | 5 - Very satisfied | 56% | 56% | 57% | 52% | 53% | 61% | 59% | 71% |
| TOTAL | | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| Average | | 4.3 | 4.3 | 4.5 | 4.3 | 4.3 | 4.6 | 4.3 | 4.4 |
| Median | | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 |
| n = | | 344 | 34 | 14 | 66 | 159 | 18 | 29 | 24 |
| HOW LIKELY ARE YOU TO RETURN TO THIS AREA WITHIN THE NEXT YEAR | Definitely | 44% | 42% | 43% | 33% | 38% | 50% | 72% | 79% |
| | Probably | 21% | 15% | 21% | 21% | 25% | 22% | 3% | 17% |
| | Maybe | 16% | 15% | 21% | 20% | 18% | 17% | | 4% |
| | Unlikely | 13% | 21% | 7% | 21% | 14% | | 3% | |
| | Will not return | 6% | 6% | 7% | 5% | 5% | 11% | 21% | |
| TOTAL | | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| | n = | 343 | 33 | 14 | 66 | 159 | 18 | 29 | 24 |

24 Nov 04
Source: RRC Associates

## NORTHEAST WASHINGTON VISITORS SURVEY 2004
## Preliminary Results - Pend Oreille County

| *IMPORTANCE IN SETTING ITINERARY FOR THIS TRIP* | | Overall Pend Oreille | BOX LOCATION | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Newport Ranger District | Box Canyon Dam | Tiger Store | Historical Society | Cutter Theater | Sullivan Lake Road | Intercept |
| IMPORTANCE IN SETTING THE ITINERARY THIS TRIP: MAGAZINE ARTICLES | 0 | 22% | 26% | 14% | 22% | 22% | 19% | 24% | 21% |
| | 1 - Not a factor | 50% | 52% | 43% | 52% | 51% | 44% | 52% | 50% |
| | 2 | 6% | 3% | 21% | 5% | 4% | 6% | 7% | 8% |
| | 3 | 12% | 13% | 14% | 9% | 13% | 19% | 10% | 8% |
| | 4 | 7% | 3% | | 9% | 6% | 6% | 3% | 13% |
| | 5 - Very | 3% | 3% | 7% | 3% | 3% | 6% | 3% | |
| TOTAL | | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| Average | | 1.8 | 1.7 | 1.9 | 1.8 | 1.8 | 2.1 | 1.7 | 1.8 |
| n = | | 263 | 23 | 12 | 51 | 123 | 13 | 22 | 19 |
| IMPORTANCE IN SETTING THE ITINERARY THIS TRIP: NEWSPAPER ARTICLES | 0 | 27% | 23% | 14% | 34% | 27% | 38% | 24% | 25% |
| | 1 - Not a factor | 48% | 55% | 50% | 48% | 48% | 44% | 55% | 29% |
| | 2 | 5% | 10% | 21% | 5% | 3% | 13% | 3% | 4% |
| | 3 | 12% | 6% | 7% | 9% | 15% | | 10% | 17% |
| | 4 | 4% | 3% | 7% | 2% | 4% | 6% | | 21% |
| | 5 - Very | 3% | 3% | | 2% | 4% | | 7% | 4% |
| TOTAL | | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| Average | | 1.8 | 1.6 | 1.7 | 1.5 | 1.8 | 1.5 | 1.7 | 2.6 |
| n = | | 243 | 24 | 12 | 42 | 115 | 10 | 22 | 18 |
| IMPORTANCE IN SETTING THE ITINERARY THIS TRIP: TELEVISION | 0 | 25% | 26% | 14% | 30% | 25% | 25% | 21% | 25% |
| | 1 - Not a factor | 55% | 52% | 64% | 53% | 56% | 56% | 62% | 38% |
| | 2 | 5% | 10% | 7% | 3% | 3% | 13% | 3% | 8% |
| | 3 | 8% | 6% | 14% | 11% | 8% | | 7% | 13% |
| | 4 | 4% | | | 2% | 5% | 6% | | 13% |
| | 5 - Very | 3% | 6% | | 2% | 3% | | 7% | 4% |
| TOTAL | | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| Average | | 1.6 | 1.7 | 1.4 | 1.5 | 1.6 | 1.4 | 1.6 | 2.2 |
| n = | | 250 | 23 | 12 | 45 | 117 | 12 | 23 | 18 |

**24 Nov 04**
**Source: RRC Associates**

## NORTHEAST WASHINGTON VISITORS SURVEY 2004
## Preliminary Results - Pend Oreille County

| *IMPORTANCE IN SETTING ITINERARY FOR THIS TRIP* | | Overall Pend Oreille | BOX LOCATION | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Newport Ranger District | Box Canyon Dam | Tiger Store | Historical Society | Cutter Theater | Sullivan Lake Road | Intercept |
| IMPORTANCE IN SETTING THE ITINERARY THIS TRIP: RADIO | 0 | 26% | 26% | 14% | 28% | 25% | 31% | 21% | 33% |
| | 1 - Not a factor | 57% | 52% | 64% | 56% | 59% | 56% | 66% | 38% |
| | 2 | 4% | 10% | 7% | 3% | 4% | | 3% | 4% |
| | 3 | 7% | 10% | 7% | 9% | 7% | | 3% | 8% |
| | 4 | 3% | | | 2% | 2% | 6% | | 17% |
| | 5 - Very | 3% | 3% | 7% | 2% | 3% | 6% | 7% | |
| TOTAL | | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| Average | | 1.5 | 1.6 | 1.6 | 1.5 | 1.5 | 1.6 | 1.5 | 2.1 |
| n = | | 248 | 23 | 12 | 46 | 117 | 11 | 23 | 16 |
| IMPORTANCE IN SETTING THE ITINERARY THIS TRIP: AAA RESOURCES | 0 | 25% | 23% | 14% | 27% | 25% | 25% | 21% | 38% |
| | 1 - Not a factor | 52% | 50% | 36% | 48% | 56% | 56% | 59% | 33% |
| | 2 | 5% | 7% | 21% | 6% | 3% | | 3% | 4% |
| | 3 | 7% | 3% | 14% | 8% | 8% | | | 13% |
| | 4 | 5% | 7% | | 6% | 3% | 6% | 3% | 8% |
| | 5 - Very | 7% | 10% | 14% | 5% | 5% | 13% | 14% | 4% |
| TOTAL | | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| Average | | 1.8 | 2.0 | 2.3 | 1.8 | 1.6 | 1.9 | 1.9 | 2.1 |
| n = | | 247 | 23 | 12 | 47 | 115 | 12 | 23 | 15 |
| IMPORTANCE IN SETTING THE ITINERARY THIS TRIP: FRIENDS OR FAMILY | 0 | 18% | 10% | 7% | 17% | 19% | 25% | 14% | 25% |
| | 1 - Not a factor | 25% | 27% | 21% | 34% | 23% | 6% | 28% | 17% |
| | 2 | 5% | | 7% | 3% | 7% | 6% | 10% | |
| | 3 | 13% | 17% | 29% | 11% | 12% | 25% | 7% | 13% |
| | 4 | 13% | 10% | 14% | 11% | 13% | 6% | 17% | 21% |
| | 5 - Very | 27% | 37% | 21% | 23% | 27% | 31% | 24% | 25% |
| TOTAL | | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| Average | | 3.1 | 3.3 | 3.1 | 2.8 | 3.2 | 3.7 | 3.0 | 3.5 |
| n = | | 272 | 27 | 13 | 53 | 124 | 12 | 25 | 18 |

**24 Nov 04**
**Source: RRC Associates**

## NORTHEAST WASHINGTON VISITORS SURVEY 2004
## Preliminary Results - Pend Oreille County

| *IMPORTANCE IN SETTING ITINERARY FOR THIS TRIP* | | Overall Pend Oreille | BOX LOCATION | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Newport Ranger District | Box Canyon Dam | Tiger Store | Historical Society | Cutter Theater | Sullivan Lake Road | Intercept |
| **IMPORTANCE IN SETTING THE ITINERARY THIS TRIP: LOCAL CHAMBER / CONVENTION & VISITORS BUREAU** | **0** | 27% | 30% | 7% | 34% | 23% | 25% | 28% | 42% |
| | **1 - Not a factor** | 42% | 47% | 50% | 38% | 46% | 44% | 31% | 29% |
| | **2** | 5% | 3% | | 2% | 8% | | 3% | 4% |
| | **3** | 11% | 7% | 36% | 9% | 10% | 13% | 21% | 4% |
| | **4** | 6% | 7% | | 8% | 7% | | | 17% |
| | **5 - Very** | 8% | 7% | 7% | 9% | 7% | 19% | 17% | 4% |
| **TOTAL** | | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| **Average** | | 2.1 | 1.9 | 2.1 | 2.2 | 2.0 | 2.3 | 2.6 | 2.4 |
| **n =** | | 241 | 21 | 13 | 42 | 118 | 12 | 21 | 14 |
| **IMPORTANCE IN SETTING THE ITINERARY THIS TRIP: THE STATE TOURISM OFFICE** | **0** | 29% | 27% | 7% | 38% | 23% | 25% | 31% | 57% |
| | **1 - Not a factor** | 46% | 47% | 50% | 41% | 52% | 56% | 34% | 26% |
| | **2** | 5% | 3% | 7% | 3% | 7% | | 3% | 4% |
| | **3** | 9% | 10% | 29% | 3% | 8% | 6% | 17% | 9% |
| | **4** | 5% | 3% | 7% | 9% | 4% | | 3% | 4% |
| | **5 - Very** | 6% | 10% | | 6% | 6% | 13% | 10% | |
| **TOTAL** | | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| **Average** | | 1.9 | 2.0 | 1.9 | 2.0 | 1.8 | 1.8 | 2.3 | 1.8 |
| **n =** | | 233 | 22 | 13 | 40 | 116 | 12 | 20 | 10 |
| **IMPORTANCE IN SETTING THE ITINERARY THIS TRIP: THE INTERNET** | **0** | 27% | 23% | 7% | 38% | 22% | 19% | 31% | 48% |
| | **1 - Not a factor** | 37% | 43% | 36% | 25% | 43% | 44% | 31% | 30% |
| | **2** | 3% | 7% | | 3% | 5% | | | |
| | **3** | 11% | 10% | 43% | 9% | 10% | 6% | 17% | 4% |
| | **4** | 9% | 7% | 14% | 6% | 10% | 6% | 3% | 13% |
| | **5 - Very** | 13% | 10% | | 19% | 11% | 25% | 17% | 4% |
| **TOTAL** | | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| **Average** | | 2.4 | 2.1 | 2.4 | 2.9 | 2.2 | 2.6 | 2.7 | 2.3 |
| **n =** | | 239 | 23 | 13 | 40 | 118 | 13 | 20 | 12 |

**24 Nov 04**
**Source: RRC Associates**

## NORTHEAST WASHINGTON VISITORS SURVEY 2004
## Preliminary Results - Pend Oreille County

| | | Overall Pend Oreille | BOX LOCATION | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Newport Ranger District | Box Canyon Dam | Tiger Store | Historical Society | Cutter Theater | Sullivan Lake Road | Intercept |
| TWO BEST SOURCES OF INFORMATION FOR TRIP PLANNING AFTER LEAVING HOME AND HITTING THE ROAD | Magazine ad | 13% | 10% | 7% | 10% | 14% | 8% | 11% | 23% |
| | Road sign | 44% | 31% | 50% | 62% | 42% | 38% | 41% | 27% |
| | Brochure | 47% | 59% | 50% | 41% | 45% | 69% | 44% | 41% |
| | Newspaper ad | 11% | 3% | 7% | 5% | 13% | 8% | 11% | 32% |
| | Chamber/visitor center | 40% | 48% | 36% | 41% | 42% | 23% | 33% | 32% |
| | Other local referral | 45% | 48% | 50% | 41% | 42% | 54% | 59% | 45% |
| TOTAL | | 200% | 200% | 200% | 200% | 200% | 200% | 200% | 200% |
| | n = | 305 | 29 | 14 | 61 | 139 | 13 | 27 | 22 |
| IN RECENT MEMORY, HAVE YOU ALTERED A TRIP BECAUSE OF A BROCURE PICKED UP ALONG THE WAY | Yes | 69% | 86% | 69% | 72% | 68% | 62% | 48% | 68% |
| | No | 23% | 14% | 23% | 13% | 26% | 38% | 30% | 23% |
| | Do not know/not sure | 9% | | 8% | 15% | 6% | | 22% | 9% |
| TOTAL | | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| | n = | 300 | 28 | 13 | 61 | 136 | 13 | 27 | 22 |
| DID YOU CHANGE YOUR TRIP ITINERARY BY | More than a day of travel time | 39% | 52% | 44% | 32% | 41% | 38% | 23% | 40% |
| | Less than a day of travel time | 33% | 35% | 44% | 43% | 29% | 25% | 23% | 33% |
| | Not much extra time at all | 28% | 13% | 11% | 25% | 30% | 38% | 54% | 27% |
| TOTAL | | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| | n = | 205 | 23 | 9 | 44 | 93 | 8 | 13 | 15 |

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Source: RRC Associates

## NORTHEAST WASHINGTON VISITORS SURVEY 2004
## Preliminary Results - Pend Oreille County

| | | | BOX LOCATION | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Overall Pend Oreille | Newport Ranger District | Box Canyon Dam | Tiger Store | Historical Society | Cutter Theater | Sullivan Lake Road | Intercept |
| STATE / COUNTRY OF ORIGIN | Washington | 45.2% | 17.9% | 56.3% | 44.6% | 44.4% | 38.9% | 71.0% | 60.9% |
| | California | 10.0% | 10.3% | 12.5% | 9.2% | 12.4% | 5.6% | 3.2% | 4.3% |
| | Idaho | 8.3% | 20.5% | | 6.2% | 6.5% | | 6.5% | 21.7% |
| | Canada | 4.7% | 2.6% | 12.5% | 12.3% | 1.8% | 5.6% | 3.2% | 4.3% |
| | Arizona | 4.2% | 5.1% | | 6.2% | 5.3% | | | |
| | Foreign | 4.2% | | | 1.5% | 4.7% | 16.7% | 9.7% | |
| | Oregon | 4.2% | 5.1% | | 3.1% | 4.1% | 22.2% | | |
| | Texas | 2.8% | | | | 5.9% | | | |
| | Utah | 2.5% | 5.1% | | 1.5% | 3.0% | | 3.2% | |
| | Minnesota | 1.4% | 2.6% | | 1.5% | 1.2% | | | 4.3% |
| | Nevada | 1.4% | 5.1% | | 1.5% | 1.2% | | | |
| | Florida | .8% | 2.6% | | 3.1% | | | | |
| | Illinois | .8% | 2.6% | | | 1.2% | | | |
| | Indiana | .8% | | 6.3% | | 1.2% | | | |
| | Montana | .8% | 2.6% | 6.3% | | .6% | | | |
| | Colorado | .6% | 2.6% | | 1.5% | | | | |
| | Kentucky | .6% | 2.6% | | | .6% | | | |
| | Nebraska | .6% | 2.6% | | | .6% | | | |
| | New Jersey | .6% | | | | 1.2% | | | |
| | New York | .6% | | | | 1.2% | | | |
| | Ohio | .6% | | | 1.5% | .6% | | | |
| | Pennsylvania | .6% | | | | .6% | | 3.2% | |
| | South Dakota | .6% | 2.6% | 6.3% | | | | | |
| | Alaska | .3% | | | | .6% | | | |
| | Arkansas | .3% | | | | | 5.6% | | |
| | Delaware | .3% | | | | | 5.6% | | |
| | Georgia | .3% | | | 1.5% | | | | |
| | Iowa | .3% | | | 1.5% | | | | |
| | Michigan | .3% | 2.6% | | | | | | |
| | Missouri | .3% | | | 1.5% | | | | |
| | Mississippi | .3% | 2.6% | | | | | | |
| | North Carolina | .3% | | | | .6% | | | |
| | New Mexico | .3% | 2.6% | | | | | | |
| | Tennessee | .3% | | | | | | | 4.3% |
| | Virginia | .3% | | | | .6% | | | |
| | Wyoming | .3% | | | 1.5% | | | | |
| TOTAL | | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |
| | n = | 361 | 39 | 16 | 65 | 169 | 18 | 31 | 23 |

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Source: RRC Associates

## NORTHEAST WASHINGTON VISITORS SURVEY 2004
### Preliminary Results - Pend Oreille County

| | | Overall Pend Oreille | BOX LOCATION | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Newport Ranger | Box Canyon | Tiger Store | Historical | Cutter | Sullivan Lake | Intercept |
| DMA | Spokane -- ID, MT, OR, WA | 37.5% | 27.0% | 28.6% | 28.6% | 32.3% | 28.6% | 81.5% | 72.7% |
| | Seattle - Tacoma -- WA | 18.0% | 13.5% | 35.7% | 26.8% | 16.5% | 21.4% | 7.4% | 13.6% |
| | Portland -- OR, WA | 4.3% | 5.4% | | 7.1% | 4.4% | 7.1% | | |
| | Phoenix -- AZ, CA | 4.0% | 5.4% | | 5.4% | 5.1% | | | |
| | San Francisco - Oakland - San Jose -- CA | 3.0% | 2.7% | | 7.1% | 3.2% | | | |
| | Salt Lake City -- CO, ID, NV, UT | 2.7% | 5.4% | | 1.8% | 3.2% | | 3.7% | |
| | Los Angeles -- CA | 2.7% | 2.7% | | 1.8% | 3.2% | | 3.7% | 4.5% |
| | Sacramento - Stockton - Modesto -- CA | 2.7% | | | | 5.1% | 7.1% | | |
| | Houston -- TX | 2.1% | | | | 4.4% | | | |
| | Yakima - Pasco - Richland - Kennewick -- OR, WA | 1.8% | | | | 3.8% | | | |
| | Medford - Klamath Falls -- CA, OR | 1.2% | | | | .6% | 21.4% | | |
| | Philadelphia -- DE, NJ, PA | .9% | | | | .6% | 7.1% | 3.7% | |
| | Indianapolis -- IN | .9% | | 7.1% | | 1.3% | | | |
| | Minneapolis - Saint Paul -- MN, WI | .9% | | | 1.8% | .6% | | | 4.5% |
| | Reno -- CA, NV | .9% | 2.7% | | 1.8% | .6% | | | |
| | New York -- CT, NJ, NY, PA | .6% | | | | 1.3% | | | |
| | Cincinnati -- IN, KY, OH | .6% | 2.7% | | | .6% | | | |
| | Chicago -- IL, IN | .6% | 2.7% | | | .6% | | | |
| | Boise -- ID, OR | .6% | 2.7% | | | .6% | | | |
| | Rapid City -- MT, SD, WY | .6% | 2.7% | | 1.8% | | | | |
| | Tucson (Sierra Vista) -- AZ | .6% | | | 1.8% | .6% | | | |
| | Palm Springs -- CA | .6% | | | 1.8% | .6% | | | |
| | San Diego -- CA | .6% | 2.7% | | | .6% | | | |
| | Las Vegas -- NV | .6% | 2.7% | | | .6% | | | |
| | Fresno - Visalia -- CA | .6% | | 7.1% | | .6% | | | |
| | Atlanta -- AL, GA, NC | .3% | | | 1.8% | | | | |
| | Albany - Schenectady - Troy -- MA, NY, VT | .3% | | | | .6% | | | |
| | Orlando - Daytona Beach - Melbourne -- FL | .3% | | | 1.8% | | | | |
| | Tampa - Saint Petersburg (Sarasota) -- FL | .3% | 2.7% | | | | | | |
| | Norfolk - Portsmouth - Newport News -- NC, VA | .3% | | | | .6% | | | |
| | Toledo -- MI, OH | .3% | | | | .6% | | | |
| | Syracuse -- NY | .3% | | | | .6% | | | |
| | Jacksonville, Brunswick -- FL, GA | .3% | | | 1.8% | | | | |
| | Grand Rapids - Kalamazoo - Battle Creek -- MI | .3% | 2.7% | | | | | | |
| | Greenville - Spartansburg - Asheville - Anderson -- GA, | .3% | | | | .6% | | | |
| | Parkersburg -- OH, WV | .3% | | | 1.8% | | | | |
| | Corpus Christi -- TX | .3% | | | | .6% | | | |
| | Rockford -- IL | .3% | | | | .6% | | | |
| | Springfield -- AR, MO | .3% | | | 1.8% | | | | |
| | Odessa - Midland -- NM, TX | .3% | | | | .6% | | | |
| | Omaha -- IA, MO, NE | .3% | | | | .6% | | | |
| | Nashville -- KY, TN | .3% | | | | | | | 4.5% |
| | Des Moines - Ames -- IA, MO | .3% | | | 1.8% | | | | |
| | Beaumont - Port Arthur -- TX | .3% | | | | .6% | | | |
| | Little Rock - Pine Bluff -- AR | .3% | | | | | 7.1% | | |
| | Lincoln & Hastings - Kearney -- KS, NE | .3% | 2.7% | | | | | | |
| | Fargo - Valley City -- MN, ND | .3% | | | | .6% | | | |
| | Sioux Falls (Mitchell) -- IA, MN, NE, SD | .3% | | 7.1% | | | | | |
| | Mankato -- IA, MN | .3% | 2.7% | | | | | | |

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Source: RRC Associates

**NORTHEAST WASHINGTON VISITORS SURVEY 2004**
**Preliminary Results - Pend Oreille County (cont.)**

| | | Overall Pend Oreille | BOX LOCATION | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Newport Ranger | Box Canyon | Tiger Store | Historical | Cutter | Sullivan Lake | Intercept |
| DMA | Anchorage -- AK | .3% | | | | .6% | | | |
| | Denver -- CO, NE, WY | .3% | | | 1.8% | | | | |
| | Butte - Bozeman -- MT | .3% | | | | .6% | | | |
| | Billings -- MT, WY | .3% | | 7.1% | | | | | |
| | Grand Junction - Montrose -- CO | .3% | 2.7% | | | | | | |
| | Albuquerque - Santa Fe -- AZ, CO, NM | .3% | 2.7% | | | | | | |
| | Bakersfield -- CA | .3% | | 7.1% | | | | | |
| | Eugene -- OR | .3% | | | | .6% | | | |
| | Chico - Redding -- CA | .3% | 2.7% | | | | | | |
| TOTAL | | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |
| | n = | 328 | 37 | 14 | 56 | 158 | 14 | 27 | 22 |

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**Source: RRC Associates**

## NORTHEAST WASHINGTON VISITORS SURVEY 2004
## Preliminary Results - Pend Oreille County

| | | Overall Pend Oreille | BOX LOCATION | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Newport Ranger District | Box Canyon Dam | Tiger Store | Historical Society | Cutter Theater | Sullivan Lake Road | Intercept |
| WASHINGTON COUNTY | Spokane | 46.3% | 28.6% | 25.0% | 31.0% | 45.3% | 28.6% | 77.3% | 64.3% |
| | King | 13.6% | | 25.0% | 20.7% | 13.3% | 14.3% | 9.1% | 7.1% |
| | Pierce | 6.2% | 42.9% | 12.5% | 13.8% | 2.7% | | | |
| | Stevens | 5.6% | | | 6.9% | 4.0% | 14.3% | 9.1% | 7.1% |
| | Snohomish | 4.3% | | 12.5% | 3.4% | 4.0% | | | 14.3% |
| | Grant | 3.1% | | 12.5% | 3.4% | 2.7% | 14.3% | | |
| | Kitsap | 2.5% | | | 3.4% | 4.0% | | | |
| | Chelan | 1.9% | | | | 4.0% | | | |
| | Clark | 1.9% | | | 3.4% | 2.7% | | | |
| | Clallam | 1.2% | | | 3.4% | 1.3% | | | |
| | Ferry | 1.2% | | | | 2.7% | | | |
| | Kittitas | 1.2% | | | | 2.7% | | | |
| | Lewis | 1.2% | 14.3% | | | 1.3% | | | |
| | Skagit | 1.2% | | 12.5% | 3.4% | | | | |
| | Thurston | 1.2% | | | | 1.3% | 14.3% | | |
| | Walla Walla | 1.2% | | | | 2.7% | | | |
| | Whatcom | 1.2% | | | | 2.7% | | | |
| | Benton | .6% | | | | 1.3% | | | |
| | Cowlitz | .6% | | | 3.4% | | | | |
| | Franklin | .6% | | | | 1.3% | | | |
| | Grays Harbor | .6% | | | | | 14.3% | | |
| | Island | .6% | 14.3% | | | | | | |
| | Okanogan | .6% | | | | | | | 7.1% |
| | Pacific | .6% | | | 3.4% | | | | |
| | Whitman | .6% | | | | | | 4.5% | |
| TOTAL | | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |
| | n = | 162 | 7 | 8 | 29 | 75 | 7 | 22 | 14 |

24 Nov 04
Source: RRC Associates