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 2 OF 4
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March 2010

APPLICATION FOR SURRENDER OF LICENSE
SULLIVAN CREEK PROJECT
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APPENDIX E.2-1
2008 UPDATED COLVILLE NATIONAL FOREST
EXISTING INFORMATION ANALYSIS

SULLIVAN CREEK HYDROELECTRIC PROJECT EXISTING INFORMATION ANALYSIS

COLVILLE NATIONAL FOREST

Introduction

The Sullivan Creek Hydroelectric Project, FERC No. 2225, (SCH) is owned by the Public Utility District No. 1 of Pend Oreille County, Washington (PUD). The Federal Energy Regulatory Commission (FERC) licensed SCH on November 25, 1958. The existing license expires on October 1, 2008.

The SCH is located at Sullivan Lake and along Sullivan Creek, in northeastern Washington State, approximately 3 miles east of the town of Metaline Falls, Washington. The original SCH was constructed by Inland Portland Cement Company in 1909 and supplied electricity to the town of Metaline Falls. The Project consisted of Sullivan Lake dam, Mill Pond dam, an intake structure on Mill Pond, a wooden flume, canal, tunnel and powerhouse. The Project operated on National Forest System (NFS) lands under a special use permit. In 1922 Mill Pond dam was replaced by a concrete dam about 130 feet long and about 55 feet high, constructed just below the log-crib dam. In 1956, the powerhouse was shutdown because of maintenance problems with the wooden flume that conveyed water from Mill Pond to the powerhouse. At that time, it was decided to terminate operations because cheaper electricity was available from Bonneville Power Administration (BPA). In 1958, the Federal Power Commission, now FERC, licensed the Project as a non-generating project, with provision for adding generating capabilities later. The Project boundary was restricted during the period of investigation for re-establishing power generation. The PUD purchased the Project in 1959. In 1992, FERC reclassified Sullivan Lake dam to “high hazard” and required that structural measures be designed to increase the factors of safety for stability; the required work was completed a short time later.

Sullivan Lake is a natural lake, which is increased in size by the presence of the Sullivan Lake dam. Currently, SCH stores and releases about 31,000 acre-feet of water annually, in accordance with the Pacific Northwest Coordination Agreement and its FERC license. Sullivan Lake pool covers 1,240 acres and is maintained to the extent possible at a constant elevation of 2,588.7 feet above mean sea level (msl) during the months of May thru September. Beginning in October, the reservoir is drawn down to provide storage for spring runoff. Mill Pond is kept at a relatively constant 2,506 feet msl. The horseshoe tunnel that connects the forebay to the powerhouse is still being used to back-feed water to the forebay as part of the water supply system of the town of Metaline Falls. The powerhouse is unused except for a small portion that houses a backup pump for the

municipal water supply. The PUD currently holds three water rights on Sullivan Creek, two of these are for power production.

The Project currently consists of Sullivan Lake dam, Mill Pond dam, Mill Pond Historic Site, a wooden flume and canal, a forebay, a horseshoe-shaped tunnel and powerhouse. Sullivan Lake has a gross volume of 270,000 acre-feet with 31,000 acre-feet of active storage capacity and covers 1,240 acres at its full pool elevation of 2,588.7 feet (msl). Sullivan Lake dam is a 58-foot long by 29-foot high concrete gravity dam and spillway abutted by two concrete gravity wing walls. Mill Pond dam is a 134-foot long by 55-foot high concrete gravity dam with an 84-foot long ogee spillway and an 850-foot long earthen dike at the left abutment. The wooden flume was about 12,500 feet long and is badly deteriorated, mostly missing. The remainder of the Project, which is not located on NFS lands, consists of a 2,200-foot long earthen canal leading into a small head-pond (forebay) 300 feet by 300 feet, a 1,160-foot long by 8 –foot diameter horseshoe tunnel connecting the forebay to the penstock. A 275-foot long steel penstock extends from the tunnel to the powerhouse. The powerhouse, located immediately upstream from State Highway 31, is a 100-foot long by 38-foot wide brick and masonry structure. There is no generating or switching machinery in the powerhouse.

Approximately 540 acres of NFS lands are contained within FERC's Sullivan Creek Hydroelectric Project boundary.

Existing Information

Setting and General Environment

The SCH is located on Sullivan Creek, which is a tributary of the Pend Oreille River. Sullivan Creek flows westerly, entering the eastside of the Pend Oreille River near Metaline Falls at approximately river mile (RM) 27.

Access to the Project is by way of County Road 9345, Sullivan Creek Road. This road runs from State Highway 31 easterly along Sullivan Creek, continues south along the west side of Sullivan Lake eventually returning to State Highway 31 south of Ione, Washington.

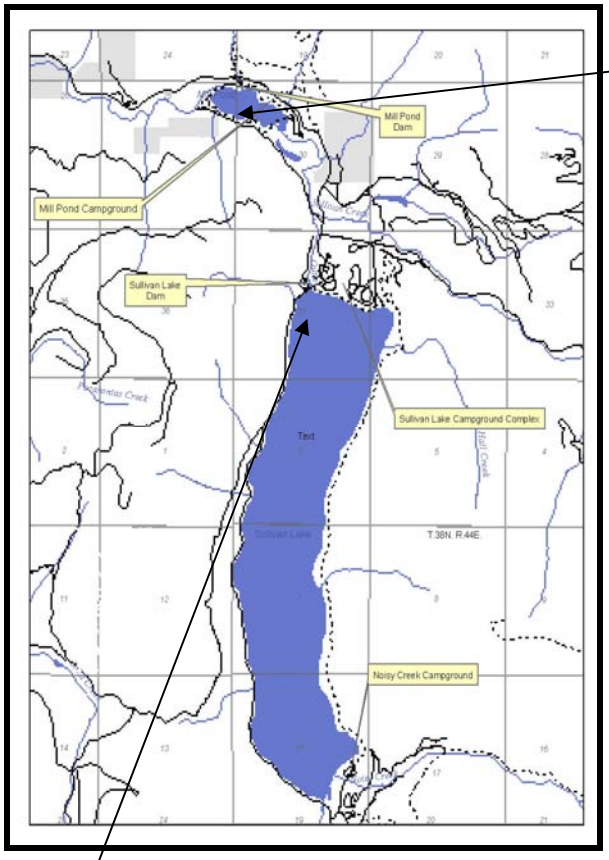
The SCH is located on NFS lands and lands owned by the PUD. There are 11 private landowners outside the Project boundary, but in the vicinity of the Project between Sullivan Lake Dam and Mill Pond. In addition, there are 13 recreation residences under permit by the USDA Forest Service within the Project area. Lands within the FERC restricted Project boundary are all NFS lands.

The SCH is surrounded by the Selkirk Mountains. The climate of the area has both continental and maritime air mass influences. Prevailing westerly winds controls most of the weather systems affecting the northeastern part of the state. Winters are rather long and influenced by cold air from the Canadian Arctic moving parallel to major north-south drainages. Summers are generally warm and sunny with light rainfall. Air from the Pacific Ocean has a moderating influence throughout the year. Daily temperatures range from 15°F to 30°F in the winter and 46°F to 76°F in the summer. Annual precipitation varies from 15 to 25 inches in the valleys to 40 inches in the mountains.

The surrounding topography is relatively abrupt and the mountains are steep and rugged. The vegetative cover is typical of coniferous forests of the region. Two main tributaries, Harvey Creek and Sullivan Creek, affect the hydrology of the Project. Sullivan Creek and Harvey Creek originate at the peaks of Salmo and Monumental Mountains at elevation 6,400 and 5,711 feet, respectively. Sullivan Creek drains the area east and northeast of Sullivan Lake, a total drainage basin area of approximately 70 sq. miles. Harvey Creek drains the area south and southeast of Sullivan Lake, a total drainage area of approximately 52 sq. miles. Sullivan Lake is formed by the impoundment of Harvey Creek. Outlet Creek is formed by the outflow from Sullivan Lake and joins Sullivan Creek approximately 0.5 miles downstream of Sullivan Lake Dam.

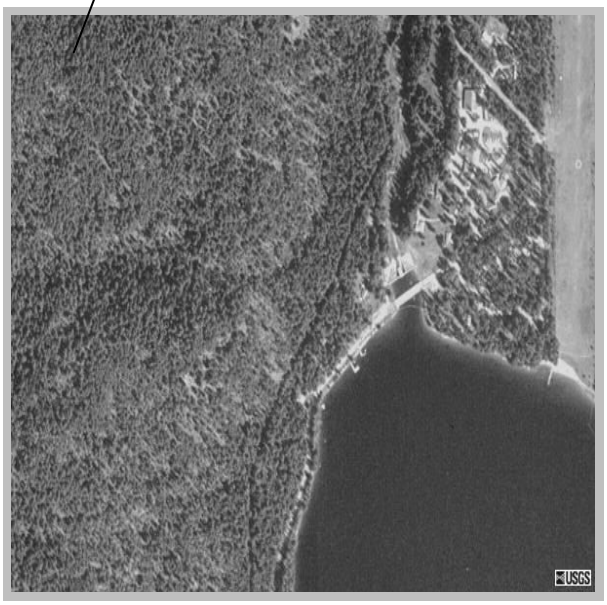
The closet population centers are the communities of Ione, Metaline and Metaline Falls located approximately 60 miles north of Newport, Washington and approximately 95 miles north of Spokane, Washington. They are the northern most population centers in Pend Oreille County. The county has a total population of approximately 11,604 (1999 Census Bureau estimate). The reopening of the Cominco mine north of Metaline Falls has had a positive effect on the local economy.

Figure 1 – Reference Map



Mill Pond

Project Overview



Sullivan Lake Dam

Land Uses

Existing Condition

NFS lands located within and adjacent to SCH are a mixture of developed and undeveloped lands. There are NFS recreation sites at both Sullivan Lake and Mill Pond. The USDA Forest Service Sullivan Lake Ranger District administrative site is also located at Sullivan Lake, as well as 13 recreational residences under permit from the USDA Forest Service. County Road 9345, Sullivan Lake Road, provides access to the Project. USDA Forest Service management activities within the Project area have primarily been limited to recreation, timber harvest and wildlife management. Dispersed recreation is also evident throughout the area, principally along Sullivan Creek.

The presence of several developed recreation sites, as well as recreation residences, within and adjacent to the Project boundary is reflective of the recreational opportunities which the lake and Project afford. These facilities were developed in such a way as to maintain a natural setting around the lake, along Sullivan Creek and at Mill Pond. When the Forest Plan was developed in the late 1980's the majority of the NFS land immediately adjacent to the Project area was allocated to Management Area 3A, with an emphasis on roaded and unroaded recreation in a natural setting. Additionally, lands were allocated to Management Area 5 with an emphasis on scenery and timber production.

Land uses within the Project area have remained relatively unchanged over the term of the license with the exception of expansion and upgrading of recreation sites.

Scope of Analysis Area

The scope of the analysis area encompasses all NFS lands within and immediately adjacent to the Project boundary as defined in the FERC license.

Scenery Management

Existing Condition

The SCH lies within the mountainous northeastern corner of Washington State and includes the glacially sculptured Sullivan Lake and man made Mill Pond. The setting has provided a unique, high quality outdoor recreational experience for visitors since the early 1900s.

Figure 2 – Sullivan Lake from swim beach

The condition of the landscape is measured as scenic integrity. Scenic integrity is an evaluation of the human-caused deviations in form, line, color and texture from the landscape. The scenic integrity levels range in five categories from very high to very low. Generally, the moderates to high, high, and very high, categories are natural appearing where changes are not dominant. The low to very low categories would indicate deviation begin to dominate the landscape. Scenic integrity serves as a baseline measurement upon which potential changes can be measured in relative terms.

The current Forest Plan allocates the NFS lands surrounding Sullivan Lake and Millpond as a "Scenic Viewshed" (Sullivan Lake Road, Forest Plan 1988, FEIS III-102). The visual condition of this viewshed is listed as natural appearing, giving it a scenic integrity rating of high. The current analysis under the Forest Plan revision process will determine the future scenic integrity objectives for the area.

During the winter months however, Sullivan Lake is drawn down exposing stumps and bare mud flats. This temporary condition occurs during low use periods. The lake also has recreation residences and occupancy generally drops off after Labor Day with residents returning by mid-May. The majority of recreation visitors see the lake at full pool.

Millpond does retain stable shoreline vegetation.

Pend Oreille County planning has recognized the value of this landscape, and the importance of state and federal land management to the local economy and quality of life. They have set goals related to promoting the beauty of the county's natural attractions, and see this as a basis for building a more stable economy (Pend Oreille County Comprehensive plan, 1995 Draft). The major scenic concern is for the preservation of what is a unique, and highly valued, landscape.

Scope of the Analysis Area

The area within the viewshed, as designated in the current Forest Plan, provides views of the Project.

Recreation Management

Existing Condition

Spokane, Washington is approximately 120 miles driving distance from the Sullivan Lake/Mill Pond analysis area.

Demographic changes make it likely that during the next 30-year period, the use of the Sullivan Lake area will increase. These changes include increases in the number of traveling retirees, the amount of leisure time and money, the search for scenic places, etc. (Cordell 1999). The demand for trails, especially those near water, is high (Interagency Committee for Outdoor Recreation, 1995) and demand for recreational activities in a natural setting are increasingly important. Linear activities are noted as the most popular, and a "significant portion of all linear activity, especially walking and bicycling, takes place close to home. . ." (Interagency Committee for Outdoor Recreation, 2002).

The North Pend Oreille Scenic Byway (NPOSB) was established in 1993. The Chambers of Commerce and the County are promoting tourism in this area (Pend Oreille County Comprehensive plan, 1995 Draft). Local residents working together with the State on a Scenic Byway project through the area view the analysis area as a source of attraction, which could help develop a tourist-based economy.

Current use surveys at the developed campgrounds within the analysis area show that beginning in July and running through Labor Day the campsites are occupied to a level that suggests a need to consider expansion or development of new facilities. Prior to expansion of the existing facilities on NFS lands, there needs to be an evaluation of potential locations for overnight camping opportunities on both public and private lands in the area.

The existing recreation sites within the analysis area are part of the Colville National Forest 2005 Recreation Facility Master Plan process which considers the cost efficiency

of providing the existing site amenities and level of service, as well as whether the site supports the concepts proposed under the Recreation Niche statement for the Forest.

Sullivan Lake:

The water level of the lake fluctuates during the year with an annual draw down of approximately 25 feet during the winter months. The water level is held up during the summer months to accommodate recreation use.

Facilities at both Noisy Creek and Sullivan Lake recreation areas are in good condition due to recent reconstruction efforts and meet appropriate standards for accessibility, health and safety.

Noisy Creek Recreation Area:

The area is totally within NFS lands at the south end of Sullivan Lake. Facilities within the area include Noisy Creek campground, day use parking, and boat launch, trailheads for the Lakeshore Trail (Trail #504) and the Noisy Creek Trail (#588), a group camping area, and a privately owned recreation residence (under a special-use authorization).

Sullivan Lake Recreation Area:

The area is totally within NFS land at the north end of Sullivan Lake. The facilities within the area include East Sullivan Campground, West Sullivan Campground, day use parking, a boat launch, trailheads for the Lakeshore Trail (Trail #504) and the Nature Trail (#509), a group camping area, and several recreation residences (authorized under special-use authorizations).

Millpond:

The area is totally within NFS land approximately 1 mile northwest of the Sullivan Lake Recreation Area. The facilities within the area include Millpond Campground, Millpond Historic Site, trailheads for the Mill Pond Flume Trail (#520), South Mill Pond Trail (#550) and Elk Creek Trail (#560), and a picnic area. Facilities at Millpond have not been reconstructed and are in need of upgrading to meet current standards.

Recreation use levels for both the Sullivan Lake and Millpond areas are shown in the following table based on actual campground use counts provided by the concessionaire.

Table 1 – Recreation Use Levels

Campground Name	Number of Campsites	Percent Occupancy During High Use Weekends in 2003	Average Percent Occupancy During Season of Use* in 2003
East and West Sullivan Lake	48	93 %	54%
Millpond	10	83%	34%
Noisy Creek	19	87%	39%

* Season of use is the general open season when services are provided and facilities maintained.

Sullivan Lake includes day use areas at the East and West Sullivan and the Noisy Creek developed facilities. Use is concentrated at shoreline and boat launch areas. East Sullivan has a boat launch, dock and floating swim platform near the picnic area. West Sullivan has a picnic shelter and a designated swim area with swim dock. The lake is popular for boat fishing, water skiing, personal watercraft, kayaking, and canoeing. Fishing activity is for rainbow, German Brown, cutthroat, Kokanee, and ling cod (Burbot).

Trail #509 near East Sullivan is a 0.6-mile nature/interpretive walk. Trail #504 runs along the east shore and connects the Sullivan Lake Group Campground with the Noisy Creek Day Use area. The trailhead near the Noisy Creek Group Camp provides access to Trail #588 and the Hall Mountain Trail #540 leading to a former lookout site.

Mill Pond day use activity is concentrated at the Mill Pond Historic site where visitors can see remnants of the early 1900's hydroelectric project. Accessible, interpretive trail #520 loops through the historic site. There is also a low level of day use boating activity and use of the small lake for fishing (rainbow, German brown, eastern brook, and Kokanee).

Day users include those using the lake, viewing the scenery, picnicking, hiking, and visiting historic sites. Counts of day use parking permits provided by the concessionaire for the 2004 season show that day use facilities receive the heaviest use on Saturdays and Sundays. Since the area is close to local communities, it is assumed that many day users come for only part of a day. An estimated 90 % of the overnight users also utilize the day use facilities at both lakes. Additional day use occurs from locals and people passing through the areas while traveling the North Pend Oreille Scenic Byway and International Selkirk Loop corridor.

The site acreage and existing season of use is provided in the following table.

Table 2 – Recreation Facility Size and Season of Use

Recreation Facility	Acreage	Season of Use
East Sullivan Campground and Day Use Area	26	Week before Memorial Day through the week after Labor Day
West Sullivan Campground and Day Use Area	10	Same
Sullivan Group site	2	Same
Millpond Campground	10	Same
Millpond Historical Site	5	Same
Noisy Creek Campground, Day Use, and Group site	20	Same

Scope of Analysis Area

The analysis area includes Sullivan Lake, Mill Pond, Outlet Creek, Sullivan Creek (between Outlet Creek and Mill Pond), Lower Harvey Creek and the recreation facilities and residences affiliated with these areas. The area includes dispersed recreation opportunities and developed recreation facilities and trails.

Geology and Soils

Existing Condition

The SCH consists of two impoundment facilities – Sullivan Lake Dam and Mill Pond Dam. The affected environment includes the impoundment facilities and the streams (Harvey Creek, Outlet Creek, Sullivan Creek) extending from just above the Sullivan Lake to the Pend Oreille River. The geologic information is from Geologic Map of the Colville Quadrangle, Nancy Joseph, 1992. The soil information is from the Soil Survey of Pend Oreille County Area, Washington, USDA SCS, 1992

Sullivan Lake:

Sullivan Lake is a natural lake formed by glacial action. The natural outlet and dam are located on a moraine at the north end of the lake. The Sullivan Lake dam is about 30 feet tall. Under current operations, the lake level is lowered in the fall and winter, rises in the spring, and remains at 'full pool' through the summer.
The north end of the lake is a moraine. The moraine appears to be made of unconsolidated sand, gravels and cobbles[1]. The original outlet appears to have been

[1] During construction of the Outlet Bridge, liquification was experienced on the east most piling, suggesting that the interior of the moraine may include finer textured materials.

located about 100 feet upstream from the current dam (Sewell Engineering, 1920). The moraine appears to be porous – seeps occur on the downstream side of the moraine into Outlet Creek, and the water well on the Sullivan Lake Ranger District compound shows changes in response to lake levels. The primary soil on the moraine is Bonners silt loam. Any topsoil that may have existed in the reservoir fluctuation zone[2] has been eroded away. The beach material is mostly coarse gravel. The beach gravels do not appear to have eroded significantly from lake level fluctuations or wave action.

The east and west sides of the lake are characterized by steep, rocky slopes. The bedrock on the west side is Maitlen Phyllite, and on the east side the bedrock is dominated by both Maitlen Phyllite and Gypsy Quartzite. Soil series found along the sides of the reservoir are generally formed in residuum and colluvium. Common soils include Rufus, Belzar, Rasio, Hartill, Newbell, and Inkler. Rufus is shallow (<20" to bedrock); and Belzar, Hartill, Inkler and Rasio are moderately deep (20-40" to bedrock). Newbell is formed on glacial till and is deep (>60" to bedrock). Rufus, Belzar, Rasio, Newbell are found in complex with rock outcrops. In general, fines and topsoil that may have existed in the reservoir fluctuation zone have been eroded away. The resulting lakeshore is rocky and largely immune to the effects of further water erosion.

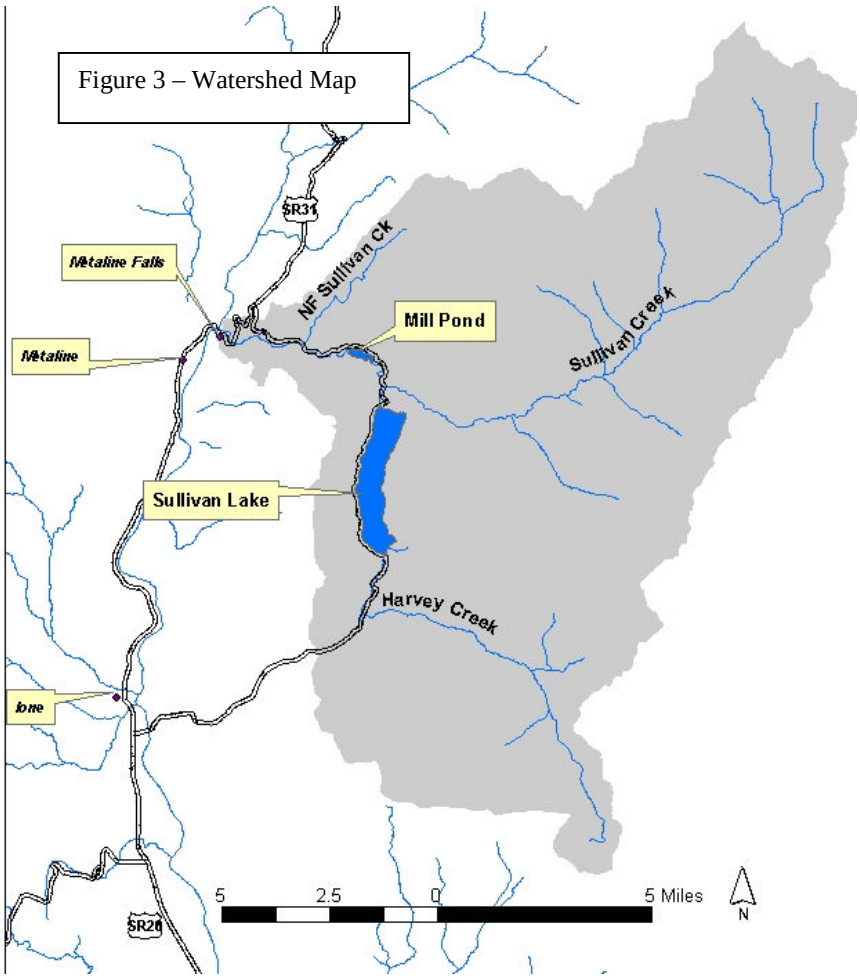


Figure 3 – Watershed Map

Most of the water enters the lake at the south end – Noisy Creek enters in the southeast corner and Harvey Creek enters at the southwest corner. Harvey Creek is the largest stream flowing into the lake. The gradient of the Harvey Creek valley as it enters

[2] The reservoir fluctuation zone is the shoreline between the normal high- and low-water levels.

Sullivan Lake is very low. The south end of the lake is characterized by nearly flat slopes of fine-textured depositional materials. Scotia series, formed on glaciofluvial material, is the primary series mapped at the south end of the lake. This flat depositional land type extends up the Harvey Creek valley for about a mile. Noisy Creek Campground and some private homes are built on this depositional land type.

About 7,000 feet (1.3 miles) before it enters Sullivan Lake, Harvey Creek turns abruptly to the east-southeast and enters a steep, narrow canyon. The canyon contains several small landslides in glacial material and bedded metasedimentary rock, visible from FR 1925. The landslide material includes both rounded cobbles and boulders (glacial), and angular material (metasedimentary). These landslides have provided a lot of bedload material into Harvey Creek. Bedload deposits have been observed about 7,000 feet upstream from the lake, where Harvey Creek changes from a steep to a flat gradient.

Where Harvey Creek enters Sullivan Lake the deposition zone is seasonally inundated by the lake. This mud-flat is not covered by water in the winter. This flat contains many stumps from when the dam was built in the early 1900's. For the most part, these stumps have neither been buried nor have they been exposed – the roots are right at the current surface level. Along Harvey Creek the deposited material is coarse cobbles mixed with some sand. This coarse zone is about 50 feet wide (on each side of the creek). As you go past this 'gravel bar' the material is fine textured sand and silt greater than 30 inches deep.

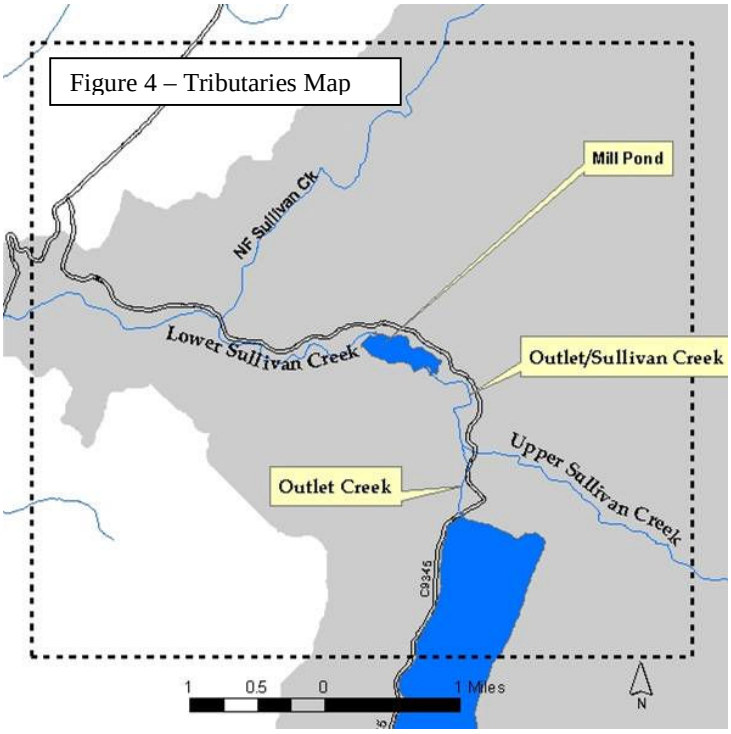


Figure 4 – Tributaries Map

Outlet/Sullivan Creeks between Mill Pond and Sullivan Lake:

Outlet Creek flows out of Sullivan Lake. About 2,500 feet (½ mile) below the dam, Outlet Creek joins Sullivan Creek. Mill Pond is formed from the impoundment of Sullivan Creek about 4,500 feet below this confluence[3].

Between Sullivan Lake and Mill Pond, Outlet/Sullivan Creek is a low gradient creek. For about 2,000 feet below the dam, Outlet Creek flows in a confined canyon formed by the moraine on one side and the mountain slope on the other. The valley is typically less

[3] It is about 4,500 feet following the creek. If you go straight down the valley it is about 3,500 feet. Sullivan Creek makes a big meander just before it enters Mill Pond.

than 100 feet wide. The geology of the mountain slope is Maitlen Phyllite; the soil formed on those slopes includes both Hartill-rock outcrop complex and Smackout loam. Hartill is formed in residuum and colluvium, while Smackout is formed in glacial till. The material on the other east and north side of the creek is glacial outwash.

Near the confluence with Sullivan Creek, the valley widens. In the spring of 1997, high flows on Sullivan Creek and Outlet Creek combined to flood a portion of CR 9345, severely damaging the road. The peak flow occurred in early June, with Sullivan Creek flowing about 1,300 CFS above the confluence, and Outlet Creek flowing about 800 CFS above the confluence.

Below the confluence Outlet/Sullivan Creek is again confined by glacial terraces. The area known as "Larsonville" appears to be a large old landslide mass just upstream of Mill Pond, on the east side of the creek.

Old landslide scars are visible along Outlet/Sullivan Creek. The narrow valley constrains the meanders, causing slumps along the canyon walls. Landslides along Sullivan Creek are discussed in newspaper articles[4] dating from the late 1800's.

Sullivan Creek at the confluence is about slightly larger than Outlet Creek. The upper Sullivan Creek watershed is about 70 square miles, while the watershed tributary to Sullivan Lake is about 52 square miles.

Sullivan Creek has a stream flow gauge above the confluence with Outlet Creek. Maximum flows occur in May and June, and minimum flows occur in the winter. Typical maximum flows are in the 500-900 CFS range.

Outlet Creek has a stream flow gauge. The flow regime in Outlet Creek is governed by releases at Sullivan Lake dam; maximum flows typically occur in the fall – starting about October and ending before December. In some years a short period of higher flows also occurs in the spring (June), perhaps to balance incoming flows. The maximum flows are typically around 100-300 CFS.

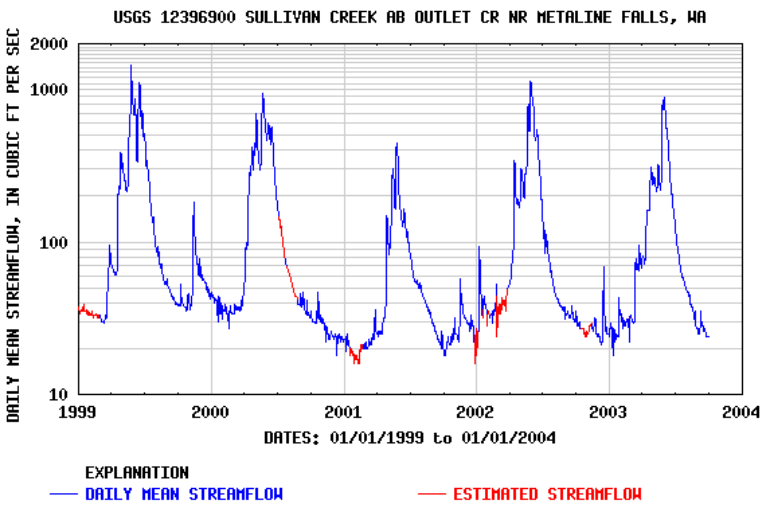


Figure 5 – Streamflow gauge printout

[4] Articles in the Newport Miner describe how these landslides impacted placer mining along the creek – often exposing new gravels for miners. Daniel Matson, personal communication.

Sullivan Creek has a stream flow gauge near Metaline Falls. Here the flow regime shows both the natural spring run-off and the dam releases. The adjacent graph shows stream flow for this site.

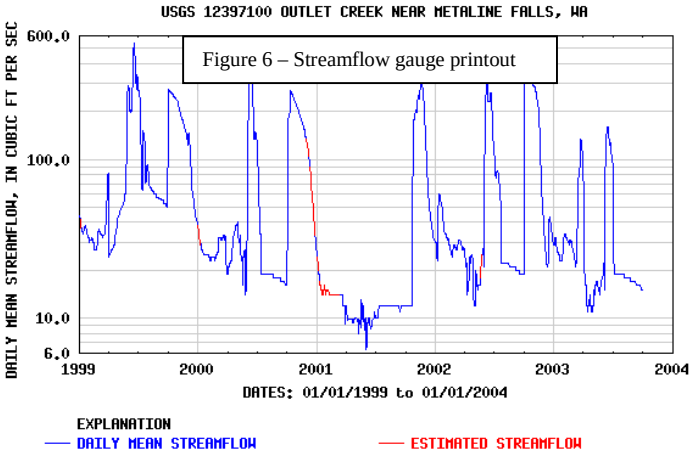


Figure 6 – Streamflow gauge printout

Mill Pond:

Mill Pond is a man-made feature. Historic photographs of the Mill Pond area prior to the dam show a stand of large western red cedar trees. The impoundment occurs in a low gradient segment of the creek (about 0.5% gradient).

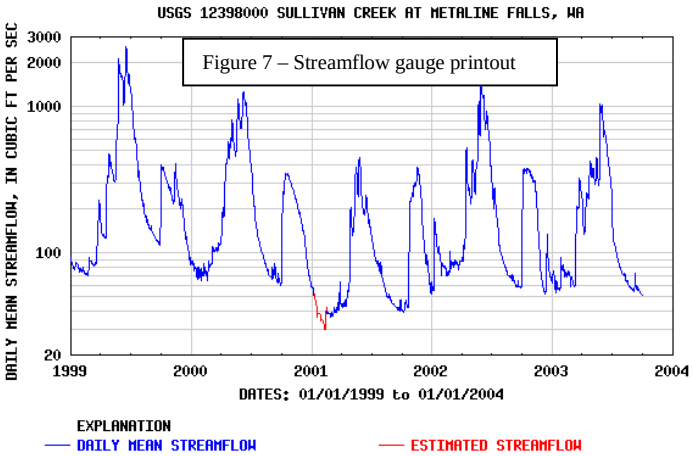


Figure 7 – Streamflow gauge printout

The surrounding valley bedrock is Maitlen Phyllite, but the slopes immediately adjacent to the pond are formed in glacial till. The side slopes range from about 20 to 40%. Soils in this area include Smackout on the south side and Aits on the north side. Both are formed over glacial till and are deep to bedrock. Because the lake level does not fluctuate significantly, riparian vegetation and topsoil occur to the waters edge.

Most of the dam is an earthen structure that is about 850 feet long and up to 500 feet wide. Most of the interpreted Mill Pond historic site is located on the dam. At the north end of the dam is a concrete outlet structure. The outlet has a fixed-elevation gate.

Sullivan Creek is the primary water flowing into Mill Pond. Mill Pond has a large depositional area at the inlet end. At the inlet, Sullivan Creek follows a meandering route dropping its bedload along the way. Based on aerial photos, much of the material was deposited in the 1960's and 1970's. The material appears to originate from a series of landslides and road failures upstream in the main stem of Sullivan Creek (Wasson and Glines, 1996; Jones, undated; Hinshaw, 1967). 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 alder and brush. The shape and condition of the submerged portions of these deposits are unknown. If the dam were removed these deposits would be exposed.

Lower Sullivan Creek below Mill Pond:

Below Mill Pond, Sullivan Creek can be broken into two segments.

The first segment, from Mill Pond to just below the confluence with North Fork Sullivan Creek (about 9,000 ft.) is low to moderate gradient (varies from less than 1% just below Mill Pond up to about 2.5% near the North Fork). The surrounding bedrock is Maitlen Phyllite. The soils in this section are Bonner silt loam and Kiehl loam, found on the low floodplain, and Newbell silt loam, Aits loam, Threemile silt loam and Waits loam which are found on the upland slopes. The low gradient stream meanders in a moderately confining valley ranging from about 300 feet to about 100 feet wide. Landslides have occurred where the stream has undercut the upland slopes. In the spring of 1997, the stream undercut the adjacent valley hill slopes, causing a landslide that closed CR 9345.

The lower segment extends from near the confluence with North Fork Sullivan Creek to near the powerhouse. The gradient increase, the canyon becomes incised, and the stream straightens. In this segment, the channel is bedrock controlled. The lower slopes are dominated by rock outcrops, while the upper slopes are composed of rock outcrops and glacial till deposits. During its years of operations (1909-1956), landslides in the upper slopes of this area destroyed or damaged the flume system to the powerhouse several times.

Downstream Beneficial Uses

The following developments are built on or near Sullivan Creek, and *may be* subject to damage from flooding or landslide debris.

1. CR 9345 follows Sullivan Creek in some locations. Undercutting has damaged this road in the past.
2. SR 31 crosses Sullivan Creek at Metaline Falls with a bridge. After the bridge, SR 31 drops into a floodplain, and below #5 the road is about 10 vertical feet above the streambed.
3. The historic building that formerly housed the power generation plant is located on the floodplain next to Sullivan Creek just above SR 31.
4. The Metaline Falls sewage treatment facility lagoons are located near Sullivan Creek below SR 31. The lagoons are about 10 vertical feet above the streambed.
5. There is a landfill of cement kiln dust waste near Sullivan Creek above SR 31. The landfill was closed by constructing an impermeable cover on the surface, and by constructing a storm water management system. Groundwater leachate is strongly alkaline, and contains elevated concentrations of arsenic and lead. The landfill is above SR 31, and the streambed is about 10 vertical feet below SR 31. The creek makes a bend at this point, with some potential to undercut the slope.

6. The Metaline Falls water supply crosses Sullivan Creek, but the exact location of this crossing is not known.

Summary

The presence of the dam at Mill Pond has undoubtedly changed the amount of sediment and bedload entering lower Sullivan Creek stream. Given the background of landslides in this terrain, it is unclear to what extent this may have increased down cutting or lateral cutting – thereby increasing the amount or size of landslides.

Sullivan Dam operations have changed the magnitude of the peak flow event in Outlet Creek and downstream in Sullivan Creek. Prior to the dam, peak flows would occur in the spring in both Outlet and Sullivan Creek. The two streams may well have peaked at or near the same time. With dam operations, the spring flows from Outlet Creek are significantly reduced so the overall peak flow is perhaps half of what occurred under pre-dam conditions. It is possible the reduction in peak flows has reduced the extent, size and frequency of landslides on lower Sullivan Creek.

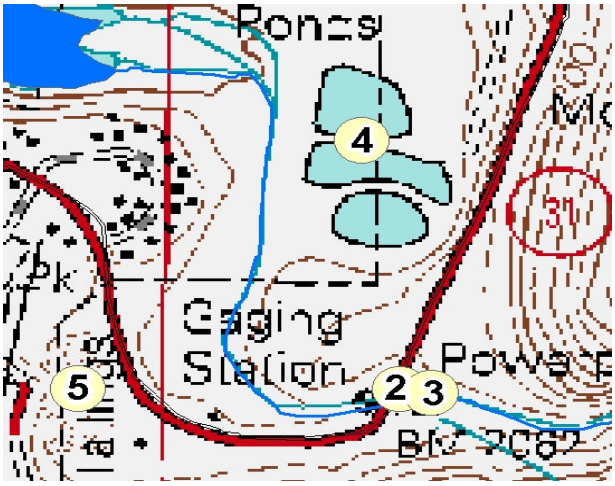
It is unclear how the reduction in bedload and the reduction in peak flows have interacted to impact slope stability, channel morphology, and flood risk in lower Sullivan Creek.

Scope of Analysis Area

The scope of the analysis area for soils and geology is—

- The area inundated by both Sullivan Lake and Mill Pond dams, with regard to sediment deposition during the life of the dams, material that may require removal or stabilization, and restoration of vegetation within the inundation zone;
- Harvey Creek upstream of Sullivan Lake for a distance of approximately 1,000 feet, with regard to the impacts of lake levels on sediment and bedload transport in Harvey Creek.
- Outlet and Sullivan Creeks, with regard to slope stability, channel conditions, and channel capacity.
- The Sullivan Creek watershed, with regard to peak flow and flooding.

Figure 8 – Map of developments



Fisheries and Hydrology

Existing Condition

Pend Oreille River:

Sullivan Creek flows into the Pend Oreille River downstream of Box Canyon Dam. Bull trout, westslope cutthroat trout, white sturgeon, mountain whitefish, northern pike-minnow, peamouth, redside shiner, sucker; sculpin and dace species were native to the Pend Oreille River system. Many of these species either have adfluvial life histories or are most likely resident within tributaries to Boundary Reservoir. The fluvial life stages of the bull trout and westslope cutthroat trout may no longer be present. Currently, bull trout are listed as threatened by the U.S. Fish and Wildlife Service and Region 6 of the USDA Forest Service considers the westslope cutthroat trout a sensitive species.

Historical data conflicted over the presence of chinook salmon and steelhead trout in the Pend Oreille system prior to impoundment (Scholz, et.al. 1985). A majority of the existing historical documentation indicates that the uppermost distribution of these species was either at Z Canyon or at Metaline Falls (the natural structure). Sullivan Creek is located just upstream of Metaline Falls (the natural structure). There is no historic data, presently known, that indicates that anadromous fish utilized habitat in the Sullivan Creek watershed.

Fish movement within the greater Pend Oreille River watershed and Lake Pend Oreille has been virtually eliminated by Albeni Falls, Box Canyon and Boundary dams. Construction of these dams without fish passage has possibly eliminated or greatly reduced adfluvial and fluvial populations of bull trout and westslope cutthroat trout (Bennett and Liter 1991).

Sullivan Creek:

Sullivan Creek watershed (1991-94) is the largest sub-watershed within the Boundary Reservoir reach. Mill Pond and Sullivan Lake dams have also isolated native species within the Sullivan Creek watershed as well as limiting movement of fish in Boundary Reservoir to only the lower 3.2 miles of this watershed.

Listed native salmonids and other salmonid species of concern (bull trout, westslope cutthroat trout and mountain whitefish) were once well distributed and abundant within the Sullivan Creek watershed. No year long, natural blockages to fish passage exist between Boundary Reservoir and the Sullivan Creek watershed (CES 1996).

With the probable restoration of passage conditions at both Albeni Falls Hydroelectric Project (USACOE email October 2003: Evan Lewis, personal communication) and Box Canyon Dam, re-colonization of the Boundary reach tributaries (including Sullivan Creek) by migratory bull trout from Lake Pend Oreille is likely to occur. Sullivan Creek is one of the largest tributaries to the lower Pend Oreille River. Portions of this

watershed have been designated as critical habitat for the recovery of the bull trout in northeast Washington. The watershed contains some of the best remaining spawning and rearing habitat for native salmonids in the lower Pend Oreille River.

The Sullivan Creek watershed, however, is not accessible (beyond 3.2 miles) to fluvial or adfluvial fish due to the presence of Mill Pond and Sullivan Lake dams. Fish passage at these dams is a high priority recommendation for the recovery of bull trout (Draft Bull Trout Recovery Plan, 2002). Bull trout are present in low numbers in the reach of the Pend Oreille River between Albeni Falls and Boundary Dams. Large (presumably adfluvial or fluvial) bull trout are present within Boundary Reservoir including lower Sullivan Creek. Bull trout have been found within the tributaries to Box Canyon Reservoir (BCR), and all life forms are present upstream of Albeni Falls Dam. Future efforts may include supplementation of locally derived adfluvial and fluvial bull trout and westslope cutthroat trout in order to strengthen these depressed stocks. Fish passage throughout the Pend Oreille River system will provide a migratory corridor for current bull trout and westslope cutthroat trout populations, as well as enhance supplementation efforts. The PUD, represented by Duke Engineering and Services (DE&S), has developed fish passage design alternatives for Box Canyon and Calispell Creek. The Army Corps of Engineers will complete an Albeni Falls Dam fish passage feasibility study by 2006.

Electro-fishing, hook and line, and trapping efforts in Boundary Reservoir, during August of 1999, have produced bull trout and cutthroat trout. The fish were large, 16-inch total length and greater and exhibited excellent condition factors (Al Solonsky, SCL per. comm. 1999: Joe Maroney, Kalispel Tribe per. comm. 1999). Water temperature may be a concern during late summer; however, westslope cutthroat and bull trout may be locating refugia within the reservoir during periods when temperatures are highest.

Table 3. Fish species composition of the Sullivan Creek watershed based upon historical and current records.

Fish Species	Native	Non-native	Extirpated
Bull Trout	X		
Cutthroat Trout	X		
Rainbow Trout		X	
Mountain Whitefish	X		
Brown Trout		X	
Brook Trout		X	
Kokanee		X	
Slimy Sculpin.	X		
Largescale Sucker	X		
Redside Shiner	X		
Dace Spp.	X		
Longnose Sucker	X		
Pygmy Whitefish	X		
Burbot	X		

* Native is defined as fish species indigenous to the Sullivan Creek system before European intervention and expansion.

Over the last ten years, the Sullivan Creek watershed has been surveyed for fish composition (Table 3) using gill nets (Sullivan Lake), snorkeling or electro-fishing methods, or a combination of methods. Biologists from the USDA Forest Service, R2 Consultants and DE&S Consultants independently conducted these surveys.

Table 4 – Fish species distribution

	Salmonids								Other		
Streams	Bull	Cut	Rain	Brown	Brook	Kokanee	Mountain Whitefish	Pygmy Whitefish	Burbot	Slimy Sculpin	Largescale Sucker
Upper Sullivan *		X	X	X	X	X	X			X	X
Lower Sullivan *	X	X	X	X	X		X		X	X	X
Sullivan Lake*		X	X	X		X		X	X	X	
N. Fork Sullivan Creek		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.

The Sullivan Creek watershed has been surveyed for physical habitat using the Hankin and Reeves aquatic habitat inventory methodology.

Habitat above Mill Pond Dam is divided into two segments; mainstem Sullivan Creek and Outlet Creek and Sullivan Lake and its tributaries. Sullivan Lake dam blocks upstream migration of salmonids into Sullivan Lake and its tributaries.

The habitat of Outlet Creek, below Sullivan Lake, is limiting to salmonids due to high water temperatures during the summer months (>60 Degrees F.), scarcity of spawning gravels as well as lack of instream large woody debris (USFS unpublished data 1996). Additionally, a major annual fluctuation in the stream flow, caused by the present operation of the SCH, occurs between October and December. The fluctuation is caused by the present operation of the SCH by the PUD. During early October, the PUD opens the gates of Sullivan Lake Dam and within a 24 hour period increases lower Sullivan Creek stream flow from 50-60 cfs to 300+ cfs. This increase in flow from Sullivan Lake continues until the level of the former natural lake is reached and outflow equals inflow. The 300+ cfs flow slowly decreases through the months of October, November and into December until this equilibrium is reached at about 50+ cfs for the remaining winter months.

A municipal water supply dam is located within the North Fork of Sullivan Creek. Below this dam are several falls that block upstream migration of fish. The habitat above

this small dam is considered to be adequate for the continued reproduction of a cutthroat population. Limiting factors appear to be the small size of the watershed and entrainment, if it occurs, of individuals over the dam. Noisy and Harvey Creeks are the two fish bearing tributaries of Sullivan Lake. Aquatic habitat of Noisy Creek has never been inventoried, except during snorkeling surveys. This stream goes subsurface for most of the year limiting access to spring spawners only. Harvey Creek, a much larger tributary, has fair to excellent quality habitat. The limiting factors are a scarcity of large in-stream wood and pool habitat on main Harvey Creek and the fact that flow goes subsurface approximately 1000 feet from its mouth for 8 months of the year disconnecting Sullivan Lake from the rest of this watershed. The apparent reasons, for this existing condition, are past riparian harvest, fires and at least one major flood event, which have caused a significant amount of aggradation in the stream habitat within main Harvey Creek. The annual filling of the lake from March through June coincides with peak flows in Harvey Creek limiting the ability of the stream to move this accumulated bedload.

Habitat of upper Sullivan Creek and its tributaries ranges from fair to excellent in quality. Limiting factors in this stream include scarcity of in-stream large woody debris and pool habitat, substrate embeddedness and marginal summer water temperatures on main Sullivan Creek. These limiting factors can be traced back to past historic riparian logging, stream cleaning and the location of the existing road system. The habitat of the tributaries of Sullivan Creek above Mill Pond tends to be more complex and of better quality with steep gradients being the limiting factor.

More detailed discussion of surveyed stream habitat (Sullivan, Harvey, North Fork Harvey, Middle Fork Harvey, Deemer, Leola, Gypsy, Fireline, Copper, Mankato, Stony, Thor and North Fork Sullivan Creeks) may be found in USDA Forest Service stream survey data reports.

Limited data has been collected on the lakes and reservoirs within the Boundary Reservoir area of influence. Information that has been collected includes fish presence/absence surveys and limited water quality data.

All lands adjacent to Sullivan Lake are under USDA Forest Service management. Sullivan Lake dam located at the outlet to Sullivan Lake controls lake stage. Lake elevation was raised approximately 30 feet above the natural lake stage by the dam with an approximate max depth at controlled full pool of 312 feet. Sullivan Lake supports reproducing populations of brown, rainbow and cutthroat trout, kokanee, burbot, and pygmy whitefish, as well as dace, redside shiner and sucker species. Mill Pond Reservoir contains brown, rainbow, brook and cutthroat trout, kokanee and sucker species. It is unknown whether these populations are declining, increasing or stable. A limnological survey has been conducted on Sullivan Lake.

Mill Pond Reservoir is 63 surface acres in size. Past land management activities initiated excessive sediment transport (Wasson pers. comm. 1999) from the upper watershed with subsequent deposition of coarse particles within the transition zone and finer clays and

silts into the lacustrine zone of Mill Pond, thereby decreasing pool volume of the reservoir over time. Very little water quality or habitat data exists on Mill Pond reservoir. Mill Pond Dam intercepts large woody debris and gravel being transported downstream.

Although an aquatic habitat survey of Sullivan Lake will not be completed until the end of the summer of 2005, it is reasonable to suggest that littoral habitat is comprised of gravels and cobbles, which may provide limited shoreline spawning. Limiting factors to successful shoreline spawning and rearing would include drastic changes in lake levels, lack of littoral zone, and possibly lack of littoral cover**.** Sullivan Lake is considered oligotrophic, exhibiting low overall productivity (Smith, et al 2000). The zooplankton population levels are apparently sufficient to support kokanee and pygmy whitefish populations. Much of the habitat complexity for fish appears to be related to the differences in the lake substrate and less from large wood. The quality and quantity of spawning substrate in Sullivan Lake for lake spawning species such as pygmy whitefish, kokanee and burbot is unknown, but reproduction of these species continues to be successful.

Scope of Analysis

The scope of analysis for this Project includes the complete Sullivan Creek watershed. This watershed includes Sullivan Creek and its tributaries, as well as, Sullivan Lake and its tributaries.

Heritage

Existing Condition

The SCH has one site (45PO148) listed as eligible to the National Register of Historic Places.

The historic portion of the SCHP consists of two main components: the Mill Pond complex and the Sullivan Dam complex.

The Mill Pond historic complex is comprised of multiple components. These include:

1. Original 1909 log crib dam (inundated),
2. Existing (modified) concrete dam and spillway,
3. Existing log cabin,
4. Log flume,
5. Historic archaeological component,
6. Earthen dam/dike, and
7. Associated deteriorating historic structures.

The Sullivan Dam complex includes:

1. Existing (modified) concrete dam and spillway, and
2. Diversion ditch from Sullivan Creek to Sullivan Lake.

None of the above historic properties or historic property locations are currently evaluated to National Register standards. The Washington State Department of Archaeology and Historic Preservation (SHPO) files reflect that some of the above historic properties are documented as not eligible to the National Register. However, the SHPO, in a letter dated November 4 1993, concurred with the recommendation in the Cultural Resource Assessment for the SCHP that the project was eligible to the National Register as a Historic District.

The Project Area is within the traditional use area of the Kalispel Tribe, and archaeological resources discovered in these adjacent areas well-document the pattern of traditional Kalispel life ways (Thoms 1987, Sanders 1991). Archaeological site numbers 06210500082 and 06210500083 have been partially excavated and determined eligible to the National Register of Historic Places.

Scope of Analysis Area

The Scope of Analysis is the Area of Potential Effect (APE). The APE is defined as the geographical area or areas within which an undertaking can cause changes in the character or use of historic properties, if such properties exist (36 CFR 800.2 C). The APE does not discriminate between Federal and non-Federal land ownership. Depending on the scope of the undertaking, the APE may encompass an area greater than simply the Project boundaries. Specifically, if an historic property is found to be wholly or partially within the Project boundary, that property must be recorded and evaluated. For the SCH, the APE is the FERC licensed project boundary.

Terrestrial

Existing Condition

Sullivan Lake is a natural lake formed by a glacial moraine. Harvey Creek is the primary and largest stream entering the lake. Where Harvey Creek enters Sullivan Lake, the lake seasonally floods the depositional zone area. The mudflat contains numerous stumps from when the dam was built in 1909 and is exposed during the drawdown period (i.e. winter). Sullivan Lake has a seasonal fluctuation zone of 20 some odd vertical ft that affects establishment of shoreline riparian vegetative communities and the species dependent and associated with those communities.

Mill Pond log-crib dam was constructed in 1909. Historic photographs of the Mill Pond area prior to construction indicate that the reservoir flooded a stand of large western red cedar. Sullivan and Outlet Creeks are the primary water-sources flowing into Mill Pond. The impoundment occurs in a low gradient segment of Sullivan Creek. Because the lake

level does not fluctuate significantly, riparian vegetation and topsoil occur to the waters edge. At the inlet end, Sullivan Creek has created a large depositional area that is well vegetated with alder and brush.

Both dams may affect riparian species connectivity and contribute to habitat fragmentation.

Fauna

Threatened and Endangered Species:

Table 5 - (FWS reference: 1-9-00-SP-073 (118.0000)).

Species	Status	Essential Habitats Within or Adjacent to the Project Area
gray wolf *(Canis lupus)*	E	foraging - habitats that support big game, particularly winter ranges, calving/fawning sites denning - moderately steep slopes on south aspects within 400 feet of water seclusion from human disturbance
grizzly bear *(Ursus arctos)*	T	Grizzly bear recovery habitat is located on the Sullivan Lake Ranger District. spring foraging - lower elev. riparian areas, meadows, with succulent grasses, herbs, etc. summer/fall foraging - mid to high elevation, berry producing shrub fields denning - north side of ridge tops with deep soils seclusion from human disturbance

Grizzly bear (*Ursus arctos*)

Lands lying east of Sullivan Lake and north of County Road 9345 (just across from Mill Pond) are within the Selkirk Mountain Grizzly Bear Recovery Area. The week after Labor Day weekend of 2004, a collared bear moved through the Project area.

Palatable grasses, sedges, and forbs provide spring forage for grizzly bears. Within the Project area, these plants can be found principally within two small wetlands; one located at the south end of Sullivan Lake, and the other just southwest of Mill Pond. As outlined in the previous section on bald eagles, present operation of the Project is preventing littoral vegetation from establishing along the shoreline of Sullivan Lake. If this vegetation were able to develop, some of these plants could provide food resources for bears. However, the presence of developed campgrounds and trails, the ranger district compound, private residences, and County Road 9345 within close proximity to the lake could hamper the ability of bears to fully utilize these resources.

Gray wolf (*Canis lupus*)

The Northern Rocky Mountain Wolf Recovery Plan (USDI, 1987) identifies three areas for wolf recovery: the Yellowstone and Glacier National Park ecosystems, and central Idaho. Currently, there are no plans for wolf recovery in Washington State.

On rare occasion, wolves or wolf tracks have been reported within proximity to the Project area. Few sightings of wolves on the Colville National Forest can be confirmed as such. Many people who own land near the Project area own dogs, and some of these are wolf hybrids. Large coyotes seen for a brief time can be mistaken for wolves.

There is no evidence of a pack of wolves using the forest. A pack is basically a family unit containing an adult pair (the pack's leaders), this year's pups, and young of past years. The presence of a pack would mean that breeding is occurring and a pack territory has been established. At this time, animals seen on the forest appear to be transient, moving over large areas.

In the Northern Rocky Mountains, wolves prey mainly on big game animals (Hansen, 1986). Potential prey animals found within the Project area include mule and white-tailed deer, elk, moose, and Rocky Mountain Bighorn Sheep. "Forage, water, and cover are the primary habitat factors that limit deer and elk populations" (Thomas, et al, 1979). Optimum calving and fawning habitats contain high quality foraging areas and dense cover within close proximity to water.
The Project area and surrounding environs provide both summer and winter habitats for big game. Potential calving / fawning sites exist within the Project area; particularly along Outlet and Sullivan Creeks, and the wetland located southwest of Mill Pond.

Present operation of the dam on Sullivan Lake leads to a quick, 20-foot drop in the lake level in October of each year. This lower level is maintained until February. Thus, there is little opportunity for riparian plants such as sedges and willows to become permanently established along the lakeshore. These plants could provide important forage resources for big game. Riparian shrub patches could provide protective hiding cover that would make for secluded resting and watering sites. A fully developed littoral zone on Sullivan Lake could provide additional calving / fawning habitat for deer and elk.

Regional Forester Special Status Species (RFSSS):

Table 6 - RFSSS Wildlife Species with Potential to Occur in the Project Area.

Species	**Potential to Occur**	**Range/Essential Habitats**
bald eagle *(Haliaeetus leucocephalus)*	Documented (nesting confirmed)	foraging - rivers, large lakes with abundant fish (both Sullivan Lake and Mill Pond) nesting/perching - large trees typically located close to a foraging site (active nest on Outlet Creek) roosting - late and old structural stage stands with good canopy closure
common loon *(gavia imner)*	Documented (nesting not confirmed)	Loons require large lakes or rivers with abundant fish (example; Pend Oreille River) that have adequate shoreline vegetation to conceal a nest. Seclusion from human disturbance is critical to nesting loons.
Northern leopard frog *(Rana pipiens)*	Low	Found in wet meadows, potholes and riparian areas with much concealing cover, this frog may be very susceptible to predation by bullfrogs.

Species	Potential to Occur	Range/Essential Habitats
Eared Grebe *(Podiceps nigricollis)*	Documented (Sullivan Lake)	Not listed as sensitive for the Colville NF
Townsend's big-eared bat *(Corynorhinus townsendii)*	Documented (Lakeshore Mine)	hibernation - caves or mine adits that are generally close to freezing reproduction - nursery colonies are typically located in sites above 50 degrees F., often in old abandoned buildings roosting – caves, mine adits, old buildings, and the undersides of bridges
wolverine *(Gulo gulo)*	Low – likely to occur only during dispersal	denning - rock slides, caves, crevices, particularly in glacial cirque basins foraging - all habitats but particularly those where carrion can be found seclusion from human disturbance
great gray owl *(Strix nebulosa)*	Low	foraging - open, grassy habitat including open forest stands, selective and clear-cut logged areas, meadows and wetlands nesting - forest stands near lakes, wet meadows, and pastures nest structures - large, broken topped snags, abandoned raptor nests
sandhill crane *Grus canadensis)*	Low	feeding/resting - large tracts of undisturbed marshes or meadows nesting - isolated sites with good cover more than ¼ mile from roads
Peregrine falcon *(falco peregrinus anatum)*	Low	foraging – habitats that provide waterfowl, upland game birds, and larger passerine birds; particularly open marshes, rivers, seacoasts nesting – scrapes placed on a ledge of a tall (150+ foot) sheer cliff.
Pacific fisher *(Martes pennanti)*	Low	Fishers inhabit dense coniferous or mixed coniferous/deciduous forests with good canopy closure. They prefer late / old structural stage stands. travel habitat – stands adjacent to lakeshores, riparian areas, ridges denning – large hollow logs or snags, tree cavities, brush piles, etc.
Harlequin duck (*Histrionicus histrionicus*)	Documented	nesting – along clear rock streams foraging – stream bottoms for crustaceans and mollusks
Eared grebe (*Podiceps nigricollis*)	Likely to occur	nesting – on marshy ponds foraging – dives in ponds for small aquatic insects and crustaceans
Pygmy shrew (*Microsrex hoyi*)	Likely to occur	habitat – wooded and open areas, wet or dry

Bald Eagle (*Haliaeetus leucocephalus*)

Nest trees selected by bald eagles are commonly among the largest in the stand, often towering above the main forest canopy. Such trees provide a panoramic view of the surrounding area, a sturdy platform on which to build a large nest, and an unobstructed flight path to and from the nest (Stalmaster, 1987). Perch trees are typically located close to a foraging area such as the Sullivan Lake (Steenhof et al. in USDI, 1986). Eagles consistently use preferred branches for perching.

Active eagle nests are typically well distributed along the shoreline of a river or lake. Nesting pairs defend a nest territory in order to monopolize food resources in an area. Active territories include favored perch, roost, and nest trees that are used exclusively by the nesting pair. In Washington State, nest territories were found to be as large as 8.14 square kilometers (Stalmaster, 1987). Grubb (in USDI, 1986) found the average nest territory in western Washington to have a radius of 2.6 kilometers.

In the spring of 2003, a bald eagle pair established a new nest in a snag located on Outlet Creek, about 100 yards below the Sullivan Lake dam. This nest was started quite late in the season and was eventually abandoned. This nest was active again in 2004. As was

the case the previous year, incubation by the eagle pair was initiated late in the season and the nest was abandoned. The second nesting attempt at this site (2004) failed again. Since 2004 the eagle nest has been active.

There may be a new bald eagle nest on the south shore of Sullivan Lake. The week of March 14, 2005, two adult birds are near what appears to be a stick platform.

The most important component of habitat used by eagles is a foraging area that provides enough food with a minimum of disturbance from humans (Stalmaster, 1987). Typically a few bald eagles (1-5 or so) are observed at the mouth of Harvey Creek (main Sullivan Lake inlet) from about mid November through December or later, when the kokanee are spawning in the creek. One or two birds may be seen on Outlet Creek at this time as well. In the springtime starting about April, one or more birds may be seen at these same locations. Eagles are occasionally seen foraging on Mill Pond during the summer.

As the Project is presently operated, the water level of Sullivan Lake is drawn down 20 feet each year from October to February. Because of this annual draw down, algae, aquatic vegetation, emergent vegetation, and riparian shrubs cannot gain a permanent foothold along the edge of the lake. These plants would provide cover for shoreline spawning fish. They would also provide habitats for aquatic invertebrates on which fish feed. The annual fluctuation in the lake's water level may also be causing the eggs of fall, shoreline-spawning fish to be de-watered.
Before the dam on Sullivan Lake was constructed, the extent of the riparian and in-stream habitat on Harvey Creek was greater than it is today. Present operation of the dam continues to suppress the development of this habitat on Harvey Creek: the major spawning area for fish in Sullivan Lake.

When the gates of Sullivan Lake dam are opened the first week of October, there is a substantial increase in flow in Outlet and Sullivan Creek. Thus, fall spawning fish in these creeks have access to more available habitat at this time. However, flows return to their pre-October levels by the beginning of December, leaving many redds in the temporarily expanded stream habitat de-watered.

All of the above continuing impacts to fish productivity act to reduce the potential forage base for bald eagles and other fish eating birds in the Project area.

Common loon (*Gavia imner*)

Loons are totally dependent on water and prefer to nest on the edges of large (>40 acre) lakes and rivers. They select the most secluded shoreline habitat available for nesting and are prone to abandoning an active nest if disturbed by human activity. Nests are typically placed in dense, concealing vegetation within a few feet of the water's edge. Loons are awkward on land, so a gentle grade to the shoreline is desirable for nesting purposes.

During migrations, loons sometimes use Sullivan Lake and Mill Pond as resting and foraging sites. There are no known records of loons nesting on either water body. Before permanent developments such as campgrounds, access roads, trails, interpretive sites, etc., were constructed on these lakes, loons may have used them for nesting. Of the two lakes, Sullivan Lake likely had much greater potential for nesting opportunities owing to its large size.

The Project as it is presently operated provides little opportunity for loons to successfully nest on Sullivan Lake. Early in the nesting season the water level of the lake is down, exposing an open "bath tub ring" of rock and silt along the lakeshore. There is little vegetative cover near the water at this time of year within which to conceal a nest.

As described in the previous section on bald eagles, present operation of the Project results in the suppression of fish productivity in Sullivan Lake. This, in turn, reduces the forage base for fish eating birds like loons.

Northern leopard frog (*Rana pipiens*)

This species requires wetland habitats where there is an abundance of concealing cover. Northern leopard frogs prey upon insects, spiders, sowbugs, leeches, fish, amphibians, snakes, and small birds (Leonard, et al, 1993). In the summer they may be located far from water. This frog hibernates on the bottom of ponds or slow moving streams. Identified threats to this species include predation and competition from introduced species (particularly bullfrogs), and application of agricultural chemicals (McAllistar, et al, 1999). No records of this species from the Project area exist in district records.

Potential leopard frog habitats in the Project area include two discrete wetlands. One site is a small, seasonally inundated area located at the south end of Sullivan Lake. The Sullivan Lake Dam as it is presently operated provides little opportunity for aquatic and emergent plants to become permanently established elsewhere along the lakeshore. The second wetland in the Project area is a larger, permanently flooded site located southeast of Mill Pond. This wetland contains aquatic and emergent plants, and riparian shrubs.

The following invertebrates are now listed as RFSSS for the CNF

Species	**Habitat Present?**	**Comments**
meadow fritillary (*Boloria bellona*)	Yes	Common in the eastern US in hayfields and human-disturbed habitats. In the west they occur in meadows and openings in aspen or pine forests.
Great Basin fritillary (*Speyeria egleis*)	No	This species uses forest openings and edges, generally at higher elevations.
Rosner's hairstreak (*Callophyrus nelsoni*)	Yes	Habitat for this species includes openings and edges in coniferous forest around western red cedar stands.
magnum mantleslug (*Magnipelta*	Yes	Found in a variety of low to mid-elevation sites, often with water in the general vicinity.

mycophaga)		
Fir pinwheel (*Radiodiscus abietum*)	Yes	Most often found in moist and rocky Douglas fir forest at mid-elevations in valleys and ravines and sometimes in western redcedar. Often found in or near talus of a variety of rock types, or under fallen logs.
masked duskysnail (Lyogyrus spp.)	Yes	This species is a kettle lake associate.

CNF Management Indicator Species:

Table 7 – Management Indicator Species with Potential to Occur in the Project Area.

Species	Potential to Occur in the Project Area	Habitat Represented
Grizzly Bear	Documented	Specific habitat components and seclusion
Caribou	Low	Specific habitat components
Big Game	Documented	Winter range
Blue Grouse	Low	Winter habitat – mature trees or clumps of trees along ridge tops. Nesting habitat – open forest with grass/shrub understory at lower elevations.
Franklin's Grouse	Low	Young lodgepole pine with interspersed mature spruce.
Northern Three-toed Woodpecker	Good	Mature lodgepole pine or subalpine fir.
Pileated Woodpecker	Documented	Mature and old growth forest in Douglas fir or cedar/hemlock working group. Large snags and logs.
Woodpeckers	Documented	Special habitat component snags.
Barred Owl	Documented	Lower elevation mature and old growth forest.
Marten	Good	Mature & old growth mesic conifer forest, down trees at moderate to high elevations.
Beaver	Good	Aquatic & riparian, aspen or willow.
Large Raptors/Great Blue Heron	Documented	Nest trees.
Northern Bog Lemming	Low	High elevation bogs.
Trout	Documented	Lacustrine, riverine & riparian.

Other Wildlife Species:

Big game - The Project area and surrounding environs provide winter range habitat for several species of ungulates including Rocky Mountain bighorn sheep, elk, and mule and white-tailed deer. A small herd of Rocky Mountain Bighorn Sheep use Hall Mountain (east side of Sullivan Lake) throughout the year. There was a feeding station for these animals located at Noisy Creek at the south end of Sullivan Lake. The WDFW phased out this operation in winter of 2002-2003. The herd numbers around 35 animals now and

is not hunted. Small bands of elk live in the area. A good elk-viewing site is in a farmer's field about 2 miles west of Mill Pond on County Road 9345 (Sullivan Lake Road). Up to 30 animals may be seen in the spring in this field. The Project area provides winter range for elk, white tailed deer and some mule deer.

Present operation of the dam on Sullivan Lake leads to a quick drop in the lake level of over 20 feet in October of each year. This lower level is maintained until February. Thus, there is little opportunity for riparian plants such as sedges and willows to become established along the lakeshore. These plants could provide important winter forage resources for elk and deer, as well as protective hiding cover that would better enable these animals to find resting sites and access to water during the warm months.

Waterfowl - Sullivan Lake and Mill Pond support several pairs of breeding ducks and grebes each year. Mill Pond tends to support a greater diversity of species and produce more broods than Sullivan Lake. This may be because Mill Pond has comparatively greater amounts of aquatic and emergent vegetation, shallow water areas, and areas of dense cover along its shoreline. The Sullivan Lake dam as it is presently operated provides little opportunity for riparian and aquatic plants to become permanently established along the margins of Sullivan Lake. These plants could provide concealing shoreline cover for nesting ducks and grebes. Aquatic plants and the macro-invertebrates they support could provide food resources for many water birds. In addition, present operation of the dam suppresses the fish productivity of the lake (as described in the section on bald eagles). This indirectly results in a reduced forage base for fish eating birds like mergansers.

Harlequin ducks nest on the banks of swift moving mountain streams. They dive into the water to forage on macro-invertebrates on the stream bottom. Each year, a few pairs of harlequin ducks nest on Harvey and Sullivan Creeks above Mill Pond. Before Mill Pond was created, the section of Sullivan Creek that was inundated likely looked very similar to forested riparian habitats higher up in the drainage. The section of creek that was inundated might have provided nesting habitat for this species.

Land birds - Many neotropical migrant songbirds are associated with riparian shrub habitat. This habitat type is important to willow flycatchers, yellow warblers, song sparrows, and a number of other songbirds. The margins of Mill Pond and the wetland upstream from the pond provide habitats for a wide array of land birds. The rapid fluctuation of the water level of Sullivan Lake prevents riparian vegetation from gaining a foothold along most of that lake’s shoreline. The bird conservation goal for this habitat on National Forests in Washington and Oregon are to have no net loss of habitat, to enhance connectivity, enhance for multiple layers, and to minimize degradation (Altman, 2000).

Flora

RFSSS Species:

Sensitive plant species, habitat and its potential to occur within the Project area. Those plants known from the Project are indicated as documented. The potential for sensitive plants suspected to occur in the Project is rated as low or good.

Table 8 – RFSSS Plant Species

Vascular Plants		
Species	**Potential to Occur**	**Habitats**
Nuttal's pussy-toes *(Antennaria parvifolia)*	Low	Dry, open places, on sandy or gravelly riverbanks, openings of ponderosa pine forests 1900-2600 ft.
Least bladdery sedge *(Astragulus microcystis)*	Low	Open woodlands near shorelines, riverbanks, floodplains, 1900-2100 ft.
Prairie moonwort *(Botrychium ascendens)*	Good	Dry meadows, 3000-3400 ft.
Crenulate moonwort *(Botrychium crenulatum)*	Good	Western redcedar-western hemlock forests, streambanks, floodplains, 2030-4600 ft.
Western moonwort *(Botrychium hesperium)*	Low	Dry to moist meadows, 3200-3300 ft.
Skinny moonwort *(Botrychium lineare)*	Good	Western redcedar-western hemlock forests, streambanks, floodplains, 2000-4000 ft.
Two-spiked moonwort *(Botrychium paradoxum)*	Good	Dry meadows, perennial and intermittent streams, 2500-3600 ft.
Stalked moonwort *(Botrychium pedunculosum)*	Low	Dry to moist meadows, perennial streams, 2500-3300 ft.
Hair-like sedge *(Carex capillaris)*	Low	Streambanks, wet meadows, moderate to high elevations.
Bristly sedge *(Carex comosa)*	Low	Marshes, lake margins, drainage ditches, wet meadows, 30-2000 ft.
Yellow bog sedge *(Carex dioica* var. *gynocrates)*	Low	Bogs, marshes, moderate to high elevations.
Yellow sedge *(Carex flava)*	Documented	Fens, bogs, wet meadows and ponds, 2420-4300 ft.
Bronze sedge *(Carex foenea)*	Documented	Marshes, 2585 ft.
Porcupine sedge *(Carex hystricina)*	Low	Wet meadows, ponds, marshes, seeps, 550-1500 ft.
Russet sedge *(Carex saxatilis var. major)*	Low	Wet meadows and margins of lakes and streams.
Bulb-bearing water hemlock *(Cicuta bulbifera)*	Low	Marshes, bogs, wet meadows, edge of ponds, shores of beaver ponds, shallow standing water, 2200-3720 ft.
Water avens *(Geum rivale)*	Low	Wet meadows, fens, bogs, perennial streams and shrub wetlands, 2900-3700 ft
Stellar's rockbrake *(Cryptogramma stelleri)*	Low	Cliffs, 3000-35000 ft.
Yellow lady's slipper *(Cypripedium parviflorum)*	Low	Perennial streams on limestone rock under mixed conifer forest, 2300-2700 ft.
Yellow mountain avens *(Dryas drummondii)*	Low	Cliffs, 2000 ft.
Crested shield fern *(Dryopteris cristata)*	Low	Fens, wet meadows and wooded swamps, 2150-4100 ft.
Green keeled cotton-grass *(Eriophorum viridicarinatum)*	Low	Fens and marshes, 2900-4650 ft.
Creeping snowberry *(Gaultheria hispidula)*	Low	Moist areas in coniferous woods, 2960-3360 ft.
Canadian St. John's -wort *(Hypericum majus)*	Low	Mudflats, 1500 ft.

Treelike clubmoss *(Lycopodium dendroideum)*	Low	Coniferous forests, 3000-3650 ft.
Marsh muhly (Muhlenbergia glomerata)	Low	Bogs, fens, streambanks, wet meadows, marshes, lake and pond margins, 2950-3380 ft.
Adder's tongue (Ophioglossum pusillum)	Low	Moist meadows, 2800-3200 ft.
Small northern bog-orchid (Planthera obtusata)	Low	Moist meadows and perennial streams in coniferous forests, 4100-4400 ft.
Hoary willow *(Salix candida)*	Low	Fens, 2400-3000 ft.
MacCall's willow *(Salix maccalliana)*	Low	Fens, 2400-3000 ft.
Northern willow *(Salix pseudomonticola)*	Low	Fens, 2900 ft.
Black snake-root *(Sanicula marilandica)*	Low	Bogs, fens, streambanks, floodplains, benches, 1800-3050 ft.
Blue-eyed grass *(Sisyrinchium septentrionale)*	Low	Dry to moist meadows, perennial streams, 2200-3850 ft.
Prairie cordgrass *(Spartina pectinata)*	Low	Sandy, silt loam soil adjacent areas seasonally flooded and moist in late summer along large rivers, 2000 ft.
Woodsage *(Teucrium canadense* ssp. *viscidum)*	Low	Wet margins of lakes and ponds, streambanks, 1500-2300 ft.
Purple meadowrue *(Thalictrum dasycarpum)*	Low	Dry meadows, mixed conifer forests, riverbanks, floodplains, 2000 ft.
Velvet-leaf blueberry *(Vaccinium myrtilloides)*	Low	Western redcedar-western hemlock forests, 2000-3000 ft.
Non-Vascular Plants: Lichens		
Brook lichen *(Dermatocarpon luridum)*	Low	Aquatic; on rocks, boulders and bedrock in streams, rivers, or seeps, usually submerged or inundated for most of the year.
Jellyskin *(Leptogium burnetiae* var. *hirsutum)*	Low	Typically epiphytic on trees but also on decaying logs, rocks and moss.
Blue jellyskin *(Leptogium cyanescens)*	Low	Tree bark of conifers and hardwoods, logs, mossy rocks in cool, moist micro-sites.
Naked kidney lichen *(Nephroma bellum)*	Good	On branches and twigs of trees, especially conifers. Also on mossy rocks in humid forests.
Black saddle lichen *(Peltigera neckeri)*	Low	Mossy logs, soil and tree bases in wet forested habitats.
Fringed pelt *(Peltigera pacifica)*	Low	Mossy logs, soil and rocks in moist forest habitats
Non-vascular Plants: Mosses		
Luminous moss *(Schistotega pennata)*	Low	Damp acidic rock, soil and decaying wood, in dark places (openings of caves or mine shafts), in rock crevices or overhangs, animal burrows, on shaded banks, in crevices of root balls, fallen trees or around tree roots in dark forests.
Splashzone moss *(Scouleria marginata)*	Low	Semi-aquatic on rocks along the edge of streams.
Tetraphis moss *(Tetraphis geniculata)*	Low	Moist coniferous forest with large down logs. It occurs on the cut or broken ends, or lower sides of decay class 3, 4, 5 rotted logs or stumps and occasionally on peaty banks in moist coniferous forests from sea level to subalpine elevations.

There is little information regarding the number, distribution and condition of sensitive plants in the Project area. *Carex flava* (yellow sedge) and *Carex foenea* (bronze sedge) are the only USDA Forest Service (Region 6) sensitive plant species documented from the Project area (USDA Forest Service 2005). Each is known from one location in the area. Because these two plants are documented from less than 20 sites in the state, the Washington National Heritage Program (WNHP) category for them is sensitive. This means the species are "vulnerable or declining and could become endangered or threatened in the state without active management or removal of threats (WNHP 1997)."

Other Plant Species:

The Washington Natural Heritage Program (WNHP 1997) tracks rare plants on all lands within the state and assigns them to one of six categories: Endangered, Threatened, Sensitive, Possibly Extirpated from or Extinct in Washington, Review (Groups 1 or 2) and Watch.

Five taxa documented from the Pend Oreille Valley are considered Review Taxa. These are plants for which more information is needed to accurately assess their category of rarity. Chaffweed (*Centunculus minimus*), golden corydalis (*Corydalis aurea*), water star-grass (*Heteranthera dubia*) and common butterwort (*Pinguicula vulgaris*) are on the Review Group 1 list, which includes taxa for which more fieldwork is needed to assess their rarity and the degree to which they are threatened. Orange balsam (*Impatiens aurella*), on the Review Group 2 list, is a taxa with unresolved taxonomic questions.

Three plants known from northeastern Washington are in the WNHP Watch Category. These include the green spleenwort (*Asplenium trichomanes*), smooth cliff-brake (*Pellaea glabella var. simplex*) and woolgrass (*Scirpus antrocinctus*), formerly recognized as *S. cyperinus*). Watch Category taxa are more abundant and/or less threatened in Washington than previously thought. Botanical surveys in Pend Oreille Valley in the last eight years revealed several plant species that were not known to occur in Washington: *Carex tenera* (slender sedge), *Galium palustre* (common marsh bedstraw) and *Hedeoma sp. nov.* (penny-royal). An evaluation of their rarity category in Washington is needed.

In the Flora of Pend Oreille County, Washington (Layser 1980) the author states, "Sullivan Lake and its immediate environs do not represent unique plant habitat in the sense that has been considered earlier. Sullivan Lake is treated here because recreation attractions bring many people to visit the area about the lake. Some of the interesting or attractive plants to be found about the lake are given below. At one time before the large cedars were cut and the lake level raised, the place where Harvey Creek entered the lake may have been a particularly interesting and floristically rich area. Fluctuating water levels have now converted that place into mudflats that support various waterweeds for part of the year. One small, but unusual, plant to look for in the pools as the lake recedes is *Tillaea aquatica* [Crassula aquatica]."
Layser continues with a couple of lists, "Some interesting plants occurring on the bench at the north end of Sullivan Lake area:"

Scientific Name	Scientific Name
Allium cernuum	*Hieracium albiflorum*
Calypso bulbosa	*Lilium columbianum*
Carex rossii	*Oryzopsis asperifolia*
Gaultheria ovatifolia	*Pyrola asarifolia asarifolia*
Habenaria unalascensis	*Vaccinium myrtillus*

"Some interesting plants occurring on the rock outcrops along the Sullivan Lake trail include:"

Scientific Name	Scientific Name
Clarkia pulchella	*Saxifraga bronchialis austromontana*
Corydalis aurea	*Sedum lanceolatum*
Crptogramma crispa acrostichoides	*Selaginella wallacei*
Montia parvifolia	*Woodsia scopulina*

Kreager collected in Pend Oreille County as far north as Box Canyon. Sullivan Lake is mentioned in 1950 when W. B. and V. E. Cooke collected there. From 1967 to 1973 Earle Layser collected throughout Pend Oreille County in preparation for his book on the flora of the county.

Noxious Weeds:

Table 9 - Documented and Suspected Noxious Weeds in the Project Area.

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*

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.

When the water level of Sullivan Lake is drawn down in the fall, there is an exposed "bath tub" ring around the lake that is mostly less than 100 feet wide. After many years of wave action and fluctuating lake levels, there is much exposed rock in the draw down zone and soils for the most part are very sterile. The exception to this condition is at the shallow, south end of the lake where a several hundred foot wide fan of alluvial sediments becomes exposed during draw down.

Existing noxious weeds in the Sullivan Lake area that could potentially invade areas of exposed soils include spotted and diffuse knapweed, Dalmatian toadflax, St. John's wort, meadow and orange hawkweeds, plumeless thistle, and common tansy. These plants are presently unable to establish in the exposed soils of Sullivan Lake since they would become inundated as the lake fills each spring.

Mill Pond has a stable lake level and a well-vegetated shoreline. Noxious weeds exist in the area around the pond; particularly in the interpretive site located west of the pond. Knapweeds and hawkweeds are the most prevalent species in this area.

Scope of Analysis Area

The analysis area includes the following:

- Sullivan Lake, Mill Pond, Outlet Creek, Sullivan Creek (between Outlet Creek and Mill Pond), Lower Harvey Creek (up 0.25 mile from its mouth) and the riparian habitat conservation areas (RHCAs) around these water bodies,
- The BEMA and BECA used by the nesting pair of bald eagles on Outlet Creek and Noisy Creek campground, if it is larger than the RHCAs,

- Areas of existing noxious weed infestations or exposed soils within 0.5 mile of the water bodies listed above. These would include the interpretive site located adjacent to and west of Mill Pond, and exposed cut slopes above Sullivan Lake on County Road 9345 (Sullivan Lake Road).
- For the gray wolf and grizzly bear. Salmo and Sullivan-Hughes Grizzly Bear Management Units.

Engineering

Existing Condition

Sullivan Lake Dam, National Inventory of Dams No. WA00011:

Sullivan Lake Dam is comprised of concrete gravity spillway section and two concrete gravity wing walls on each side of the spillway. The dam is 34 ft. high and 210 ft. long. The spillway crest is 58 ft. long and accommodates six vertical 5 ft. wide by 4 ft. high wooden gates. At the base of the spillway and low-level discharged are manually operated by personnel form the Box Canyon Project.

Sullivan Lake is maintained at a constant elevation of 2,588.66 ft. mean sea level (MSL) for recreational purpose during the months of May through September. Beginning in October, Sullivan Lake is drawn down to provide storage for spring runoff. The minimum elevation of Sullivan Lake Dam is 2,564 ft. MSL. Sullivan Lake dam is a high hazard, class B dam (according to the USDA Forest Service administration classification and hazard assessment classification contained in USDA Forest Service Manual 7500). There is an emergency action plan (EAP) proposed in 1999 and updated annually by the PUD. Its purpose is to clarify outline procedures for emergency personnel in event of dam failure. It should be noted that failure of the Sullivan Lake Dam is more likely to occur when Sullivan Lake is full during the period from May through September. Downstream along Outlet Creek are seasonal passages. These are currently monitored by the PUD.

Mill Pond Dam, National Inventory of Dams No. WA00012:

Mill Pond Dam is located about 1.5 miles downstream form Sullivan Lake Dam. The dam is a composite structure consisting of a concrete gravity dam and an earthen dike. The concrete gravity dam is about 55 feet high from foundation to the crest of the un-gated spillway at El. 2505.7. The trapezoidal-shaped spillway section is notched in the center of the dam. The spillway crest length is 34 feet at El. 2505.7, and 81 feet at El. 2513.9. The total top width of the dam is about 120 feet. The earthen dike extends beyond the left abutment of the gravity dam a distance of about 850 feet. The dike has a crest length of about 10 feet and side slopes of 1.5 H: 1.0 V upstream and downstream. The crest of the dike is at El. 2517.5, except for the far left 250 feet, which is set at about

El.2515.5 to pass emergency flood flows. A pedestrian bridge was constructed in 1989 over the top of the dam as part of a cost sharing recreational enhancement project.

Mill Pond Dam has a 1,962 acre-feet capacity and covers 80.5 acres at its normal peak elevation of 2,505.7 feet. The overflow section operates continuously and is of such a shape that it is almost impossible to be plugged by debris, even with the pedestrian bridge which provides a 10-ft. opening between the bottom of the bridge and the top of the spillway crest. The flow of water over the spillway increases as the flow of Sullivan Creek increases.

Mill Pond Dam is a high hazard, class B dam. There is EAP, which is updated annually by the PUD.

Other Facilities Possibly Affected by the Sullivan Lake and Mill Pond Dam Impoundments

Well:

The sole water source for the Sullivan Lake Ranger District administrative site is an 8’’cased, 62 foot deep well, located west of the main office. It tests at 55 gallons per minute. Significant change in the lake level could impact the well.

Septic tank/ Drain fields:

Currently the office, bunkhouse, fire warehouse, and two residences east of the Sullivan Lake dam have septic tank drain field systems.

Inlet Bridge:

This 78 foot, 3 span bridge was built in 1938. It is located on the inlet to Sullivan Lake on Harvey creek. This structure is owned by Pend Oreille County and is on NFS land. There are currently plans to replace the structure with analysis and design planned for 2007.

Outlet Bridge:

This 190 foot multi-span structure was constructed in 1992 and is in good condition. It sits about 100 feet upstream of Sullivan Lake dam. It is supported by concrete pilings. During construction, liquefaction was experienced on the east most piling. Pend Oreille County currently owns the bridge and has maintenance responsibility. The bridge is located on NFS land.

Scope of Analysis Area

The scope of this analysis is confined to the dams and nearby facilities that may be impacted by changes in the dam structures, impoundments or project operations.

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

APPENDIX E.2-2
2009 MILL POND BATHYMETRY AND SEDIMENT EVALUATION STUDY

Sullivan Creek Hydroelectric Project (FERC No. 2225)

Mill Pond Bathymetry and Sediment Evaluation

Final Report

Prepared for
Seattle City Light

Prepared by
Tetra Tech

June 30, 2009

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Mill Pond Bathymetry and Sediment Evaluation
Final Report
Sullivan Creek Hydroelectric Project (FERC No. 2225)

1 INTRODUCTION

The Mill Pond Bathymetry and Sediment Evaluation is being conducted for Seattle City Light (SCL) and the Pend Oreille County Public Utility District (PUD) in support of the decommissioning of the Sullivan Creek Hydroelectric Project (Project), Federal Energy Regulatory Commission (FERC) No. 2225. This is the final report for the 2009 field efforts of the Mill Pond Bathymetry and Sediment Evaluation.

2 STUDY OBJECTIVES

Mill Pond is located along Sullivan Creek, downstream from Sullivan Lake. The surface of Mill Pond is 2,506 feet above mean sea level and occupies approximately 63 acres (Figure 1; figures and tables are provided at the end of this report). The Mill Pond log dam was constructed around 1910 for the purpose of hydroelectric power production. Around 1921 a concrete dam and flood gates were constructed approximately 40 feet west of the wooden log dam. The flood gates and wooden trestle over the wooden log dam were removed in 1970. The remaining concrete spill way is 55 feet high; however, operation for power generation ceased in 1956. From Mill Pond, Sullivan Creek flows west for approximately three miles to the confluence with the Pend Oreille River near the town of Metaline Falls.

As part of settlement negotiations during the decommissioning process, the PUD has agreed to fund a study to evaluate sediment toxicity and quantity in Mill Pond. In turn, SCL will conduct the study, which the parties agree will be informative in the negotiation process for both the Boundary and Sullivan Lake projects.

Due to the history of mining in the vicinity and potential mining residue in the area, there is concern that the sediments may contain elevated levels of toxics, particularly heavy metals. The results of this survey effort should assist the negotiating team in better understanding the potential for toxics in the sediment behind the Mill Pond dam and allow a more informed decision moving forward.

2.1. Geophysical (Subbottom) Profiling and Bathymetry

The primary objective of this task is to collect data to estimate the volume of sediment accumulated behind the dam and to assist in determining the sediment core depths needed to characterize the sediment.

2.2. Characterization of Mill Pond Sediments

The field sampling program included collecting representative sediment cores from Mill Pond and sampling accumulated sediment for a broad suite of analytes in sediments behind the Mill Pond dam. The list of contaminants analyzed was based on the Regional Sediment Evaluation Framework (USACE et al. 2009). In addition, the sediment cores were logged and sampled to establish the physical characteristics of the sediment (grain size etc) that will be input into the sediment transport analysis.

3 STUDY AREA

The potential source(s) for toxics in the vicinity around Mill Pond are primarily from mining and/or upstream locations (i.e., Sullivan Creek). When a stream enters a reservoir, such as Mill Pond, the flow velocity is greatly reduced. As a result, sediments, and any associated toxics, tend to drop out of suspension at these reduced water velocities. As this deposition process continues over time, any toxics carried into the reservoir would tend to concentrate in the deposited sediments. The most likely places for deposited sediments to accumulate would include locations such as:

- Shortly after water velocities have decreased, i.e., near the inflow to the reservoir
- The deepest part(s) of the reservoir where there is the least likelihood of flushing effects
- Areas of lowest water velocities, such as near the dam itself

Sediment sampling was conducted at eight (8) locations distributed along the historic main channel and in areas throughout Mill Pond to provide an assessment of the entire pond in areas where confirmation was needed or additional spatial data were needed. The initial sample locations were modified in the field based on site-specific conditions (e.g., results of the subbottom profile survey). A sample was planned for between the concrete spillway and the wooden dam at the west end of Mill Pond. However, this location was not accessible due to safety related issues.

4 METHODS

The following sections describe the methodologies employed in the field to meet the objectives of the field activity.

4.1. Geophysical (Subbottom) Profiling and Bathymetry

The survey at Mill Pond included single-beam bathymetry and subbottom profiling. A small aluminum jon boat equipped with the necessary electronic equipment was used to collect the data.

Survey data were collected on May 6 and 7, 2009 in 100-foot transects approximately perpendicular to the flow direction of the stream (northwest to southeast) with cross lines collected at 100-foot line spacing approximately parallel to the stream flow direction (northeast to southwest). After preliminary examination of the data, additional data lines were collected

parallel to the flow direction (northwest to southeast) in between the previous lines to bring the line spacing to 50 feet.

Positioning was done via a real-time kinematic (RTK) global positioning system (GPS). A boundary marker (Sullivan Creek Project PUD No. 1) was used as the control point for the survey. No information was available for the point, so the GPS was set up and data were collected and sent to the National Geodetic Survey (NGS) On-line Positioning User Service (OPUS) to obtain a solution that can be used for the survey. Details on the establishment and quality control for survey positioning are presented in Appendix 1.

A combined bathymetry and subbottom survey was conducted with a Specialty Devices, Inc., BSS+5 system. The BSS+5 allows for the collection of bathymetry data, with a 208 kilohertz (kHz) transducer, while collecting up to four different subbottom profiling frequencies (50, 24, 12, and 4 kHz). The BSS+5 system consists of a towfish with in-water transducers and hydrophone receivers and a shipboard processing system that receives digital data from the towfish. The towfish was hard-mounted in a fixed position alongside the survey vessel to enable data collection in very shallow water, as well as to provide the high quality positional data that a fixed mounting offers.

An acoustic pulse is generated by the transducers and acoustic reflections from the lake subbottom are received by the hydrophones. Data are transmitted via cable from the towfish to the shipboard processing system workstation running the Specialty Devices BSS+5 and HYPACK® software. The subbottom processing system logs the return pulse signals, processing the data into time-based cross sections of the acoustic response of the subbottom. By imputing the speed of sound measured at the site (during the single-beam sonar calibration) the time sections can be converted into pseudo-depth sections. Data are displayed as pseudo-depth cross sections of acoustic response with time on a computer screen, logged to a computer hard drive, and archived to a universal serial bus (USB) flash drive for data transfer and later post-processing. The Specialty Devices software also outputs bathymetry data directly into HYPACK.

4.2. Characterization of Mill Pond Sediments

Field activities at the site also included surveying to determine the horizontal and vertical coordinates of each sampling station, sediment coring using a vibracore sampler, surface sediment sampling using a Van Veen sampler, logging and sampling of the sediment cores, and analyzing samples for chemistry and geotechnical parameters. Sediment sampling began on May 5, 2009 and continued through May 8, 2009. Figure 2 shows the locations where sediment core samples and surface samples were collected.

4.2.1. Survey Control

Navigation to each proposed sediment sampling location was accomplished using a hand-held Trimble® GEO-XT or GEO-XH digital GPS (DGPS) unit. Actual locations where samples were collected were recorded at the time of collection using Integrated WAAS correction in the field. Horizontal positioning was recorded in northing/easting using Washington State Plane, North

American Datum of 1983 (NAD 83). The elevation of each sampling station was determined based on the bathymetry data collected by Tetra Tech.

4.2.2. Sediment Sampling

The sediment sampling effort included collection of surface sediment samples and the collection of sediment cores to evaluate the vertical and horizontal extent of the sediment. Sediment sampling and analysis were performed in accordance with the approved proposal and in general accordance with U.S. Environmental Protection Agency (EPA)-recommended and Washington State Department of Ecology methodologies.

Sediment core samples were collected first at each location because they cause less disruption to the sediment surface than the Van Veen sampler used to collect surface samples. Sediment cores were collected using a 4-inch outer diameter aluminum or stainless steel tube with a high density polyethylene liner inside. The core tube was driven into the sediment using a vibracore head from the "A-frame" on the sampling platform. Prior to sampling, the Site Scientist would direct the vessel to the marked sample location and the vessel was anchored into place. The depth to the mud line was measured using a plate with a line attached. Based on the depth to mud line and the required core length for the specific sample location, the core tube was connected to the vibracore head and lowered into place, just at the mud line. The DGPS was then used to log the northing and easting of the location for at least 30 seconds into the hand-held DGPS and recorded on the sample collection form. The vibracore head was turned on and the core tube was driven into the sediment and then brought to the surface. If the percent recovery was acceptable (i.e., > 75 percent), the core was capped, taped, labeled, and placed in a rack for transport back to the processing room. Up to three cores were taken from each sampling station if necessary to achieve the required recovery. If after at three attempts, recovery was less than 75 percent, the core with the highest recovery was retained for logging and analysis.

Surface sediment samples were collected from the top 15 centimeters (6 inches) using a Van Veen sampler. The sampler was lowered into place atop the sediment and the doors were released closing around the sediment. The sampler was raised and placed on the deck of the vessel and the percent recovery was measured. Four inches of recovery was the minimum amount of material required for a satisfactory sample. Up to three attempts were made at each location, if necessary, with the highest acceptable recovery being retained for analysis. The sample that showed the highest recovery was retained and transported back to the processing area for sampling.

4.2.3. Core Logging and Sampling

Sediment cores were brought to the processing area and logged using the Unified Soil Classification System (USCS) prior to sampling. The field forms were reviewed, the percent recovery was verified, and the cores were stored upright if necessary. The cores were then cut open and logged by a qualified geologist for visual description of sediment properties and stratigraphy. Core log descriptions are provided in Appendix 2. Selected photographs of field activities are included in Appendix 3.

Samples were collected at 1-foot intervals within each sediment core. For each sample location the surface sample collected with the Van Veen sampler (0 to 0.5 foot or "A" interval) was submitted for analysis. The 2- to 3-foot interval ("C" sample) from the sediment core was also analyzed for select parameters. The third interval analyzed from each core varied depending on the lithology. All other intervals that were not initially targeted for chemical analyses were archived (frozen) for possible future analysis. Table 1 shows the sample stations, rationale, target intervals, and coordinates.

Samples for analysis were homogenized in a stainless steel bowl and placed into laboratory provided jars, labeled, bagged, and placed in a chilled cooler for shipment to the laboratory. Coolers were secured with custody seals when not in direct control of the sample team.

4.2.4. Laboratory Analysis

Sediment samples were hand delivered to Analytical Resources Incorporated (ARI) on May 11, 2009 and analyzed in accordance with the revised proposal dated February 23, 2009. Analyses included:

- Total Solids (%) by EPA Method 2450-G
- Total organic carbon (TOC) (%) by
- Total Sulfides by Puget Sound Estuary Program (PSEP) 1997
- Ammonia by Plumb 1981
- Grain size distribution by the American Society for Testing and Materials (ASTM) D-422 mod
- Metals by EPA 200.8 (7471A for mercury)
- Semivolatile organic compounds (SVOCs) by EPA Method 8270D
- Polychlorinated biphenyls (PCBs) by EPA Method 8082
- Pesticides by EPA Method 8081
- Polycyclic aromatic hydrocarbons (PAHs) by EPA Method 8270D-selective ion mode
- Dioxin and Furans using EPA Method 8290
- Polybrominated diphynel ethers (PBDEs) using EPA Method 8270C-selected ion mode (sim)

Surface samples were analyzed for the entire suite. Samples from the 2- to 3-foot interval ("C" samples) were analyzed for metals, PCBs, PAHs, and TOC. An additional interval that varied between cores was analyzed for metals, PCBs, and TOC.

4.2.5. Sample Identification and Handling

The field sample identification system used provided unique sample locations and sample numbers for each sample collected. Samples were identified as follows:

MP-SC (or SS)-XX-Y

where:

MP – Mill Pond

SC – Sediment core
SS – Surface sample
XX – Sample Station 01, 02, 03, 07, 08, 09, 10, or 11
Y – Depth interval within the core (A: 0 to 1 foot, B: 1 to 2 feet, etc)

A rinsate blank was collected off of sampling equipment in the processing area and was identified as "MP-RB." A source blank was collected of the tap water used for decontaminating equipment and was labeled "MP-SB." Duplicate samples were identified by placing a "2" after the depth interval (i.e., MP-SS-01A2 is a duplicate sample of MP-SS-01).

4.2.6. Equipment Decontamination

All nondisposable components of the sediment coring equipment, or other equipment used to collect sediment samples that contacts the sediments, were decontaminated as follows:

- Potable water rinse
- Alconox/Liquinox detergent wash
- Potable water rinse
- Deionized (DI) water rinse
- Air dry

All sampling equipment that contacts the sediments will be decontaminated as follows:

- Potable water rinse
- Alconox detergent wash
- DI water rinse

5 RESULTS

5.1. Geophysical Surveys—Subbottom Profiling and Bathymetry

Mill Pond's average pool elevation was 2,513 feet (North American Vertical Datum 1988) during the survey. A combined bathymetry and water depth map is presented in Figure 2. The water depths shown on Figure 2 are relative to the average pool elevation of 2,513 feet. The prior creek channel is still evident within the pond everywhere except in the southeast corner of the pond where the current delta deposits have filled it in. No abrupt grade changes ("falls") are evident in the exposed channel. The subbottom data did not resolve the channel where it may be buried within the in-filled area by the delta.

The pond bottom sediments did contain some biogenic gas that limited subbottom acoustic energy penetration. The presence of coarse-grained material (gravel) attenuated the acoustic signal, further limiting penetration. Therefore, data were not obtained all the way down to bedrock. The subbottom data do appear to have penetrated most, if not all, of the post-impoundment deposited fine sediment (silt) outside of areas with biogenic gas that limited acoustic signal penetration (MP-02, MP-03, MP-08, and MP-09). The correlation with vibracore stratigraphy (Table 2) is good for areas where subbottom penetration was not limited by biogenic gas within the silt (MP-01, MP-07, MP-10, and MP-11). The subbottom interpreted sediment

thickness at all of the coring locations was either very similar to the full core penetration (MP-11), similar to the silt strata (MP-07, MP-10), or shallower than seen in the cores (MP-02, MP-03, MP-08, and MP-09).

Sediment thickness as interpreted from the subbottom profiling data (Figure 3) had a maximum of 12.4 feet, with an average of 4.8 feet (Figure 4). This isopac has a volume of approximately 465,800 cubic yards. This thickness likely underestimates the post-impoundment sediment thickness in areas where biogenic gas is present, but it could also overestimate the thickness in areas where greater penetration was achieved, since there is no clear stratigraphic layer evident in the data (discontinuity) that defines the transition between pre- and post-impoundment sediments. An example of this type of marker stratigraphic layer is shown in Figure 5a, where a clear pre-impoundment discontinuity can be seen. Figure 5b shows data from Mill Pond in which a dark band (high signal return) of gas-charged silt can be seen in the shallow subsurface and then the greatly diminished remaining acoustic signal quickly attenuating below, limiting the ability to delineate the previous ground surface (if it is even resolvable).

Appendix 4 contains the following electronic file deliverables (note: "Possible Former Ground Surface" was not able to be determined, so "Bottom of Subbottom Data Penetration" replaces this):

- XYZ bathymetry (csv file or txt, or xls)
- Bathymetry contours (dxf)
- Bathymetry surface (ArcGrid, GeoTiff)
- XY thickness (sediment thickness, csv)
- Isopac of sediment thickness contours (dxf)
- XYZ bottom of subbottom data penetration (csv)
- Bottom of subbottom data penetration (ArcGrid)
- An estimate of the volume of sediment (difference between bathymetry surface and bottom of subbottom data penetration)
- Mill Pond.scene file that anyone can view with the free software viewer to view the bathymetry and bottom of subbottom data penetration surface

5.2. Characterization of Mill Pond Sediments

The average length of sediment recovered in the cores was 6.0 feet with an average recovery percentage of 81 percent. The core logs show that in most cores the upper 3.8 to 6.5 feet consist of silt (ML), underlain by poorly graded sand (SP) of well-graded sands (SW) or gravels(GW). The sediment core from MP-03 showed little silt (approximately 1.2 feet) underlain by well-graded sand with gravel (SW) to 4 feet and well-graded gravel with sand (GW) to 7.0 feet. The lithology encountered in MP-03 is typical of a higher energy depositional environment where Sullivan Creek enters into Mill Pond. Figure 6 shows the grain size analytical results for the surface samples in tabular and graphical form. It is apparent from the graph that aside from MP-02 and MP-03 (both near the Sullivan Creek delta) the grain size of the surface samples is dominated by silt.

Tables 2 through 7 present the analytical results. The data packages from the lab are provided in Appendix 5. None of the samples collected exceeded the screening levels identified in Table 8. The analytical results for the metals samples did not show any statistically significant increases with depth or across horizons on Mill Pond. Pyrene (n = 2) and fluoranthene (n = 2) were the only PAHs detected. Only two SVOCs (4-methylphenol and chrysene) were detected above the method reporting limit (19 micrograms per kilogram [µg/kg]) and the two detections (20 µg/kg) were just above the reporting limit. Neither PCBs nor pesticides were detected above the method reporting limit.

Three surface sediment samples were selected and analyzed for dioxins and furans. The toxicity equivalency quotient (TEQ) was calculated by multiplying the analytical result for each congener by the toxicity equivalency factor (TEF). The TEFs used were from the World Health Organization (Van den Berg et al. 1998). Very few dioxin and furan congeners were detected above the method reporting limit, consequently the TEQs calculated for each sample were very low and did not exceed screening level concentrations. The same surface sediment samples were also analyzed for 17 PBDE congeners. None of the samples analyzed for PBDEs were detected above the method reporting limit.

5.3. Data Validation and Usability

A data quality assessment was prepared to evaluate the chemical analytical data and the implementation of the sampling and analytical procedures for the Mill Pond project. Samples were analyzed by ARI for chemical analysis. The detailed data validation package is provided in Appendix 6.

6 SUMMARY OF RESULTS

The results of the field investigation activities are summarized below:

- No abrupt grade changes (“falls”) are evident in the exposed channel.
- The prior creek channel is still evident within the pond everywhere except in the SE corner of the pond where the current delta deposits have filled it in.
- The subbottom data did not resolve the channel where it is buried within the in-filled area by the delta.
- The pond bottom sediments did contain some biogenic gas that limited subbottom acoustic energy penetration.
- There is no clear stratigraphic layer evident in the data (discontinuity) that defines the transition between pre and post impoundment sediments.
- Subbottom data were not obtained all the way down to bedrock.
- The amount of fine grained sediment located behind the dam is estimated to be 465,800 cubic yards.
- The lithology of Mill Pond is dominated by silt underlain by coarse sand or gravel.
- The analytical results showed no detections above screening levels.

7 MODIFICATIONS TO ORIGINAL PROPOSAL

The modification to the original proposal is noted below:

- The proposal stated that 12-foot cores would be used. Based on the bathymetry and subbottom data, it was determined that most sample locations had 8 feet or less of sediment. One exception was at sample location MP-11. Ten feet or more of sediment was anticipated at this location; however, the 12-foot stainless steel core tube encountered refusal at a depth of 6 feet and was bent beyond repair. The location was moved and an 8-foot core tube was used.

8 REFERENCES

USACE(U.S. Army Corps of Engineers – Seattle, Portland, and Walla Walla District, Northwestern Division), Environmental Protection Agency Region 10, Washington Department of Ecology, Washington Department of Natural Resources, Oregon Department of Environmental Quality, Idaho Department of Environmental Quality, National Marine Fisheries Service, and U.S. Fish and Wildlife Service. 2009. Draft Final Sediment Evaluation Framework for the Pacific Northwest. Prepared by USACE. February.

Van den Berg et al. 1998. World Health Organization TEFs for human risk assessment based on the conclusions of WHO meeting in Stockholm, Sweden, June 1997.

Tables

Table 1. Sample Locations, Target Depths, Recoveries, and Brief Lithologies

Sample Location	Date	Northing	Easting	Target Depth (Feet)	Recovered (Feet)	Recovery (Percent)	Subbottom Thickness (Feet)	Brief Lithology
MP-01	5/7/2009	697331.96	2490266.27	8.0	7.3	91%	6.0	Silt (ML) to 6.2 ft, Poorly Graded Sand (SP) to 8.0 ft
MP-02	5/6/2009	696390.11	2491617.22	8.0	7.2	90%	2.6 (gas)	Silt (ML) to 6.5 ft, Poorly Graded Sand (SP) 6.5 to 6.6 ft, Silt (ML) 6.6 to 7.0 ft, Poorly Graded Gravel with Sand (GP) to 8.0 ft
MP-03	5/6/2009	696862.74	2491702.51	8.0	6.8	85%	2.9 (gas)	Silt (ML) to 4.7 ft, Poorly Graded Sand (SP) 4.7 to 8.0 ft
MP-07	5/6/2009	697132.77	2490629.15	7.0	5.5	79%	4.0	Silt (ML to 1.2 ft, Well Graded Sand with Gravel (SW) 1.2 to 4.0 ft, Well Graded Gravel with Sand (GW) 4.0 to 7.0 ft
MP-08	5/7/2009	696659.27	2490977.15	7.0	3.5	50%	3.5 (gas)	Silt (ML) to 6.0 ft, Well Graded Sand with Gravel (SW) 6.0 to 7.0 ft
MP-09	5/7/2009	696562.13	2490592.32	7.0	5.7	81%	4.8 (gas)	Silt (ML) to 6.5 ft, Well Graded Sand with Gravel (SW) 6.5 fto 7.0 ft
MP-10	5/8/2009	697082.84	2490931.48	7.0	5.8	83%	3.1	Silt (ML) to 3.8 ft, Well Graded Sand (SW) 3.8 to 4.0 ft, Well Graded Gravel (GW) 4.0 to 6.0 ft, Well Graded Gravel with Silt (GW-GM) 6.0 to 7.0 ft
MP-11	5/8/2009	697240.72	2489830.66	7.0	6.4	91%	7.0	Silt (ML) to 6.0 ft, Silty Sand (SM) 6.0 to 6.8 ft, Silt with Sand (ML) 6.8 to 6.9 ft, Well Graded Gravel with Silt (GW-GM) 6.9 to 7..0 ft

Table 2. Analytical Results for Metals, TOC, Sulfides, and Ammonia

	Sample ID	**MP-SS-01-A**	**MP-SS-01-A2**	**RPD**	**MP-SC-01-C**	**MP-SC-01-F**	**MP-SS-02-A**	**MP-SC-02-C**	**MP-SC-02-G**	**MP-SS-03-A**	**MP-SC-03-C**	**MP-SC-03-E**	**MP-SS-07-A**	**MP-SC-07-C**	**MP-SS-08-A**
	Units	mg/Kg dry	mg/Kg dry	Percent	mg/Kg dry	mg/Kg dry	mg/Kg dry	mg/Kg dry	mg/Kg dry	mg/Kg dry	mg/Kg dry	mg/Kg dry	mg/Kg dry	mg/Kg dry	mg/Kg dry
	Matrix	Sediment	Sediment	na	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment
	Sample Date	5/8/09	5/8/09	na	5/8/09	5/8/09	5/6/09	5/6/09	5/6/09	5/6/09	5/6/09	5/6/09	5/6/09	5/6/09	5/8/09
	SDG	OY51	OY51	na	OY51	OY51	OY48	OY48	OY48	OY48	OY48	OY48	OY48	OY48	OY51
Grain Size (ASTM D422)															
% Gravel					na	na		na	na		na	na		na	
% Sand					na	na		na	na		na	na		na	
% Fines (silt + clay)					na	na		na	na		na	na		na	
Metals	***Action Level*** [1/]														
Antimony	na	< 0.4	< 0.4	*na*	< 0.3	< 0.3	< 0.4	< 0.4	< 0.2	< 0.3	< 0.4	< 0.4	< 0.4	< 0.2	< 0.4
Arsenic	20	5.0	5.1	*2%*	6.2	3.4	4.3	6.0	4.7	5.2	5.9	6.3	6.0	3.9	6.1
Cadmium	1.1	< 0.4	0.5	*na*	< 0.3	0.3	< 0.4	0.5	0.3	0.3	0.5	0.4	0.5	< 0.2	< 0.04
Chromium	95	23	22	*4%*	22	19	15	24	22	18	21	21	23	10.2	22
Copper	80	40	40	*0%*	33.0	26.5	29	38.7	32.9	28.3	38	38.8	44	14.4	40
Lead	340	14	15	*7%*	15	10	12	16	11	11	15	14	16	8	15
Mercury	0.28	< 0.05	< 0.04	*na*	< 0.04	< 0.03	< 0.04	< 0.04	< 0.03	< 0.04	< 0.04	< 0.04	< 0.05	< 0.03	< 0.04
Nickel	60	24	25	*4%*	25.3	22.5	18	26.9	25.1	22.0	25	25.5	27	16.2	25
Silver	2.0	< 0.4	< 0.4	*na*	< 0.3	< 0.3	< 0.4	< 0.4	< 0.2	< 0.3	< 0.4	< 0.4	< 0.4	< 0.4	< 0.04
Zinc	130	75	76	*1%*	68	56	58	81	61	61	78	75	81	45	76
Total Solids	na	45.20%	44.90%	*1%*	53.7%	69.70%	42.30%	52.90%	76.10%	61.20%	51.00%	57.10%	44.00%	88.30%	47.90%
Total Organic Carbon	na	2.36%	3.49%	*39%*	1.90%	0.818%	3.03%	1.15%	0.206%	2.86%	2.02%	2.02%	2.28%	0.372%	2.36%
Sulfide	na	104	66	*45%*	na	na	132	na	na	39.7	na	na	102	na	81.5
N-Ammonia	na	12.1	14.7	*19%*	na	na	21.5	na	na	12.4	na	na	18.3	na	11.9

Notes

[1/] Lowest Action level as described in Table 1

N-Ammonia units in mg-N/kg

Abbreviations and Acronyms

J = Value below calibration range

mg/kg = milligram per kilogram

na = data not available

RPD = relative percent difference (not calculated for non-detects)

Table 2. Analytical Results for Metals, TOC, Sulfides, and Ammonia

	Sample ID	**MP-SC-08-C**	**MP-SC-08-F**	**MP-SS-09-A**	**MP-SC-09-C**	**MP-SC-09-G**	**MP-SS-10-A**	**MP-SC-10-C**	**MP-SC-10-D**	**MP-SS-11-A**	**MP-SC-11-C**	**MP-SC-11-F**	**MP-RB**	**MP-SB**
	Units	mg/Kg dry	mg/Kg dry	mg/Kg dry	mg/Kg dry	mg/Kg dry	mg/Kg dry	mg/Kg dry	mg/Kg dry	mg/Kg dry	mg/Kg dry	mg/Kg dry	ug/L	ug/L
	Matrix	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Water	Water
	Sample Date	5/8/09	5/8/09	5/7/09	5/7/09	5/7/09	5/8/09	5/8/09	5/8/09	5/8/09	5/8/09	5/8/09	5/8/09	5/8/09
	SDG	OY51	OY51	OY48	OY48	OY48	OY51	OY51	OY51	OY51	OY51	OY51	OY48	OY48
Grain Size (ASTM D422)														
% Gravel		na	na		na	na		na	na		na	na	na	na
% Sand		na	na		na	na		na	na		na	na	na	na
% Fines (silt + clay)		na	na		na	na		na	na		na	na	na	na
Metals	***Action Level*** [1/]													
Antimony	na	< 0.3	< 0.3	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.5	< 0.4	< 0.3	< 0.2	< 0.2
Arsenic	20	5.8	4.5	6.0	5.9	6.7	5.2	5.3	5.1	2.2	4.4	5.9	< 0.2	< 0.2
Cadmium	1.1	0.4	0.3	0.5	0.5	0.6	0.4	0.4	0.5	< 0.5	0.5	< 0.3	< 0.2	< 0.2
Chromium	95	20	22	27.0	25.0	28.0	19	23	23	14	27	20	< 0.5	< 0.5
Copper	80	37.3	26.9	45	43.3	44.2	37	34.9	33	24	43.6	33.4	< 0.5	3.7
Lead	340	16	13	16	17	21	14	15	17	8	18	13	< 1	< 1
Mercury	0.28	< 0.03	< 0.03	< 0.05	< 0.04	< 0.03	< 0.05	< 0.04	< 0.04	< 0.05	< 0.03	< 0.03	< 0.1	< 0.1
Nickel	60	25.9	23.9	28	28.3	31.8	23	26.7	27	17	34.1	28.8	< 0.5	0.5
Silver	2.0	< 0.3	< 0.3	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.5	< 0.4	< 0.3	< 0.2	< 0.2
Zinc	130	73	67	89	83	88	78	91	96	52	103	70	< 4	9
Total Solids	na	58.20%	73.90%	45.70%	52.70%	53.30%	46.30%	53.50%	47.50%	41.20%	54.20%	77.60%	na	na
Total Organic Carbon	na	1.42%	0.989%	3.27%	1.34%	2.31%	3.26%	1.82%	2.89%	2.85%	1.18%	0.170%	na	na
Sulfide	na	na	na	145	na	na	62.3	na	na	272	na	na	< 0.050	< 0.050
N-Ammonia	na	na	na	21.8	na	na	15.2	na	na	10.2	na	na	< 0.010	< 0.010

Notes

[1/] Lowest Action level as described in Table 1

N-Ammonia units in mg-N/kg

Abbreviations and Acronyms

J = Value below calibration range

mg/kg = milligram per kilogram

na = data not available

RPD = relative percent difference (not calculated for non-detects)

Table 3. Analytical Results for PAHs

	Sample ID	**MP-SS-01-A**	**MP-SS-01-A2**	**RPD**	**MP-SC-01-C**	**MP-SC-01-F**	**MP-SS-02-A**	**MP-SC-02-C**	**MP-SC-02-G**	**MP-SS-03-A**	**MP-SC-03-C**
	Units	ug/Kg	ug/Kg	Percent	ug/Kg	ug/Kg	ug/Kg	ug/Kg	ug/Kg	ug/Kg	ug/Kg
	Matrix	Sediment	Sediment	na	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment
	Sample Date	5/8/09	5/8/09	na	5/8/09	5/8/09	5/6/09	5/6/09	5/6/09	5/6/09	5/6/09
	SDG	OY51	OY51	na	OY51	OY51	OY48	OY48	OY48	OY48	OY48
PAHs	***Action Level*** [1/]										
Naphthalene	500	na	na	*na*	< 4.8	na	na	< 4.9	na	na	< 4.8
2-Methylnaphthalene	470	na	na	*na*	< 4.8	na	na	< 4.9	na	na	< 4.8
Acenaphthylene	470	na	na	*na*	< 4.8	na	na	< 4.9	na	na	< 4.8
Acenapthene	1,100	na	na	*na*	< 4.8	na	na	< 4.9	na	na	< 4.8
Fluorene	1,000	na	na	*na*	< 4.8	na	na	< 4.9	na	na	< 4.8
Phenanthrene	6,100	na	na	*na*	< 4.8	na	na	< 4.9	na	na	< 4.8
Anthracene	1,200	na	na	*na*	< 4.8	na	na	< 4.9	na	na	< 4.8
Fluoranthene	11,000	na	na	*na*	< 4.8	na	na	< 4.9	na	na	8.7
Pyrene	8,800	na	na	*na*	< 4.8	na	na	4.9	na	na	< 4.8
Benzo(a)anthracene	4,300	na	na	*na*	< 4.8	na	na	< 4.9	na	na	< 4.8
Chrysene	4,300	na	na	*na*	< 4.8	na	na	< 4.9	na	na	< 4.8
Benzo(b)fluoranthene	600	na	na	*na*	< 4.8	na	na	< 4.9	na	na	< 4.8
Benzo(k)fluoranthene	600	na	na	*na*	< 4.8	na	na	< 4.9	na	na	< 4.8
Benzo(a)pyrene	3,300	na	na	*na*	< 4.8	na	na	< 4.9	na	na	< 4.8
Indeno(1,2,3-cd)pyrene	4,100	na	na	*na*	< 4.8	na	na	< 4.9	na	na	< 4.8
Dibenz(a,h)anthracene	800	na	na	*na*	< 4.8	na	na	< 4.9	na	na	< 4.8
Benzo(g,h,i)perylene	4,000	na	na	*na*	< 4.8	na	na	< 4.9	na	na	< 4.8

Notes

[1/] Lowest Action level as described in Table 1

Abbreviations and Acronyms

J = Value below calibration range

ug/kg = microgram per kilogram

na = data not available

RPD = relative percent difference (not calculated for non-detects)

Table 3. Analytical Results for PAHs

	Sample ID	**MP-SC-03-E**	**MP-SS-07-A**	**MP-SC-07-C**	**MP-SS-08-A**	**MP-SC-08-C**	**MP-SC-08-F**	**MP-SS-09-A**	**MP-SC-09-C**	**MP-SC-09-G**	**MP-SS-10-A**
	Units	ug/Kg	ug/Kg	ug/Kg	ug/Kg	ug/Kg	ug/Kg	ug/Kg	ug/Kg	ug/Kg	ug/Kg
	Matrix	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment
	Sample Date	5/6/09	5/6/09	5/6/09	5/8/09	5/8/09	5/8/09	5/7/09	5/7/09	5/7/09	5/8/09
	SDG	OY48	OY48	OY48	OY51	OY51	OY51	OY48	OY48	OY48	OY51
PAHs	***Action Level*** [1/]										
Naphthalene	500	na	na	< 4.6	na	na	na	na	< 4.9	na	na
2-Methylnaphthalene	470	na	na	< 4.6	na	na	na	na	< 4.9	na	na
Acenaphthylene	470	na	na	< 4.6	na	na	na	na	< 4.9	na	na
Acenapthene	1,100	na	na	< 4.6	na	na	na	na	< 4.9	na	na
Fluorene	1,000	na	na	< 4.6	na	na	na	na	< 4.9	na	na
Phenanthrene	6,100	na	na	< 4.6	na	na	na	na	< 4.9	na	na
Anthracene	1,200	na	na	< 4.6	na	na	na	na	< 4.9	na	na
Fluoranthene	11,000	na	na	< 4.6	na	na	na	na	< 4.9	na	na
Pyrene	8,800	na	na	< 4.6	na	na	na	na	< 4.9	na	na
Benzo(a)anthracene	4,300	na	na	< 4.6	na	na	na	na	< 4.9	na	na
Chrysene	4,300	na	na	< 4.6	na	na	na	na	< 4.9	na	na
Benzo(b)fluoranthene	600	na	na	< 4.6	na	na	na	na	< 4.9	na	na
Benzo(k)fluoranthene	600	na	na	< 4.6	na	na	na	na	< 4.9	na	na
Benzo(a)pyrene	3,300	na	na	< 4.6	na	na	na	na	< 4.9	na	na
Indeno(1,2,3-cd)pyrene	4,100	na	na	< 4.6	na	na	na	na	< 4.9	na	na
Dibenz(a,h)anthracene	800	na	na	< 4.6	na	na	na	na	< 4.9	na	na
Benzo(g,h,i)perylene	4,000	na	na	< 4.6	na	na	na	na	< 4.9	na	na

Notes

[1/] Lowest Action level as described in Table 1

Abbreviations and Acronyms

J = Value below calibration range

ug/kg = microgram per kilogram

na = data not available

RPD = relative percent difference (not calculated for non-detects)

Table 3. Analytical Results for PAHs

	Sample ID	**MP-SC-10-C**	**MP-SC-10-D**	**MP-SS-11-A**	**MP-SC-11-C**	**MP-SC-11-F**
	Units	ug/Kg	ug/Kg	ug/Kg	ug/Kg	ug/Kg
	Matrix	Sediment	Sediment	Sediment	Sediment	Sediment
	Sample Date	5/8/09	5/8/09	5/8/09	5/8/09	5/8/09
	SDG	OY51	OY51	OY51	OY51	OY51
PAHs	***Action Level*** [1/]					
Naphthalene	500	< 4.9	na	na	< 4.8	na
2-Methylnaphthalene	470	< 4.9	na	na	< 4.8	na
Acenaphthylene	470	< 4.9	na	na	< 4.8	na
Acenapthene	1,100	< 4.9	na	na	< 4.8	na
Fluorene	1,000	< 4.9	na	na	< 4.8	na
Phenanthrene	6,100	< 4.9	na	na	< 4.8	na
Anthracene	1,200	< 4.9	na	na	< 4.8	na
Fluoranthene	11,000	10	na	na	< 4.8	na
Pyrene	8,800	8.3	na	na	< 4.8	na
Benzo(a)anthracene	4,300	< 4.9	na	na	< 4.8	na
Chrysene	4,300	< 4.9	na	na	< 4.8	na
Benzo(b)fluoranthene	600	< 4.9	na	na	< 4.8	na
Benzo(k)fluoranthene	600	< 4.9	na	na	< 4.8	na
Benzo(a)pyrene	3,300	< 4.9	na	na	< 4.8	na
Indeno(1,2,3-cd)pyrene	4,100	< 4.9	na	na	< 4.8	na
Dibenz(a,h)anthracene	800	< 4.9	na	na	< 4.8	na
Benzo(g,h,i)perylene	4,000	< 4.9	na	na	< 4.8	na

Notes

[1/] Lowest Action level as described in Table 1

Abbreviations and Acronyms

J = Value below calibration range

ug/kg = microgram per kilogram

na = data not available

RPD = relative percent difference (not calculated for non-detects)

Table 4. Analytical Results for SVOCs

	Sample ID	**MP-SS-01-A**	**MP-SS-01-A2**	**RPD**	**MP-SC-01-C**	**MP-SC-01-F**	**MP-SS-02-A**	**MP-SC-02-C**	**MP-SC-02-G**	**MP-SS-03-A**	**MP-SC-03-C**	**MP-SC-03-E**
	Units	ug/Kg	ug/Kg	Percent	ug/Kg	ug/Kg	ug/Kg	ug/Kg	ug/Kg	ug/Kg	ug/Kg	ug/Kg
	Matrix	Sediment	Sediment	na	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment
	Sample Date	5/8/09	5/8/09	na	5/8/09	5/8/09	5/6/09	5/6/09	5/6/09	5/6/09	5/6/09	5/6/09
	SDG	OY51	OY51	na	OY51	OY51	OY48	OY48	OY48	OY48	OY48	OY48
SVOCs	***Action Level*** [1/]											
Phenol	420	< 20	< 20	*na*	na	na	< 20	na	na	< 19	na	na
1,4-Dichlorobenzene	3.1	< 20	< 20	*na*	na	na	< 20	na	na	< 19	na	na
Benzyl Alcohol	57	< 20	< 20	*na*	na	na	< 20	na	na	< 19	na	na
1,2-Dichlorobenzene	2.3	< 20	< 20	*na*	na	na	< 20	na	na	< 19	na	na
2-Methylphenol	63	< 20	< 20	*na*	na	na	< 20	na	na	< 19	na	na
4-Methylphenol	670	< 20	< 20	*na*	na	na	< 20	na	na	20	na	na
Hexachloroethane	na	< 20	< 20	*na*	na	na	< 20	na	na	< 19	na	na
2,4-Dimethylphenol	29	< 20	< 20	*na*	na	na	< 20	na	na	< 19	na	na
Benzoic Acid	650	170 J	< 200	*na*	na	na	< 200	na	na	< 190	na	na
1,2,4-Trichlorobenzne	0.81	< 20	< 20	*na*	na	na	< 20	na	na	< 19	na	na
Naphthalene	500	< 20	< 20	*na*	na	na	< 20	na	na	< 19	na	na
Hexachlorobutadiene	3.9	< 20	< 20	*na*	na	na	< 20	na	na	< 19	na	na
2-Methylnaphthalene	470	< 20	< 20	*na*	na	na	< 20	na	na	< 19	na	na
Dimethyl phthalate	46	< 20	< 20	*na*	na	na	< 20	na	na	< 19	na	na
Acenaphthylene	470	< 20	< 20	*na*	na	na	< 20	na	na	< 19	na	na
Acenaphthene	1,100	< 20	< 20	*na*	na	na	< 20	na	na	< 19	na	na
Dibenzofuran	400	< 20	< 20	*na*	na	na	< 20	na	na	< 19	na	na
Diethyl phthalate	61	< 20	< 20	*na*	na	na	< 20	na	na	< 19	na	na
Fluorene	1,000	< 20	< 20	*na*	na	na	< 20	na	na	< 19	na	na
N-Nitrosodipheynlamine	11	< 20	< 20	*na*	na	na	< 20	na	na	< 19	na	na
Hexachlorobenzene	0.38	< 20	< 20	*na*	na	na	< 20	na	na	< 19	na	na
Pentachlorophenol	400	< 98	< 98	*na*	na	na	< 98	na	na	< 96	na	na
Phenanthrene	6,100	< 20	< 20	*na*	na	na	< 20	na	na	< 19	na	na
Anthracene	1,200	< 20	< 20	*na*	na	na	< 20	na	na	< 19	na	na
di-n-Butyl phthalate	220	< 20	< 20	*na*	na	na	< 20	na	na	< 19	na	na
Fluoranthene	11,000	< 20	< 20	*na*	na	na	< 20	na	na	9.8 J	na	na
Pyrene	8,800	< 20	< 20	*na*	na	na	< 20	na	na	< 19	na	na
Butyl benzyl phthalate	260	< 20	< 20	*na*	na	na	< 20	na	na	< 19	na	na
Benzo(a)anthracene	4,300	< 20	< 20	*na*	na	na	< 20	na	na	< 19	na	na
bis(2-Ethylhexyl)phthalate	220	< 20	< 20	*na*	na	na	< 20	na	na	< 19	na	na
Chrysene	5,900	< 20	< 20	*na*	na	na	< 20	na	na	20	na	na
di-n-Octyl phthalate	26	< 20	< 20	*na*	na	na	< 20	na	na	< 19	na	na
Benzo(b)fluoranthene	600	< 20	< 20	*na*	na	na	< 20	na	na	< 19	na	na
Benzo(k)fluoranthene	600	< 20	< 20	*na*	na	na	< 20	na	na	< 19	na	na
Benzo(a)pyrene	3,300	< 20	< 20	*na*	na	na	< 20	na	na	< 19	na	na
Indeno(1,2,3-cd)pyrene	4,100	< 20	< 20	*na*	na	na	< 20	na	na	< 19	na	na
Dibenz(a,h)anthracene	800	< 20	< 20	*na*	na	na	< 20	na	na	< 19	na	na
Benzo(g,h,i)perylene	4,000	< 20	< 20	*na*	na	na	< 20	na	na	< 19	na	na
1-Methylnaphthalene	na	< 20	< 20	*na*	na	na	< 20	na	na	< 19	na	na

Notes

[1/] Lowest Action level as described in Table 1

Abbreviations and Acronyms

J = Value below calibration range
ug/kg = microgram per kilogram
ug/L = microgram per liter
na = data not available
no = no analysis conducted
RPD = relative percent difference (not calculated for non-detects)

Table 4. Analytical Results for SVOCs

	Sample ID	**MP-SS-07-A**	**MP-SC-07-C**	**MP-SS-08-A**	**MP-SC-08-C**	**MP-SC-08-F**	**MP-SS-09-A**	**MP-SC-09-C**	**MP-SC-09-G**	**MP-SS-10-A**	**MP-SC-10-C**	**MP-SC-10-D**
	Units	ug/Kg	ug/Kg	ug/Kg	ug/Kg	ug/Kg	ug/Kg	ug/Kg	ug/Kg	ug/Kg	ug/Kg	ug/Kg
	Matrix	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment
	Sample Date	5/6/09	5/6/09	5/8/09	5/8/09	5/8/09	5/7/09	5/7/09	5/7/09	5/8/09	5/8/09	5/8/09
	SDG	OY48	OY48	OY51	OY51	OY51	OY48	OY48	OY48	OY51	OY51	OY51
SVOCs	***Action Level*** [1/]											
Phenol	420	< 20	na	< 20	na	na	< 20	na	na	< 20	na	na
1,4-Dichlorobenzene	3.1	< 20	na	< 20	na	na	< 20	na	na	< 20	na	na
Benzyl Alcohol	57	< 20	na	< 20	na	na	< 20	na	na	< 20	na	na
1,2-Dichlorobenzene	2.3	< 20	na	< 20	na	na	< 20	na	na	< 20	na	na
2-Methylphenol	63	< 20	na	< 20	na	na	< 20	na	na	< 20	na	na
4-Methylphenol	670	16 J	na	< 20	na	na	< 20	na	na	< 20	na	na
Hexachloroethane	na	< 20	na	< 20	na	na	< 20	na	na	< 20	na	na
2,4-Dimethylphenol	29	< 20	na	< 20	na	na	< 20	na	na	< 20	na	na
Benzoic Acid	650	< 200	na	< 200	na	na	< 200	na	na	< 200	na	na
1,2,4-Trichlorobenzne	0.81	< 20	na	< 20	na	na	< 20	na	na	< 20	na	na
Naphthalene	500	< 20	na	< 20	na	na	< 20	na	na	< 20	na	na
Hexachlorobutadiene	3.9	< 20	na	< 20	na	na	< 20	na	na	< 20	na	na
2-Methylnaphthalene	470	< 20	na	< 20	na	na	< 20	na	na	< 20	na	na
Dimethyl phthalate	46	< 20	na	< 20	na	na	< 20	na	na	< 20	na	na
Acenaphthylene	470	< 20	na	< 20	na	na	< 20	na	na	< 20	na	na
Acenaphthene	1,100	< 20	na	< 20	na	na	< 20	na	na	< 20	na	na
Dibenzofuran	400	< 20	na	< 20	na	na	< 20	na	na	< 20	na	na
Diethyl phthalate	61	< 20	na	< 20	na	na	< 20	na	na	< 20	na	na
Fluorene	1,000	< 20	na	< 20	na	na	< 20	na	na	< 20	na	na
N-Nitrosodipheynlamine	11	< 20	na	< 20	na	na	< 20	na	na	< 20	na	na
Hexachlorobenzene	0.38	< 20	na	< 20	na	na	< 20	na	na	< 20	na	na
Pentachlorophenol	400	< 97	na	< 98	na	na	< 99	na	na	< 98	na	na
Phenanthrene	6,100	< 20	na	< 20	na	na	< 20	na	na	< 20	na	na
Anthracene	1,200	< 20	na	< 20	na	na	< 20	na	na	< 20	na	na
di-n-Butyl phthalate	220	< 20	na	< 20	na	na	< 20	na	na	< 20	na	na
Fluoranthene	11,000	< 20	na	< 20	na	na	< 20	na	na	< 20	na	na
Pyrene	8,800	< 20	na	< 20	na	na	< 20	na	na	< 20	na	na
Butyl benzyl phthalate	260	< 20	na	< 20	na	na	< 20	na	na	< 20	na	na
Benzo(a)anthracene	4,300	< 20	na	< 20	na	na	< 20	na	na	< 20	na	na
bis(2-Ethylhexyl)phthalate	220	< 20	na	< 20	na	na	< 20	na	na	11 J	na	na
Chrysene	5,900	< 20	na	< 20	na	na	< 20	na	na	< 20	na	na
di-n-Octyl phthalate	26	< 20	na	< 20	na	na	< 20	na	na	< 20	na	na
Benzo(b)fluoranthene	600	< 20	na	< 20	na	na	< 20	na	na	< 20	na	na
Benzo(k)fluoranthene	600	< 20	na	< 20	na	na	< 20	na	na	< 20	na	na
Benzo(a)pyrene	3,300	< 20	na	< 20	na	na	< 20	na	na	< 20	na	na
Indeno(1,2,3-cd)pyrene	4,100	< 20	na	< 20	na	na	< 20	na	na	< 20	na	na
Dibenz(a,h)anthracene	800	< 20	na	< 20	na	na	< 20	na	na	< 20	na	na
Benzo(g,h,i)perylene	4,000	< 20	na	< 20	na	na	< 20	na	na	< 20	na	na
1-Methylnaphthalene	na	< 20	na	< 20	na	na	< 20	na	na	< 20	na	na

Notes

[1/] Lowest Action level as described in Table 1

Abbreviations and Acronyms

J = Value below calibration range
ug/kg = microgram per kilogram
ug/L = microgram per liter
na = data not available
no = no analysis conducted
RPD = relative percent difference (not calculated for non-detects)

Table 4. Analytical Results for SVOCs

	Sample ID	**MP-SS-11-A**	**MP-SC-11-C**	**MP-SC-11-F**	**MP-RB**	**MP-SB**
	Units	ug/Kg	ug/Kg	ug/Kg	ug/L	ug/L
	Matrix	Sediment	Sediment	Sediment	Water	Water
	Sample Date	5/8/09	5/8/09	5/8/09	5/8/09	5/8/09
	SDG	OY51	OY51	OY51	OY48	OY48
SVOCs	***Action Level*** [1/]					
Phenol	420	< 20	na	na	< 1.0	< 1.0
1,4-Dichlorobenzene	3.1	< 20	na	na	< 1.0	< 1.0
Benzyl Alcohol	57	< 20	na	na	< 5.0	< 5.0
1,2-Dichlorobenzene	2.3	< 20	na	na	< 1.0	< 1.0
2-Methylphenol	63	< 20	na	na	< 1.0	< 1.0
4-Methylphenol	670	< 20	na	na	< 1.0	< 1.0
Hexachloroethane	na	< 20	na	na	< 1.0	< 1.0
2,4-Dimethylphenol	29	< 20	na	na	< 1.0	< 1.0
Benzoic Acid	650	< 200	na	na	< 10	< 10
1,2,4-Trichlorobenzne	0.81	< 20	na	na	< 1.0	< 1.0
Naphthalene	500	< 20	na	na	< 1.0	< 1.0
Hexachlorobutadiene	3.9	< 20	na	na	< 1.0	< 1.0
2-Methylnaphthalene	470	< 20	na	na	< 1.0	< 1.0
Dimethyl phthalate	46	< 20	na	na	< 1.0	< 1.0
Acenaphthylene	470	< 20	na	na	< 1.0	< 1.0
Acenaphthene	1,100	< 20	na	na	< 1.0	< 1.0
Dibenzofuran	400	< 20	na	na	< 1.0	< 1.0
Diethyl phthalate	61	< 20	na	na	< 1.0	< 1.0
Fluorene	1,000	< 20	na	na	< 1.0	< 1.0
N-Nitrosodipheynlamine	11	< 20	na	na	< 1.0	< 1.0
Hexachlorobenzene	0.38	< 20	na	na	< 1.0	< 1.0
Pentachlorophenol	400	< 98	na	na	< 5.0	< 5.0
Phenanthrene	6,100	< 20	na	na	< 1.0	< 1.0
Anthracene	1,200	< 20	na	na	< 1.0	< 1.0
di-n-Butyl phthalate	220	< 20	na	na	< 1.0	< 1.0
Fluoranthene	11,000	< 20	na	na	< 1.0	< 1.0
Pyrene	8,800	< 20	na	na	< 1.0	< 1.0
Butyl benzyl phthalate	260	< 20	na	na	< 1.0	< 1.0
Benzo(a)anthracene	4,300	< 20	na	na	< 1.0	< 1.0
bis(2-Ethylhexyl)phthalate	220	< 20	na	na	< 1.0	< 1.0
Chrysene	5,900	< 20	na	na	< 1.0	< 1.0
di-n-Octyl phthalate	26	< 20	na	na	< 1.0	< 1.0
Benzo(b)fluoranthene	600	< 20	na	na	< 1.0	< 1.0
Benzo(k)fluoranthene	600	< 20	na	na	< 1.0	< 1.0
Benzo(a)pyrene	3,300	< 20	na	na	< 1.0	< 1.0
Indeno(1,2,3-cd)pyrene	4,100	< 20	na	na	< 1.0	< 1.0
Dibenz(a,h)anthracene	800	< 20	na	na	< 1.0	< 1.0
Benzo(g,h,i)perylene	4,000	< 20	na	na	< 1.0	< 1.0
1-Methylnaphthalene	na	< 20	na	na	< 1.0	< 1.0

Notes

[1/] Lowest Action level as described in Table 1

Abbreviations and Acronyms

J = Value below calibration range
ug/kg = microgram per kilogram
ug/L = microgram per liter
na = data not available
no = no analysis conducted
RPD = relative percent difference (not calculated for non-detects)

Table 5. Analytical Results for PCBs and Pesticides.

	Sample ID	**MP-SS-01-A**	**MP-SS-01-A2**	**RPD**	**MP-SC-01-C**	**MP-SC-01-F**	**MP-SS-02-A**	**MP-SC-02-C**
	Units	ug/Kg	ug/Kg	Percent	ug/Kg	ug/Kg	ug/Kg	ug/Kg
	Matrix	Sediment	Sediment	na	Sediment	Sediment	Sediment	Sediment
	Sample Date	5/8/09	5/8/09	na	5/8/09	5/8/09	5/6/09	5/6/09
	SDG	OY51	OY51	na	OY51	OY51	OY48	OY48
PCBs & Pesticides	***Action Level*** [1/]							
1016	60	< 9.8	< 9.9	*na*	< 9.9	< 9.8	< 9.9	< 9.8
1242	60	< 9.8	< 9.9	*na*	< 9.9	< 9.8	< 9.9	< 9.8
1248	60	< 9.8	< 9.9	*na*	< 9.9	< 9.8	< 9.9	< 9.8
1254	60	< 9.8	< 9.9	*na*	< 9.9	< 9.8	< 9.9	< 9.8
1260	60	< 9.8	< 9.9	*na*	< 9.9	< 9.8	< 9.9	< 9.8
1221	60	< 9.8	< 9.9	*na*	< 9.9	< 9.8	< 9.9	< 9.8
1232	60	< 9.8	< 9.9	*na*	< 9.9	< 9.8	< 9.9	< 9.8
1262	60	na	na	*na*	na	na	< 9.9	< 9.8
1268	60	na	na	*na*	na	na	< 9.9	< 9.8
gamma-BHC	na	< 0.98	< 0.99	*na*	na	na	< 0.98	na
Heptachlor	na	< 0.98	< 0.99	*na*	na	na	< 0.98	na
Aldrin	na	< 0.98	< 0.99	*na*	na	na	< 0.98	na
Dieldrin	na	< 2.0	< 2.0	*na*	na	na	< 2.0	na
p,p'-DDE	16	< 2.0	< 2.0	*na*	na	na	< 2.0	na
p,p'-DDD	9	< 2.0	< 2.0	*na*	na	na	< 2.0	na
p,p'-DDT	34	< 2.0	< 2.0	*na*	na	na	< 2.0	na
gamma Chlordane	na	< 0.98	< 0.99	*na*	na	na	< 0.98	na
alpha Chlordane	na	< 0.98	< 0.99	*na*	na	na	< 0.98	na
Hexachlorobenzene	0.38	< 0.98	< 0.99	*na*	na	na	< 0.98	na
Hexachlorobutadiene	3.9	< 0.98	< 0.99	*na*	na	na	< 0.98	na
oxy Chlordane	na	< 2.0	< 2.0	*na*	na	na	< 2.0	na
cis-Nonachlor	na	< 2.0	< 2.0	*na*	na	na	< 2.0	na
trans-Nonachlor	na	< 2.0	< 2.0	*na*	na	na	< 2.0	na

Notes

[1/] Lowest Action level as described in Table 1

Abbreviations and Acronyms

J = Value below calibration range

ug/kg = microgram per kilogram

na = data not available

no = no analysis conducted

RPD = relative percent difference (not calculated for non-detects)

Table 5. Analytical Results for PCBs and Pesticides.

	Sample ID	**MP-SC-02-G**	**MP-SS-03-A**	**MP-SC-03-C**	**MP-SC-03-E**	**MP-SS-07-A**	**MP-SC-07-C**	**MP-SS-08-A**
	Units	ug/Kg	ug/Kg	ug/Kg	ug/Kg	ug/Kg	ug/Kg	ug/Kg
	Matrix	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment
	Sample Date	5/6/09	5/6/09	5/6/09	5/6/09	5/6/09	5/6/09	5/8/09
	SDG	OY48	OY48	OY48	OY48	OY48	OY48	OY51
PCBs & Pesticides	***Action Level*** [1/]							
1016	60	< 9.9	< 9.8	< 9.9	< 9.9	< 9.7	< 9.7	< 9.8
1242	60	< 9.9	< 9.8	< 9.9	< 9.9	< 9.7	< 9.7	< 9.8
1248	60	< 9.9	< 9.8	< 9.9	< 9.9	< 9.7	< 9.7	< 9.8
1254	60	< 9.9	< 9.8	< 9.9	< 9.9	< 9.7	< 9.7	< 9.8
1260	60	< 9.9	< 9.8	< 9.9	< 9.9	< 9.7	< 9.7	< 9.8
1221	60	< 9.9	< 9.8	< 9.9	< 9.9	< 9.7	< 9.7	< 9.8
1232	60	< 9.9	< 9.8	< 9.9	< 9.9	< 9.7	< 9.7	< 9.8
1262	60	< 9.9	< 9.8	< 9.9	< 9.9	< 9.7	< 9.7	na
1268	60	< 9.9	< 9.8	< 9.9	< 9.9	< 9.7	< 9.7	na
gamma-BHC	na	na	< 0.97	na	na	< 0.98	na	< 0.98
Heptachlor	na	na	< 0.97	na	na	< 0.98	na	< 0.98
Aldrin	na	na	< 0.97	na	na	< 0.98	na	< 0.98
Dieldrin	na	na	< 1.9	na	na	< 2.0	na	< 2.0
p,p'-DDE	16	na	< 1.9	na	na	< 2.0	na	< 2.0
p,p'-DDD	9	na	< 1.9	na	na	< 2.0	na	< 2.0
p,p'-DDT	34	na	< 1.9	na	na	< 2.0	na	< 2.0
gamma Chlordane	na	na	< 0.97	na	na	< 0.98	na	< 0.98
alpha Chlordane	na	na	< 0.97	na	na	< 0.98	na	< 0.98
Hexachlorobenzene	0.38	na	< 0.97	na	na	< 0.98	na	< 0.98
Hexachlorobutadiene	3.9	na	< 0.97	na	na	< 0.98	na	< 0.98
oxy Chlordane	na	na	< 1.9	na	na	< 2.0	na	< 2.0
cis-Nonachlor	na	na	< 1.9	na	na	< 2.0	na	< 2.0
trans-Nonachlor	na	na	< 1.9	na	na	< 2.0	na	< 2.0

Notes

[1/] Lowest Action level as described in Table 1

Abbreviations and Acronyms

J = Value below calibration range

ug/kg = microgram per kilogram

na = data not available

no = no analysis conducted

RPD = relative percent difference (not calculated for non-detects)

Table 5. Analytical Results for PCBs and Pesticides.

	Sample ID	**MP-SC-08-C**	**MP-SC-08-F**	**MP-SS-09-A**	**MP-SC-09-C**	**MP-SC-09-G**	**MP-SS-10-A**	**MP-SC-10-C**
	Units	ug/Kg	ug/Kg	ug/Kg	ug/Kg	ug/Kg	ug/Kg	ug/Kg
	Matrix	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment	Sediment
	Sample Date	5/8/09	5/8/09	5/7/09	5/7/09	5/7/09	5/8/09	5/8/09
	SDG	OY51	OY51	OY48	OY48	OY48	OY51	OY51
PCBs & Pesticides	***Action Level*** [1/]							
1016	60	< 9.9	< 9.8	< 9.9	< 9.8	< 9.9	< 9.8	< 9.9
1242	60	< 9.9	< 9.8	< 9.9	< 9.8	< 9.9	< 9.8	< 9.9
1248	60	< 9.9	< 9.8	< 9.9	< 9.8	< 9.9	< 9.8	< 9.9
1254	60	< 9.9	< 9.8	< 9.9	< 9.8	< 9.9	< 9.8	< 9.9
1260	60	< 9.9	< 9.8	< 9.9	< 9.8	< 9.9	< 9.8	< 9.9
1221	60	< 9.9	< 9.8	< 9.9	< 9.8	< 9.9	< 9.8	< 9.9
1232	60	< 9.9	< 9.8	< 9.9	< 9.8	< 9.9	< 9.8	< 9.9
1262	60	na	na	< 9.9	< 9.8	< 9.9	na	na
1268	60	na	na	< 9.9	< 9.8	< 9.9	na	na
gamma-BHC	na	na	na	< 0.99	na	na	< 0.98	na
Heptachlor	na	na	na	< 0.99	na	na	< 0.98	na
Aldrin	na	na	na	< 0.99	na	na	< 0.98	na
Dieldrin	na	na	na	< 2.0	na	na	< 2.0	na
p,p'-DDE	16	na	na	< 2.0	na	na	< 2.0	na
p,p'-DDD	9	na	na	< 2.0	na	na	< 2.0	na
p,p'-DDT	34	na	na	< 2.0	na	na	< 2.0	na
gamma Chlordane	na	na	na	< 0.99	na	na	< 0.98	na
alpha Chlordane	na	na	na	< 0.99	na	na	< 0.98	na
Hexachlorobenzene	0.38	na	na	< 0.99	na	na	< 0.98	na
Hexachlorobutadiene	3.9	na	na	< 0.99	na	na	< 0.98	na
oxy Chlordane	na	na	na	< 2.0	na	na	< 2.0	na
cis-Nonachlor	na	na	na	< 2.0	na	na	< 2.0	na
trans-Nonachlor	na	na	na	< 2.0	na	na	< 2.0	na

Notes

[1/] Lowest Action level as described in Table 1

Abbreviations and Acronyms

J = Value below calibration range

ug/kg = microgram per kilogram

na = data not available

no = no analysis conducted

RPD = relative percent difference (not calculated for non-detects)

Table 5. Analytical Results for PCBs and Pesticides.

	Sample ID	**MP-SC-10-D**	**MP-SS-11-A**	**MP-SC-11-C**	**MP-SC-11-F**	**MP-RB**	**MP-SB**
	Units	ug/Kg	ug/Kg	ug/Kg	ug/Kg	ug/L	ug/L
	Matrix	Sediment	Sediment	Sediment	Sediment	Water	Water
	Sample Date	5/8/09	5/8/09	5/8/09	5/8/09	5/8/09	5/8/09
	SDG	OY51	OY51	OY51	OY51	OY48	OY48
PCBs & Pesticides	***Action Level*** [1/]						
1016	60	< 9.9	< 9.9	< 9.8	< 9.7		
1242	60	< 9.9	< 9.9	< 9.8	< 9.7		
1248	60	< 9.9	< 9.9	< 9.8	< 9.7		
1254	60	< 9.9	< 9.9	< 9.8	< 9.7		
1260	60	< 9.9	< 9.9	< 9.8	< 9.7		
1221	60	< 9.9	< 9.9	< 9.8	< 9.7		
1232	60	< 9.9	< 9.9	< 9.8	< 9.7		
1262	60	na	na	na	na		
1268	60	na	na	na	na		
gamma-BHC	na	na	< 0.98	na	na	< 0.050	< 0.050
Heptachlor	na	na	< 0.98	na	na	< 0.050	< 0.050
Aldrin	na	na	< 0.98	na	na	< 0.050	< 0.050
Dieldrin	na	na	< 2.0	na	na	< 0.10	< 0.10
p,p'-DDE	16	na	< 2.0	na	na	< 0.10	< 0.10
p,p'-DDD	9	na	< 2.0	na	na	< 0.10	< 0.10
p,p'-DDT	34	na	< 2.0	na	na	< 0.10	< 0.10
gamma Chlordane	na	na	< 0.98	na	na	< 0.050	< 0.050
alpha Chlordane	na	na	< 0.98	na	na	< 0.050	< 0.050
Hexachlorobenzene	0.38	na	< 0.98	na	na	< 0.050	< 0.050
Hexachlorobutadiene	3.9	na	< 0.98	na	na	< 0.050	< 0.050
oxy Chlordane	na	na	< 2.0	na	na	< 0.10	< 0.10
cis-Nonachlor	na	na	< 2.0	na	na	< 0.10	< 0.10
trans-Nonachlor	na	na	< 2.0	na	na	< 0.10	< 0.10

Notes

[1/] Lowest Action level as described in Table 1

Abbreviations and Acronyms

J = Value below calibration range

ug/kg = microgram per kilogram

na = data not available

no = no analysis conducted

RPD = relative percent difference (not calculated for non-detects)

Table 6. Analytical Results for Dioxins and Furans

Sample ID	TEF [1/]	MP-SS-01-A	TEF Conc.	MP-SS-03-A	TEF Conc.	MP-SS-09-A	TEF Conc.
Units		ng/Kg		ng/Kg		ng/Kg	
2,3,7,8-TCDF	0.1	0.28 BJ	0.028	0.290 I E	0.029	0.23 I E	0.023
Total TCDF	na	0.28 BJ		0.380 BJ		< 0.094	
2,3,7,8-TCDD	1.0	< 0.096	0.048	< 0.110	0.055	< 0.190	0.095
Total TCDD	na	< 0.096		< 0.110		< 0.190	
1,2,3,7,8-PeCDF	0.05	< 0.056	0.0014	< 0.061	0.001525	< 0.072	0.0018
2,3,4,7,8-PeCDF	0.5	< 0.052	0.013	< 0.045	0.01125	< 0.042	0.0105
Total-PeCDF	na	< 0.054		< 0.053		< 0.057	
1,2,3,7,8-PeCDD	1.0	< 0.100	0.05	< 0.071	0.0355	< 0.140	0.070
Total-PeCDD	na	< 0.100		< 0.071		< 0.140	
1,2,3,4,7,8-HxCDF	0.1	< 0.048	0.0024	< 0.058	0.0029	< 0.078	0.0039
1,2,3,6,7,8-HxCDF	0.1	< 0.042	0.0021	0.085 J	0.0085	< 0.042	0.0021
2,3,4,6,7,8-HxCDF	0.1	< 0.042	0.0021	0.065 I E	0.0065	< 0.056	0.0028
1,2,3,7,8,9-HxCDF	0.1	< 0.052	0.0026	< 0.062	0.0031	< 0.036	0.0018
Total-HxCDF	na	< 0.046		0.380 J		< 0.053	
1,2,3,4,7,8-HxCDD	0.1	< 0.083	0.00415	< 0.130	0.0065	< 0.140	0.0070
1,2,3,6,7,8-HxCDD	0.1	< 0.110	0.0055	< 0.140	0.007	< 0.150	0.0075
1,2,3,7,8,9-HxCDD	0.1	< 0.130	0.0065	< 0.120	0.006	< 0.230	0.0115
Total-HxCDD	na	< 0.110		0.540 J		< 0.170	
1,2,3,4,6,7,8-HpCDF	0.01	0.17 J	0.0017	0.700 J	0.007	0.18 J	0.0018
1,2,3,4,7,8,9-HpCDF	0.01	< 0.070	0.00035	< 0.066	0.00033	< 0.070	0.00035
Total-HpCDF	na	0.17 J		0.700 J		0.32 J	
1,2,3,4,6,7,8-HPCDD	0.01	0.37 I	0.0037	2.100 J	0.021	0.50 J	0.005
Total-HpCDD	na	0.47 J		4.400 J		1.10 J	
OCDF	0.0001	0.27 I	0.000027	0.870 J	0.000087	0.33 J	0.000033
OCDD	0.0001	2.50 BJ	0.00025	16.000	0.0016	7.30 J	0.00073
TEQ	na	na	0.171777	na	0.202792	na	0.244813

Notes

[1/] World Health Organization TEFs for human risk assessment based on the conclusions of WHO meeting in Stockholm, Sweden, June 1997 (Van den Berg et al. 1998).

Abbreviations and Acronyms

J = value below calibration range
na = data not available
no = no analysis conducted
B = less than 10x higher than method blank level
I = interference present
E = estimated maximum possible concentration
< = below method reporting limit
ng/kg = nanogram per kilogram
TEF = toxicity equivalency factor
TEQ = toxicity equivalency quotient

Table 7. Analytical Results for PBDEs

Sample ID	MP-SS-01-A	MP-SS-03-A	MP-SS-09-A
Units	ug/Kg	ug/Kg	ug/Kg
PBDE 17	< 0.11	< 0.079	< 0.12
PBDE 28	< 0.11	< 0.079	< 0.12
PBDE 71	< 0.11	< 0.079	< 0.12
PBDE 47	< 0.11	< 0.079	< 0.12
PBDE 66	< 0.11	< 0.079	< 0.12
PBDE 100	< 0.11	< 0.079	< 0.12
PBDE 99	< 0.11	< 0.079	< 0.12
PBDE 85	< 0.11	< 0.079	< 0.12
PBDE 154	< 0.11	< 0.079	< 0.12
PBDE 153	< 0.11	< 0.079	< 0.12
PBDE 138	< 0.11	< 0.079	< 0.12
PBDE 128	< 0.11	< 0.079	< 0.12
PBDE 183	< 0.11	< 0.079	< 0.12
PBDE 190	< 0.11	< 0.079	< 0.12
PBDE 203	< 0.11	< 0.079	< 0.12
PBDE 206	< 1.1	< 0.79	< 1.2
PBDE 209	< 1.1	< 0.79	< 1.2

Abbreviations and Acronyms

< = below method reporting limit

PBDE = polybrominated diphenyl ethers

ug/Kg = microgram per kilogram

Table 8. Screening Levels for Standard Chemicals of Concern.

Chemical	CAS[1/] Number	Marine				Interim Freshwater	
		SL1 (dry weight)	SL2 (dry weight)	SL1[2/] (mg/kg-OC)	SL2[2/] (mg/kg-OC)	SL1 (dry weight	SL2 (dry weight)
Metals (mg/kg)							
Antimony	7440-36-0	150	150	---	---	---	---
Arsenic	7440-38-2	57	93	---	---	20	51
Cadmium	7440-43-9	5.1	6.7	---	---	1.1	1.5
Chromium	7440-47-3	260	270	---	---	95	100
Copper	7440-50-8	390	390	---	---	80	830
Lead	7439-92-1	450	530	---	---	340	430
Mercury	7439-97-6	0.41	0.59	---	---	0.28	0.75
Nickel	7440-02-0	---	---	---	---	60	70
Silver	7440-22-4	6.1	6.1	---	---	2	2.5
Zinc	7440-66-6	410	960	---	---	130	400
Polynuclear Aromatic Hydrocarbons (µg/kg)							
Total LPAH	---	5,200	5,200	370	780	6,600	9,200
Naphthalene	91-20-3	2,100	2,100	99	170	500	1,300
Acenaphthylene	208-96-8	560	1,300	66	66	470	640
Acenaphthene	83-32-9	500	500	16	57	1,100	1,300
Fluorene	86-73-7	540	540	23	79	1,000	3,000
Phenanthrene	85-01-8	1,500	1,500	100	480	6,100	7,600
Anthracene	120-12-7	960	960	220	1,200	1,200	1,600
2-Methylnaphthalene	91-57-6	670	670	38	64	470	560
Total HPAH	---	12,000	17,000	960	5,300	31,000	55,000
Fluoranthene	206-44-0	1,700	2,500	160	1,200	11,000	15,000
Pyrene	129-00-0	2,600	3,300	1,000	1,400	8,800	16,000
Benz(a)anthracene	56-55-3	1,300	1,600	110	270	4,300	5,800
Chrysene	218-01-9	1,400	2,800	110	460	5,900	6,400
Benzofluoranthenes (b+k)	205-99-2	3,200	3,600	230	450	600	4,000
	207-08-9						
Benzo(a)pyrene	50-32-8	1,600	1,600	99	210	3,300	4,800
Indeno(1,2,3-c,d)pyrene	193-39-5	600	690	34	88	4,100	5,300
Dibenz(a,h)anthracene	53-70-3	230	230	12	33	800	840
Benzo(g,h,i)perylene	191-24-2	670	720	31	78	4,000	5,200
Chlorinated Hydrocarbons (µg/kg)							
1,4-Dichlorobenzene	106-46-7	110	110	3.1	9	---	---
1,2-Dichlorobenzene	95-50-1	35	50	2.3	2.3	---	---
1,2,4-Trichlorobenzene	120-82-1	31	51	0.81	1.8	---	---
Hexachlorobenzene	118-74-1	22	70	0.38	2.3	---	---
Phthalates (ug/kg)							
Dimethyl phthalate	131-11-3	71	160	53	53	46	440
Diethyl phthalate	84-66-2	200	200	61	110	---	---
Di-n-butyl phthalate	84-74-2	1,400	1,400	220	1,700	---	---
Butyl benzyl phthalate	85-68-7	63	900	4.9	64	260	370
Bis(2-ethylhexyl) phthalate	117-81-7	1,300	1,900	47	78	220	320
Di-n-octyl phthalate	117-84-0	6,200	6,200	58	4,500	26	45
Phenols (µg/kg)							
Phenol	108-95-2	420	1,200	---	---	---	---
2-Methylphenol	95-48-7	63	63	---	---	---	---
4-Methylphenol	106-44-5	670	670	---	---	---	---
2,4-Dimethylphenol	105-67-9	29	29	---	---	---	---
Pentachlorophenol	87-86-5	400	690	---	---	---	---
Miscellaneous Extractables (µg/kg)							
Benzyl alcohol	100-51-6	57	73	---	---	---	---
Benzoic acid	65-85-0	650	650	---	---	---	---
Dibenzofuran	132-64-9	540	540	15	58	400	440
Hexachlorobutadiene	87-68-3	11	120	3.9	6.2	---	---
N-Nitrosodiphenylamine	86-30-6	28	40	11	11	---	---
Pesticides (µg/kg)							
p,p'-DDE	72-54-8	16	---	---	---	---	---
p,p'-DDD	72-55-9	9	---	---	---	---	---
p,p'-DDT	50-29-3	34	---	---	---	---	---
Aldrin	309-00-2	---	---	---	---	---	---
alpha-Chlordane	12789-03-6	---	---	---	---	---	---
Dieldrin	60-57-1	---	---	---	---	---	---
Heptachlor	76-44-8	---	---	---	---	---	---
gamma-BHC (Lindane)	58-89-9	---	---	---	---	---	---
Total PCBs	---	130	1,000	12	65	60	120

Notes:

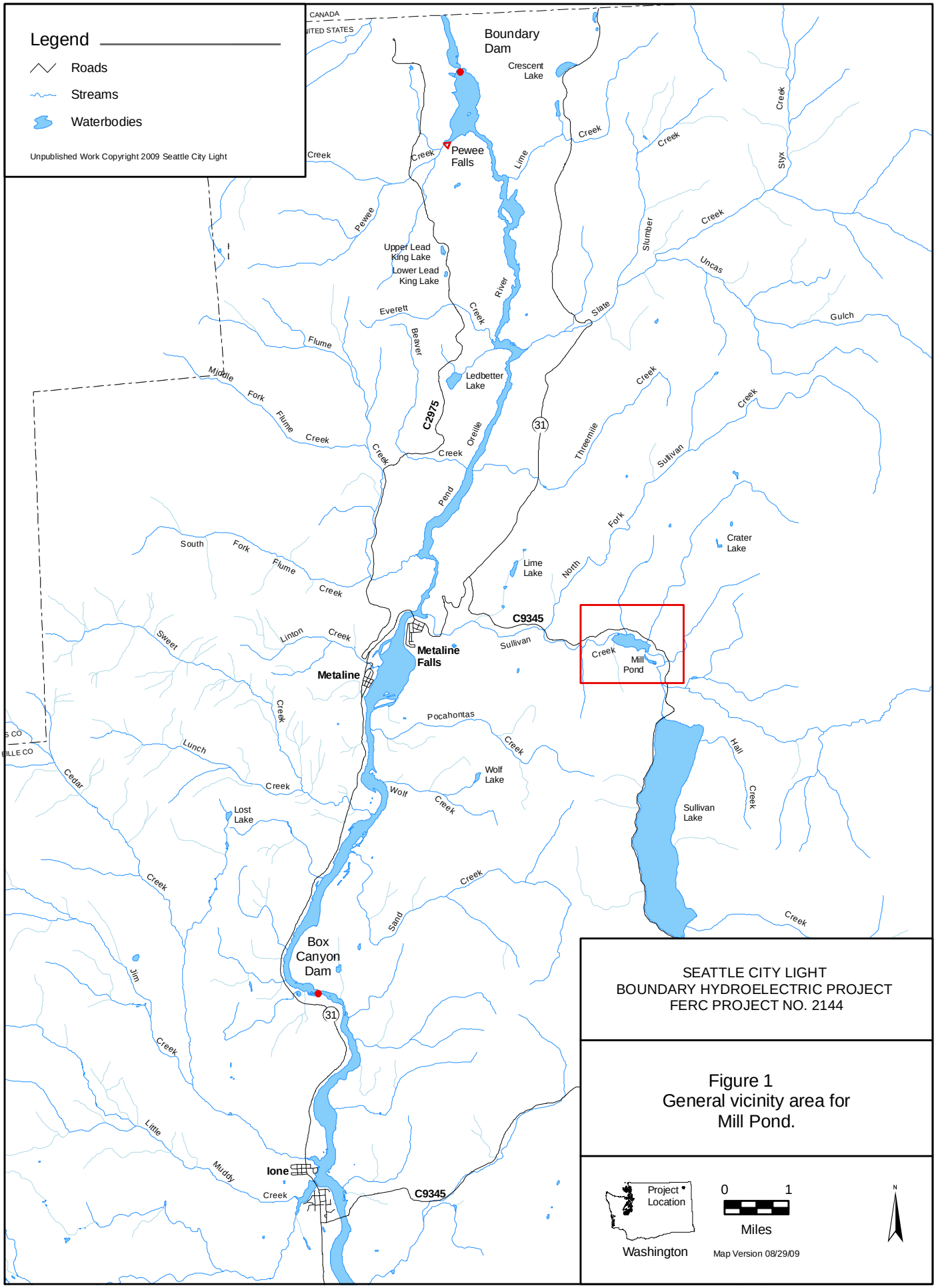
[1/] CAS = Chemical Abstract Service Registry Number

[2/] Screening levels are normalized by the fraction of organic carbon, expressed as mg/kg-OC.

Abbreviations and Acronyms

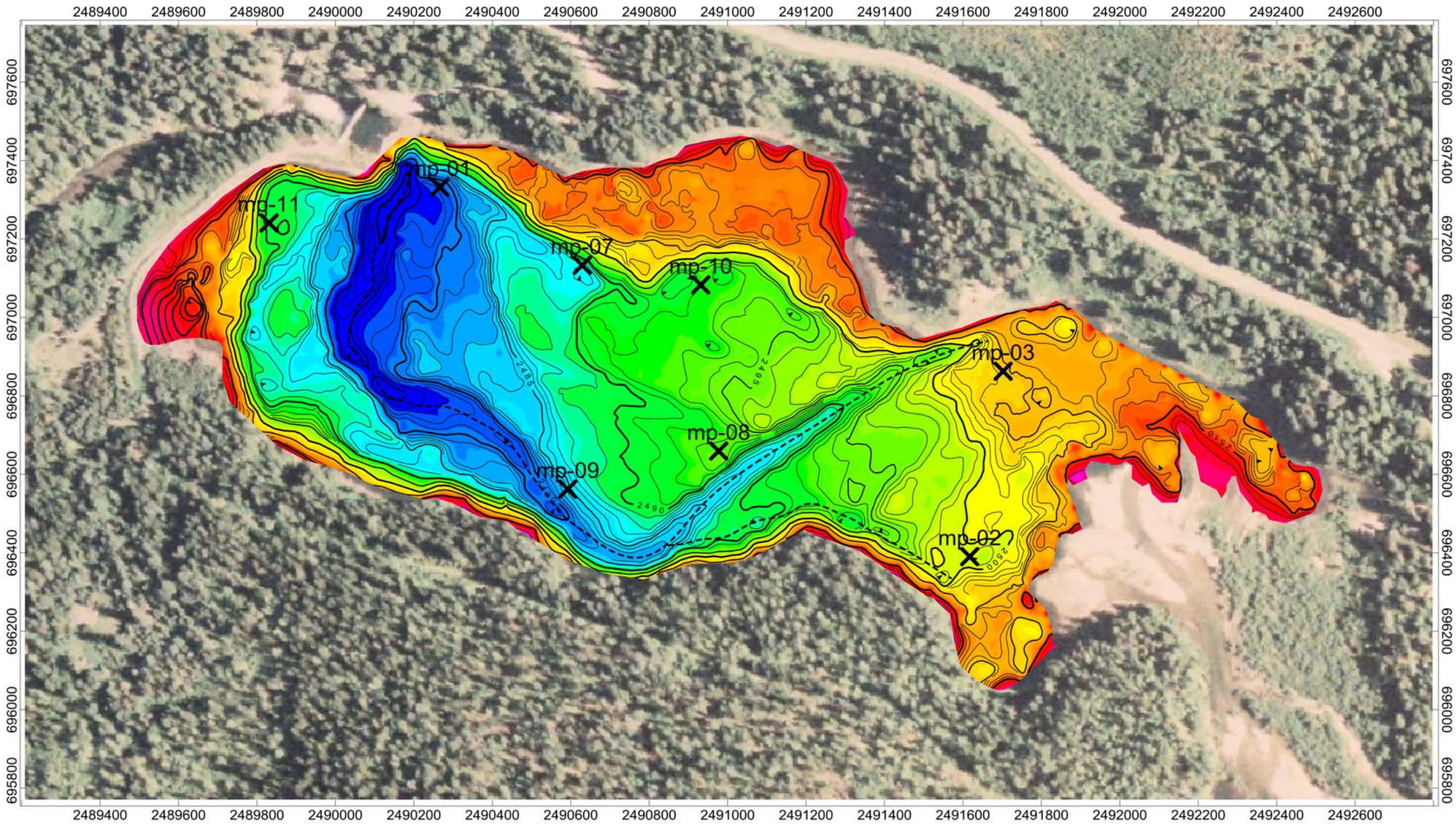
--- No data available

Figures



SEATTLE CITY LIGHT
BOUNDARY HYDROELECTRIC PROJECT
FERC PROJECT NO. 2144

Figure 1
General vicinity area for
Mill Pond.



Legend

mp-07 X — Vibracore Locations

Former Creek Channel

2540 — Bathymetry Contours

Prepared by R. Funk
\\eciseafile1\Groups\Marine Mapping\Projects\Mill Pond\Oasis\Mill_Pond\Mill_Pond_Bathy_v2.map

Mill Pond Bottom Elevation
NAVD-88 in feet

2477.1 2483.0 2487.5 2489.8 2492.4 2495.7 2500.1 2504.7 2507.3 2508.9 2510.5 2512.7 2514.2

-35.8 -29.9 -25.3 -23.0 -20.3 -16.9 -12.4 -7.9 -6.0 -4.6 -3.8 -2.8 -1.4 -0.1 0.6 2.9

Water Depths Relative to 2513 ft. Pool Elevation
Mill Pond Water Depth

Scale 1:3000

100 0 100 200 300 400 500 600 700

US survey foot

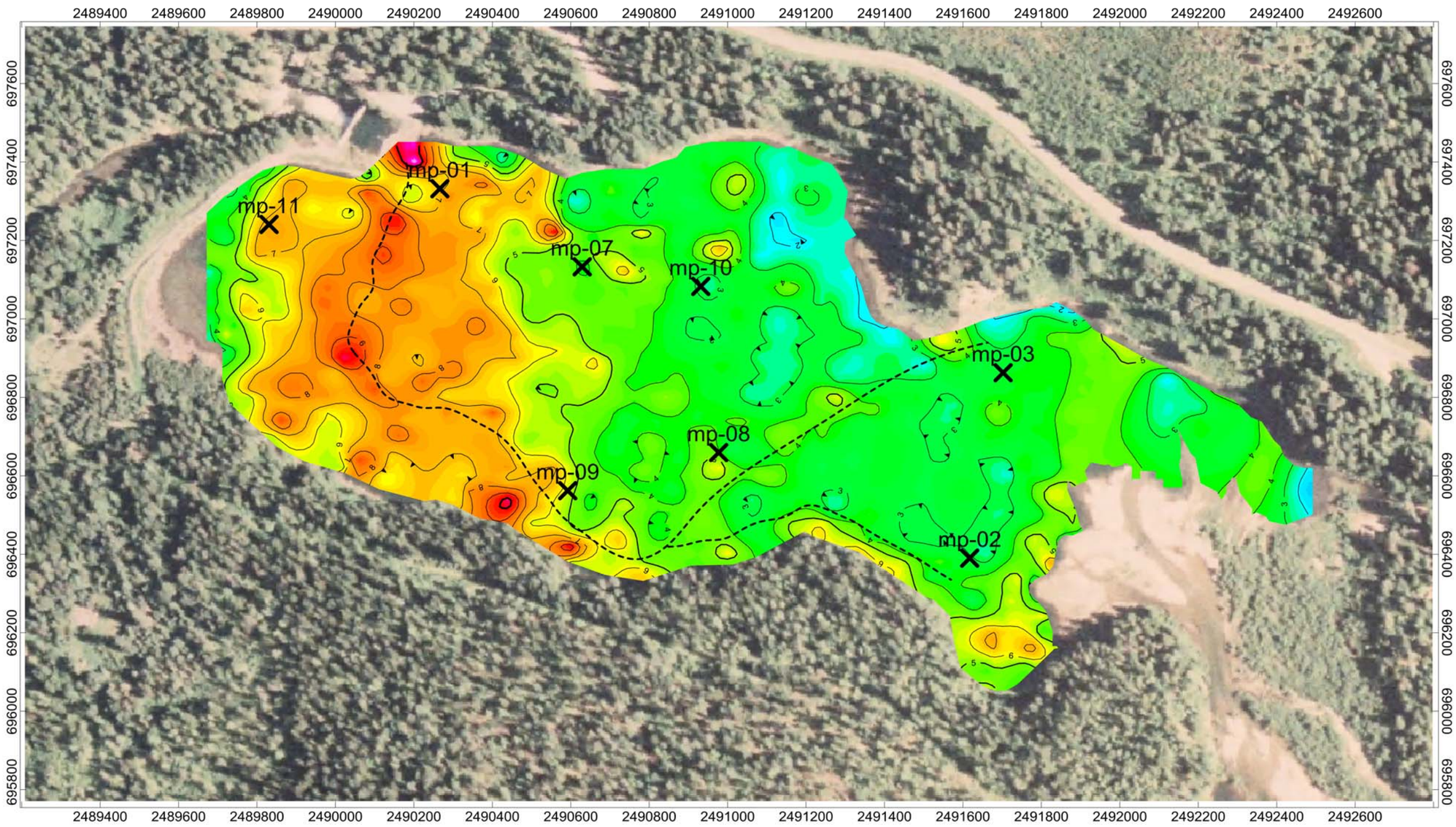
NAD83 / Washington CS83 North zone NAVD88

Seattle City Light

Mill Pond
Boundary Hydroelectric Project (FERC No. 2144)

Figure 3
Bathymetric Map with Sample Locations

TtEC Marine Mapping Group



Legend

mp-07 X — Vibracore Locations

Former Creek Channel

5 — Sediment Thickness Contours

Prepared by R. Funk
\\eciseafile1\Groups\Marine Mapping\Projects\Mill Pond\Oasis\Mill_Pond\Mill_Pond_Bathy_v2.map

Mill Pond Sediment Thickness
Isopac in Feet

0.3 0.9 1.5 2.2 2.8 3.4 4.0 4.6 5.2 5.8 6.5 7.1 7.7 8.3 8.9 9.5 10.2 10.8 11.4

Scale 1:3000

100 0 100 200 300 400 500 600 700

US survey foot

NAD83 / Washington CS83 North zone NAVD88

Seattle City Light

Mill Pond
Boundary Hydroelectric Project (FERC No. 2144)

Figure 4
Sediemnt Isopac Map with Sample Locations

TtEC Marine Mapping Group

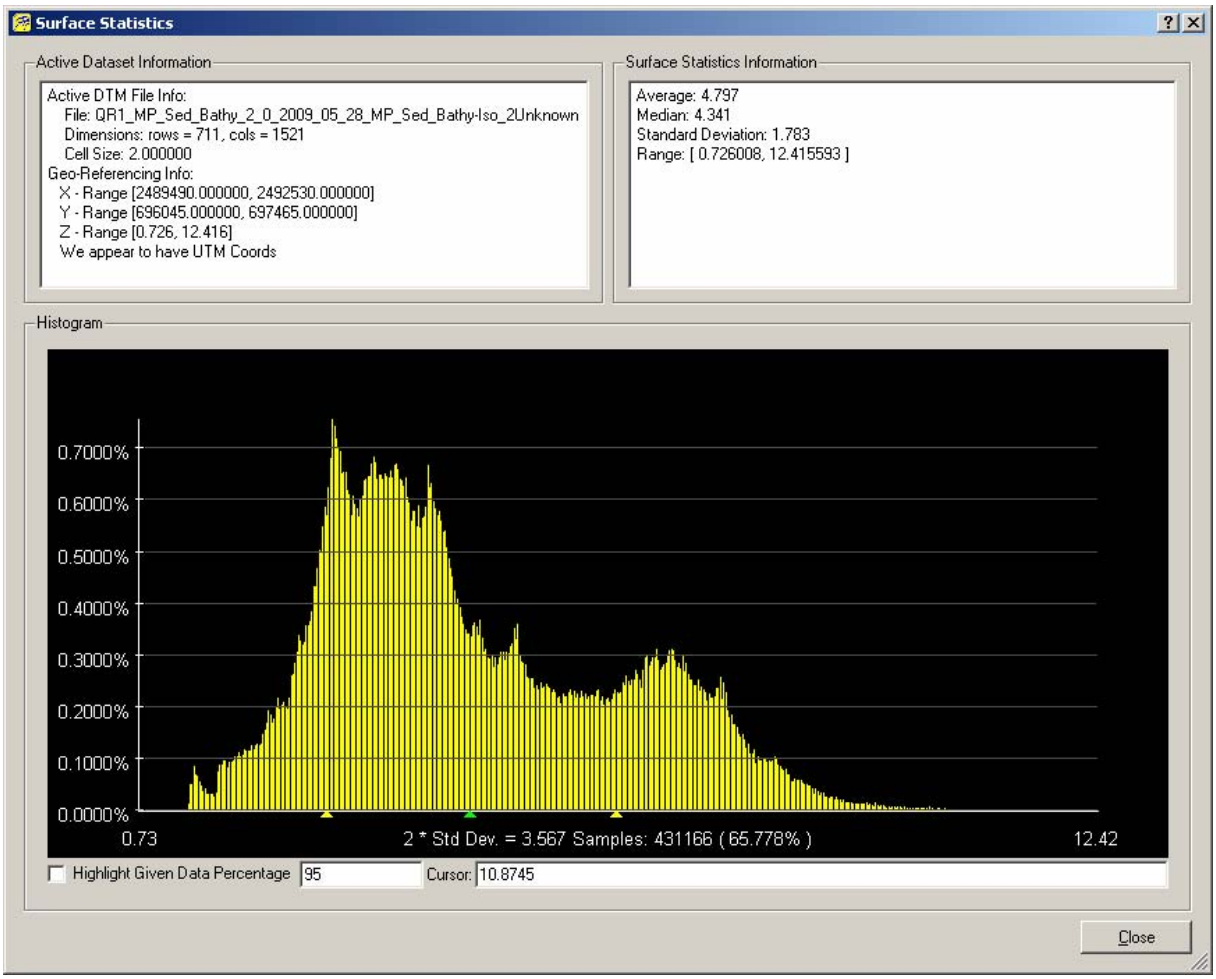


Figure 4. Sediment Volume Calculation Statistics

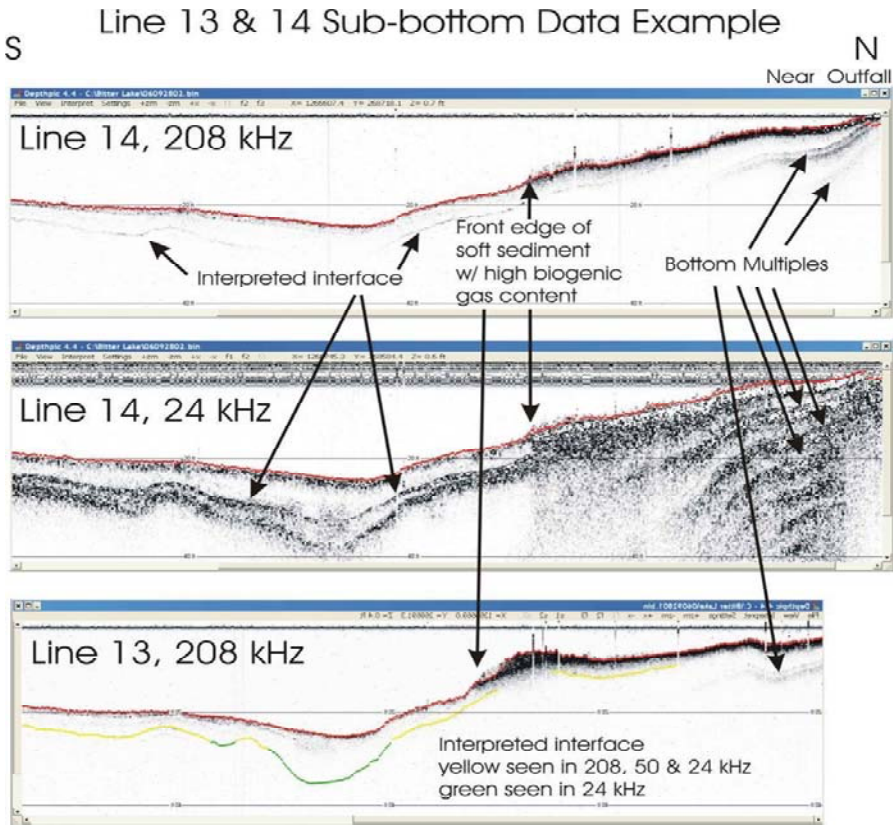


Figure 5a. Sample of BSS+5 data collected in a shallow lake in Western Washington

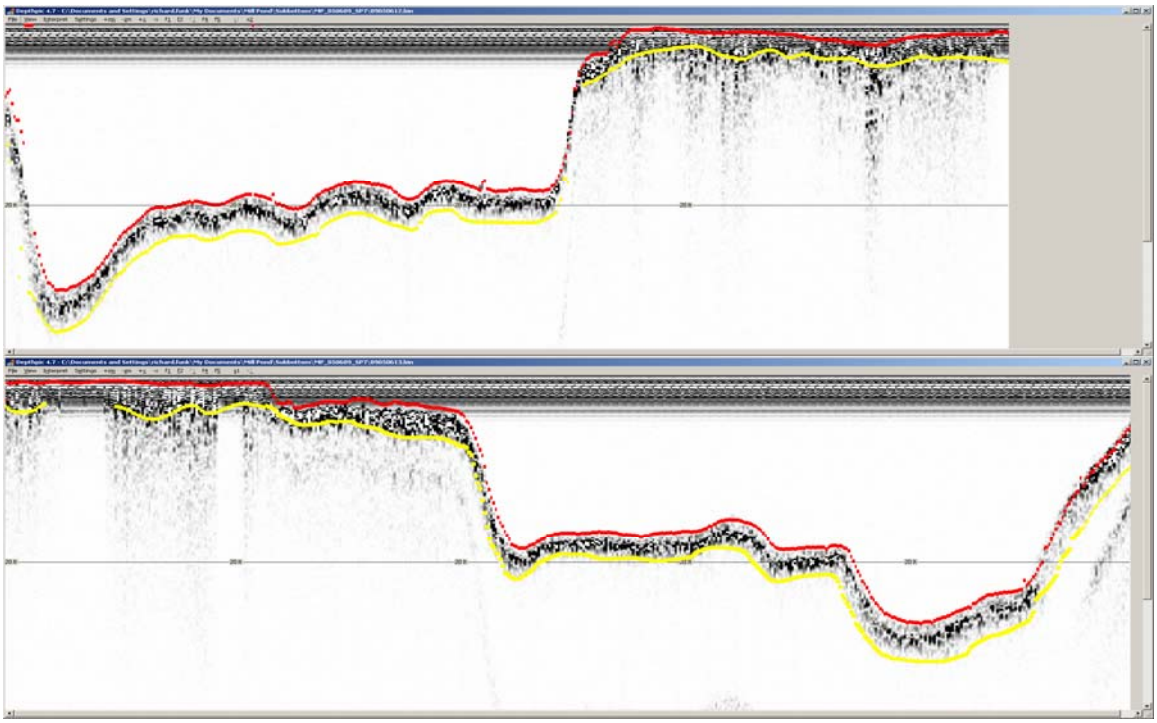
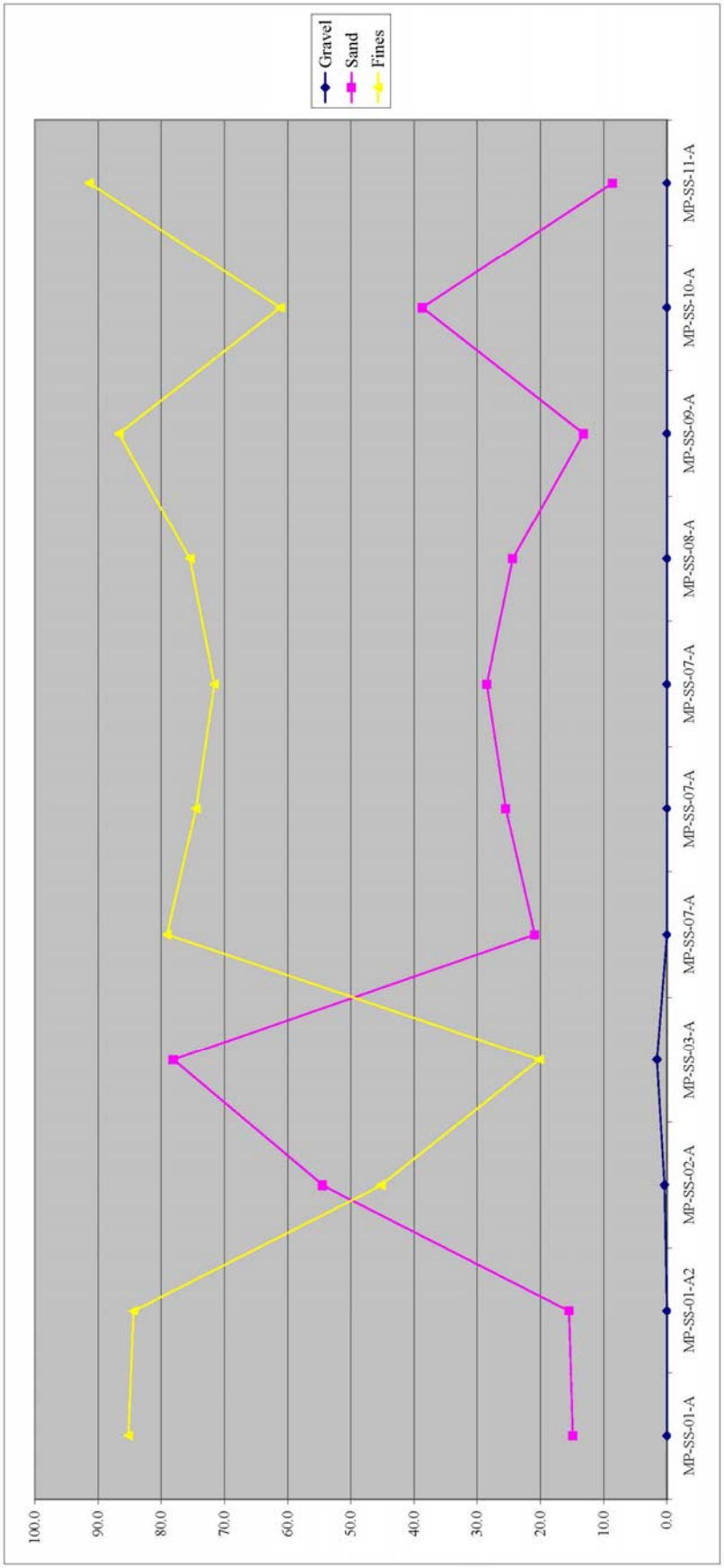


Figure 5b. Sample of BSS+5 data collected in Mill Pond

Figure 6. Grain Size Analysis Results for Surface Samples



	% Gravel	% Sand	% Fines
MP-SS-01-A	0.0	14.9	85.2
MP-SS-01-A2	0.0	15.5	84.4
MP-SS-02-A	0.4	54.5	45.2
MP-SS-03-A	1.6	78.1	20.2
MP-SS-07-A	0.0	20.9	79.1
MP-SS-07-A	0.0	25.5	74.5
MP-SS-07-A	0.0	28.5	71.6
MP-SS-08-A	0.0	24.4	75.5
MP-SS-09-A	0.0	13.2	86.7
MP-SS-10-A	0.0	38.7	61.2
MP-SS-11-A	0.0	8.6	91.4

Notes
Results are for Surface samples only.

Appendix 1: 2009 Mill Pond Geophysical Survey Survey Control

2009 Mill Pond Geophysical Survey
Survey Control

May 20, 2009

Prepared by:

TETRA TECH EC, INC.

19803 North Creek Parkway
Bothell, WA 98011
(425) 482 7600

1.1 Geodesy Settings

Horizontal (X, Y) positioning data for the project were collected in U.S. Washington State Plane North, NAD-83 and elevation data were collected in North American Vertical Datum 1988 (NAVD-88). Table 1-1 presents the geodesy settings used for the project.

Table 1-1. Survey Geodesy Settings

Parameter	Setting
Grids	State Plane NAD-83
Zone	WA-4601 Washington North
Distance Unit	Survey feet
Depth Unit	Survey feet
Ellipsoid	NAD-83 GRS 80
Geoid Model	G2003u01
Elevation	NAVD-88

1.2 GPS Control and Validation

Vertical and horizontal positioning on the survey vessel was achieved using a high-accuracy GPS system with RTK corrections provided via a radio modem from a local base station. A Leica 1230 RTK GPS was positioned over an existing benchmark near the dam spillway (Figures 1A, and 1B). Established coordinates for the bench mark were not readily available. Prior to the start of survey operations the base station control point was occupied for approximately 5 hours with data logging at 5 seconds intervals. The recorded data was then submitted to the National Geodetic Survey (NGS) Online User Positioning Service (OPUS) where a static solution with reported uncertainties was computed (Attachment 1). The OPUS reported coordinates were then entered into the base station GPS which provided a real time correction to the GPS on the survey vessel and the GPS rover using for shoreline surveying and verification of the base station correction. Table 1-2 presents a summary of the OPUS solution.

Table 1-2. NGS OPUS Solution for RTK GPS Base Station Control Point

Point ID	Date/ Time	Lat	Long	East (ft)	North (ft)	Ortho Ht. (ft)	RMS
2519.979	5/5/2009 21:46	48 51 30.329 (N)	117 18 10.840 (W)	2490019.66	8169256.51	2525.18	0.043

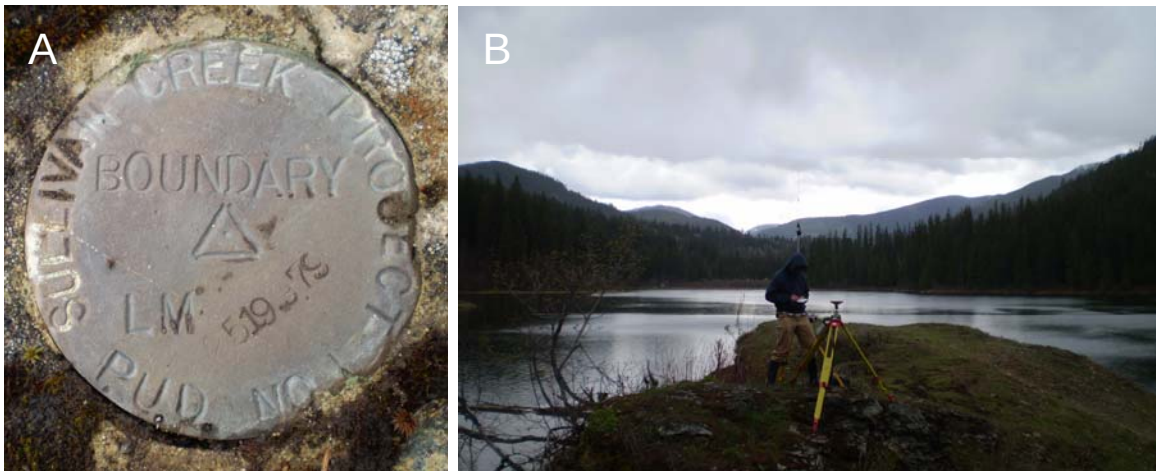


Figure 1-1. Mill Pond GPS Base Station. **A**: Existing Benchmark cemented into bedrock. **B**: Base Station Assembled over benchmark.

A Leica 1230 GPS identical to the system utilized on the survey boats was used to verify the functionality and accuracy of the RTK GPS positioning. Four Washington Department of Transportation (WADOT) control points were occupied with the RTK GPS and their positions were logged. Table 1-3 presents the coordinates and results from occupation of the control points used for verification of the GPS base station. The coordinate system is Washington State Plane North, the unit of measurement is survey feet, and the reference datum is the NAVD-88. Data sheets for the control points can be found in Attachment 2. Also included in Table 1-3 is a check of the water surface elevation on Mill Pond (WL-050809).

Table 1-3. Survey Geodesy Control Points

Point ID	Date/ Time	WADOT E(m)	WADOT N(m)	Ortho Ht.	East (ft)	North (ft)	Ortho Ht. (ft)	Diff E(ft)	Diff N(ft)	Diff Z(ft)
		Washington DOT Published Corrdinates			TtEC Surveyed Position					
6344	5/8/2009 10:16	2477829.92	702307.11	2519.65	2477830.05	702307.10	2520.65	0.13	-0.01	1.00
4249	5/8/2009 10:29	NA	NA	2518.49	2477839.23	702196.61	2519.49	NA	NA	1.00
4303	5/8/2009 11:16	2495259.04	672194.39	2595.65	2495259.03	672194.39	2596.53	-0.01	0.00	0.88
4285	5/8/2009 11:55	2513744.88	699196.19	4390.38	2513744.84	699196.28	4392.35	-0.04	0.09	1.97
WL-050809	5/8/2009 12:29				2492501.97	696511.43	2513.01			

Attachment 1
NGS OPUS Solution Report

FILE: 25191250.09o 000046760

NGS OPUS SOLUTION REPORT
==========

All computed coordinate accuracies are listed as peak-to-peak values.
For additional information: www.ngs.noaa.gov/OPUS/Using_OPUS.html#accuracy

USER: ryanscross@gmail.com DATE: May 20, 2009
RINEX FILE: 2519125q.09o TIME: 21:54:03 UTC

SOFTWARE: page5 0810.20 master28.pl 081023 START: 2009/05/05 16:55:00
EPHEMERIS: igr15302.eph [rapid] STOP: 2009/05/05 21:46:00
NAV FILE: brdc1250.09n OBS USED: 8809 / 9687 : 91%
ANT NAME: LEIAX1202 NONE # FIXED AMB: 46 / 49 : 94%
ARP HEIGHT: 0.754 OVERALL RMS: 0.013(m)

REF FRAME: NAD_83(CORS96)(EPOCH:2002.0000) ITRF00 (EPOCH:2009.3419)

X:	-1928726.094(m)	0.027(m)	-1928726.873(m)	0.027(m)
Y:	-3736356.530(m)	0.025(m)	-3736355.343(m)	0.025(m)
Z:	4780782.151(m)	0.017(m)	4780782.192(m)	0.017(m)
LAT:	48 51 30.32959	0.017(m)	48 51 30.34746	0.017(m)
E LON:	242 41 49.15960	0.022(m)	242 41 49.09894	0.022(m)
W LON:	117 18 10.84040	0.022(m)	117 18 10.90106	0.022(m)
EL HGT:	753.284(m)	0.028(m)	752.856(m)	0.028(m)
ORTHO HGT:	769.684(m)	0.047(m) [NAVD88 (Computed using GEOID03)]		

	UTM COORDINATES (UTM (Zone 11))	STATE PLANE COORDINATES (SPC (4601 WA N))
Northing (Y) [meters]	5411762.001	212575.463
Easting (X) [meters]	477774.260	758967.222
Convergence [degrees]	-0.22819449	2.62839657
Point Scale	0.99960607	1.00002593
Combined Factor	0.99948808	0.99990789

US NATIONAL GRID DESIGNATOR: 11UMQ7777411762(NAD 83)

BASE STATIONS USED

PID	DESIGNATION	LATITUDE	LONGITUDE	DISTANCE(m)
DK4088	BREW BREWSTER VLBA CORS ARP	N480753.468	W1194057.422	193556.3
DE6548	DRAO PENTICTON CORS ARP	N491921.409	W1193729.876	177280.2
DK3593	SPN6 SPOKANE 6 CORS ARP	N473106.107	W1172524.001	149288.9

NEAREST NGS PUBLISHED CONTROL POINT

TO0345	2516 22 26	N485250.	W1172028.	3721.9

Attachment 2
WADOT Control Point Data Sheets

Washington State Department of Transportation **Geographic Services**

SURVEY INFORMATION SYSTEM Report of Survey Mark

GENERAL MONUMENT INFORMATION

Designation:	GP26031-25	**T.R.S:**	39N, 43E, 15
Monument ID:	6344	**Corner Code:**	
Ngs Pid:	DL2087	**State Route:**	031
State:	WASHINGTON	**Mile Post:**	16.400
County:	PEND OREILLE	**Station:**	
Region:	EA	**Offset:**	
Nearest Town:	METALINE FALLS	**Owner:**	GS
Usgs Quad:	METALINE FALLS	**Bearing:**	M

ACCOUNTS INFORMATION

BOOK	PROJECT	INVOICE
93	XL1150	23-04029

Description

TO REACH THE STATION FROM THE INTERNATIONAL BORDER CROSSING ON SR 031 (MP 26.8) NORTHEAST OF METALINE FALLS, GO SOUTHERLY 10.4 MILES ALONG SR 031 TO MARK ON RIGHT. IT IS LOCATED IN THE BRUSHY SHOULDER ON THE NORTHWEST SIDE OF SR 031, IN THE WESTERLY SECTOR OF THE INTERSECTION WITH P.O. MINE ROAD, 19.1 METERS @ 210 DEGREES FROM THE APPROXIMATE CENTERLINE OF P.O. MINE ROAD, 12.4 METERS @ 310 DEGREES FROM THE APPROXIMATE CENTERLINE OF SR 031, 80 CM @ 35 DEGREES FROM A WITNESS POST, 90 CM @ 125 DEGREES FROM A WITNESS POST AND 30.7 METERS @ 170 DEGREES FROM A POWER POLE. THE MARK IS A WSDOT BRASS DISK SET IN THE TOP OF A ROUND CONCRETE MONUMENT AND UNDER A WSDOT MONUMENT CASE AND COVER, WHICH IS SET LEVEL WITH THE GROUND SURFACE. NOTE: THIS STATION SIGHTS GP 26031-22 AND IS IN THE VICINITY OF GP 26031-21 WHICH IS SCHEDULED TO BE DESTROYED BY CONSTRUCTION.

CURRENT SURVEY CONTROL

DATUM	LATITUDE	UNIT	LONGTITUDE	UNIT	NETWORK	METHOD	ACCURACY
NAD 83/07	48 52 24.000543	S	117 21 09.626283	W	PRIMARY	GPS	2 CM

	ELLIP HGT						
NAD 83	751.577	M				GPS	5 CM
	ORTHO HGT						
NAVD 88	768.000	M			PRIMARY	DIFF LEVELS	1 CM
SPC ZONE	**NORTHING**	**UNIT**	**EASTING**	**UNIT**	**SCALE**	**CONV.ANGLE**	**COMB.FACTOR**
N	214065.810	M	755251.744	M	1.00002934	2 35 29.1	

MONUMENTATION HISTORY

DATE	RECOVERED BY	CONDITION
10/05/2004	GEOGRAPHIC SERVICES	MONUMENTED
01/09/2008	GEOGRAPHIC SERVICES	UPDATED

SUPERSEDED CONTROL

DATUM	LATITUDE	UNIT	LONGTITUDE	UNIT	NETWORK	METHOD	ACCURACY
NAD 83/91	48 52 23.998875	S	117 21 09.627269	W	PRIMARY	GPS	2 CM
	ELLIP HGT						
NAD 83	751.705	M				GPS	5 CM

SPCZONE	NORTHING	UNIT	EASTING	UNIT	SCALE	CONV.ANGLE	COMB.FACTOR
N	214065.758	M	755251.726	M	1.00002934	2 35 29.1	

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Washington State Department of Transportation **Geographic Services**

SURVEY INFORMATION SYSTEM Report of Survey Mark

GENERAL MONUMENT INFORMATION

Designation:	G 483	**T.R.S:**	39N, 43E, 22
Monument ID:	4249	**Corner Code:**	
Ngs Pid:	TO0750	**State Route:**	031
State:	WASHINGTON	**Mile Post:**	16.550
County:	PEND OREILLE	**Station:**	
Region:	EA	**Offset:**	
Nearest Town:	METALINE FALLS	**Owner:**	GS
Usgs Quad:	METALINE FALLS	**Bearing:**	M

ACCOUNTS INFORMATION

BOOK	PROJECT	INVOICE
77	PN0013	23-99044
87	XL0715	23-00032
93	XL1150	23-04029

Description

TO REACH THE STATION FROM THE INTERSECTION OF SR 031(BRIDGE OVER PEND OREILLE RIVER) AND SULLIVAN LAKE ROAD, IN METALINE FALLS. GO NORTHEAST 2.05 MILES ALONG SR 031 TO MARK. IT IS LOCATED 40 CM @ 210 DEGREES FROM A METAL WITNESS POST, 60 CM @ 295 DEGREES FROM A WOODEN CORNER POST, 60 CM @ 5 DEGREES FROM AN ORANGE WITNESS POST, 35.1 METERS @ 30 DEGREES FROM THE APPROXIMATE CENTERLINE OF SULLIVAN LAKE ROAD AND 13.0 METERS @ 120 DEGREES FROM THE APPROXIMATE CENTERLINE OF SR 031. THE MARK IS A STAINLESS STEEL ROD WITHOUT A SLEEVE AND IS ABOVE THE LEVEL OF THE ROADWAY SURFACE.

CURRENT SURVEY CONTROL

DATUM	LATITUDE	UNIT	LONGTITUDE	UNIT	NETWORK	METHOD	ACCURACY
NAD 83/91	48 52 22.000000	N	117 21 08.000000	W	OTHER	SCALE	10 M+

	ORTHO HGT						
NAVD 88	767.645	M			PRIMARY	DIFF LEVELS	1 CM
SPC ZONE	**NORTHING**	**UNIT**	**EASTING**	**UNIT**	**SCALE**	**CONV.ANGLE**	**COMB.FACTOR**
N	214010.000	M	755290.000	M		0 00 00.0	

MONUMENTATION HISTORY

DATE	RECOVERED BY	CONDITION
01/01/1980	NGS	MONUMENTED
09/17/1999	GEOGRAPHIC SERVICES	GOOD
10/05/2004	GEOGRAPHIC SERVICES	GOOD

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Washington State Department of Transportation **Geographic Services**

SURVEY INFORMATION SYSTEM **Report of Survey Mark**

GENERAL MONUMENT INFORMATION

Designation:	SULLIVAN	**T.R.S:**	38N, 44E, 18
Monument ID:	4303	**Corner Code:**	
State:	WASHINGTON	**State Route:**	
County:	PEND OREILLE	**Mile Post:**	
Region:	EA	**Station:**	
Nearest Town:	METALINE FALLS	**Offset:**	
Usgs Quad:	METALINE FALLS	**Owner:**	GS
		Bearing:	M

ACCOUNTS INFORMATION

BOOK	PROJECT	INVOICE
85	MS3747	23-99045

Description

TO REACH THE STATION FROM THE JUNCTION OF SR 031 AND SR 020 IN TIGER, GO NORTHERLY 15.77 MILES ALONG SR 031 TO THE INTERSECTION WITH SULLIVAN LAKE ROAD, NORTH OF METALINE FALLS, TURN RIGHT AND GO EASTERLY AND SOUTHERLY A TOTAL OF 9.40 MILES ALONG SULLIVAN LAKE ROAD TO MARK ON RIGHT. IT IS LOCATED IN THE WESTERLY SIDE OF SULLIVAN LAKE ROAD, IN A GRAVEL SHOULDER WIDENING AT THE SOUTH END OF LAKE SULLIVAN, NEAR THE BRIDGE OVER HARVEY CREEK, 9.2 METERS @ 205 DEGREES FROM THE APPROXIMATE CENTERLINE OF SULLIVAN LAKE ROAD, 1.3 METERS @ 300 DEGREES FROM AN ORANGE WITNESS POST, 1.2 METERS @ 30 DEGREES FROM AN ORANGE WITNESS POST AND 23.7 METERS @ 120 DEGREES FROM THE SOUTHEAST CORNER OF A BRIDGE. THE MARK IS A WSDOT BRASS DISK SET IN THE TOP OF A ROUND CONCRETE MONUMENT, CONTAINING A MAGNETIC LOCATOR AND UNDER A WSDOT MONUMENT CASE AND COVER WHICH IS SET LEVEL WITH THE GRAVEL SURFACE.

CURRENT SURVEY CONTROL

DATUM	LATITUDE	UNIT	LONGTITUDE	UNIT	NETWORK	METHOD	ACCURACY
NAD 83/07	48 47 19.338976	N	117 17 09.956249	W	PRN	GPS	2 CM
	ELLIP HGT						
NAD 83	774.721	M				GPS	5 CM

	ORTHO HGT						
NAVD 88	791.164	M			PRIMARY	DIFF LEVELS	1 CM
SPC ZONE	**NORTHING**	**UNIT**	**EASTING**	**UNIT**	**SCALE**	**CONV.ANGLE**	**COMB.FACTOR**
N	204887.342	M	760564.205	M	1.00001088	2 38 27.6	

MONUMENTATION HISTORY

DATE	RECOVERED BY	CONDITION
09/28/1999	GEOGRAPHIC SERVICES	MONUMENTED
01/09/2008	GEOGRAPHIC SERVICES	UPDATED

SUPERSEDED CONTROL

DATUM	LATITUDE	UNIT	LONGTITUDE	UNIT	NETWORK	METHOD	ACCURACY
NAD 83/91	48 47 19.337360	N	117 17 09.957323	W	PRN	GPS	2 CM
	ELLIP HGT						
NAD 83	774.843	M				GPS	5 CM

SPCZONE	NORTHING	UNIT	EASTING	UNIT	SCALE	CONV.ANGLE	COMB.FACTOR
N	204887.292	M	760564.185	M	1.00001088	2 38 27.6	

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Washington State Department of Transportation **Geographic Services**

SURVEY INFORMATION SYSTEM **Report of Survey Mark**

GENERAL MONUMENT INFORMATION

Designation:	TOTEM	**T.R.S:**	39N, 44E, 23
Monument ID:	4285	**Corner Code:**	
State:	WASHINGTON	**State Route:**	
County:	PEND OREILLE	**Mile Post:**	
Region:	EA	**Station:**	
Nearest Town:	METALINE FALLS	**Offset:**	
Usgs Quad:	PASS CREEK	**Owner:**	GS
		Bearing:	M

ACCOUNTS INFORMATION

BOOK	PROJECT	INVOICE
85	MS3747	23-99045

Description

TO REACH THE STATION FROM THE JUNCTION OF SR 031 AND SR 020 IN TIGER, GO NORTHERLY 15.77 MILES ALONG SR 031 TO THE INTERSECTION WITH SULLIVAN LAKE ROAD, NORTH OF METALINE FALLS, TURN RIGHT AND GO EASTERLY AND SOUTHERLY 4.42 MILES ALONG SULLIVAN LAKE ROAD TO THE INTERSECTION WITH FR2212. TURN LEFT AND GO EASTERLY AND NORTHERLY 3.50 MILES ALONG FR2212 TO A FORK. BEAR RIGHT AND CONTINUE EASTERLY AND NORTHERLY 3.05 MILES ALONG FR2212 TO MARK ON RIGHT. IT IS LOCATED IN THE EASTERLY SIDE OF FR2212, IN A GRAVEL PULL-OUT OVERLOOKING TOTEM GULCH, NEAR THE BEGINNING OF A CURVE RIGHT, 2.1 METERS @ 260 DEGREES FROM A WITNESS POST, 21.0 METERS @ 20 DEGREES FROM A CMP , 10.7 METERS @ 60 DEGREES FROM THE APPROXIMATE CENTERLINE OF FOREST SERVICES ROAD 2212 AND 2.3 METERS @ 160 DEGREES FROM A WITNESS POST. THE MARK IS A WSDOT BRASS DISK SET IN THE TOP OF A ROUND CONCRETE MONUMENT, CONTAINING A MAGNETIC LOCATOR AND UNDER A WSDOT MONUMENT CASE AND COVER WHICH IS SET LEVEL WITH THE GRAVEL SURFACE.

CURRENT SURVEY CONTROL

DATUM	LATITUDE	UNIT	LONGTITUDE	UNIT	NETWORK	METHOD	ACCURACY
NAD 83/07	48 51 36.974704	N	117 12 15.208338	W	PRN	GPS	2 CM
	ELLIP HGT						
NAD 83	1322.020	M				GPS	5 CM

	ORTHO HGT						
NAVD 88	1338.205	M			PRIMARY	GPS	5 CM
SPC ZONE	**NORTHING**	**UNIT**	**EASTING**	**UNIT**	**SCALE**	**CONV.ANGLE**	**COMB.FACTOR**
N	213117.589	M	766198.755	M	1.00002635	2 42 07.0	

MONUMENTATION HISTORY

DATE	RECOVERED BY	CONDITION
09/28/1999	GEOGRAPHIC SERVICES	MONUMENTED
01/09/2008	GEOGRAPHIC SERVICES	UPDATED

SUPERSEDED CONTROL

DATUM	LATITUDE	UNIT	LONGTITUDE	UNIT	NETWORK	METHOD	ACCURACY
NAD 83/91	48 51 36.973101	N	117 12 15.209421	W	PRN	GPS	2 CM
	ELLIP HGT						
NAD 83	1322.142	M				GPS	5 CM
	ORTHO HGT						
NAVD 88	1338.185	M			PRIMARY	GPS	5 CM

SPCZONE	NORTHING	UNIT	EASTING	UNIT	SCALE	CONV.ANGLE	COMB.FACTOR
N	213117.538	M	766198.735	M	1.00002635	2 42 07.0	

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Appendix 2: Coring Logs

Project Name: Mill Pond
Boring Number: MD-SC-01
Logged By: Regan

Client: SCC
Site Manager: Steve Negri
Drilling Contractor: Tetra
Drilling Method: Vibracore
Sampling System: NA

Sheet 1 of 1
Date/Time Started: 5/7/09
Date/Time Completed: 5/7/09
Total Depth: 8'
Water Depth: —

OFS Number: 106-3414
Location: Infront of Dam

DEPTH (ft)*	Sample #	Moisture/ Water Prod.	Cobbles/ Boulders	Crs. Gravel	Fine Gravel	Crs. Sand	Med. Sand	Fine Sand	Silt/Clay	USCS Symbol	Graphic Log	Description
												Cap Data 8' push / 7.2 recovery = 90% on table 4.5' recovery = 56% log core but no sample
1	A	W							100	ML		0.0ft very loose, very dark gray (3/1 5Y) fine grained, wet, non plastic, non cohesive, no odor, minor organics, SILT (ML)
2	B							5	95	ML		occasional regions of black (7.5/1 5Y)
3	C	W					5	15	70	ML		2.4 soft, olive brown (4/3 2.5Y), fine grained, wet, low plasticity, cohesive, SILT WITH SAND (ML)
4	D											
		M			65	5	5	10	15	GM		4.1 medium to med dense, olive brown (4/3 2.5Y) coarse grained, cohesive, non plastic, organics
5												4.5 TD (GM) Silty Gravel w/ SAND, some black blotches.
6												
7												Logged but not sampled
8												

* Depth uncorrected for compaction.

Project Name: Mill Pond	Client: SCL	Sheet 1 of 1	
Boring Number: MP-SC-01	Site Manager: Steve Negri	Date/Time Started: 5/8/09	
Logged By: Bryan Graham	Drilling Contractor: TTEC	Date/Time Completed: 5/8/09	
OFS Number: 106-3414	Drilling Method: Vibracore	Total Depth: —	
Location: East of Dam & Log boom	Sampling System: SS sleeve	Water Depth: —	

* DEPTH (ft)	Sample #	Moisture/ Water Prod.	Cobbles/ Boulders	Crs. Gravel	Fine Gravel	Crs. Sand	Med. Sand	Fine Sand	Silt/Clay	USCS Symbol	Graphic Log	Description
												8 ft core / 7.8 recovered / 7.5 when brought to shore 7.3 recovered 5/8 AM = 91%
1	A	W							100	ML		0.0 soft, very dark greenish gray (3/1 5GY Gley1), fine grained, med to low plasticity, cohesive, SILT (ML), organics (thin roots?)
2	B	W							100 100	ML		1.2 very soft, color change to dark greenish gray (4/1 10Y Gley1), non plastic, very wet, SILT (ML), some organics.
3	C	W							100	ML		
4	D	W							100	ML		
5	E	W						5	95	ML		fine Sand % starts to increase
6	F	W						10	90	ML		
7	G	M					5	95	T	SP		6.2 medium, dark greenish gray (4/1 10Y Gley1), non plastic, cohesive, coarse, trace silt, Poorly GRADED SAND (SP), minor organics (roots), white mica/phyllite flakes in sand.
8	H	M					5	95	T+	SP		silt content increases slightly

* Depth corrected for compaction

Project Name: Mill Pond	Client: SCC	Sheet 1 of 1	
Boring Number: MP-SC-02	Site Manager: Steve Negri	Date/Time Started: 5/6/09	
Logged By: Bryan Graham	Drilling Contractor: T+EC	Date/Time Completed: 5/6/09	
OFS Number: 106-3414	Drilling Method: Vibracore	Total Depth: —	
Location: Mill Pond	Sampling System: SS spoon	Water Depth: —	

DEPTH (ft)	Sample #				Moisture/ Water Prod.	Size Fractions % Cobbles/ Boulders	Crs. Gravel	Fine Gravel	Crs. Sand	Med. Sand	Fine Sand	Silt/Clay	USCS Symbol	Graphic Log	Description
1		A			W								ML		8ft core 7.2ft recovery 90% recovery 0-0.3 Very Dark greenish gray (3/1 10Y Gy), fine grained, woody debris, fine grained (SILT) ML with some sand, wet 0.3 color change to (4/1 10Y Gley 1) dark greenish gray, low plasticity, cohesive, less organics than above, SILT WITH SAND ML, very soft
2		B			W										0.4 Density change, soft to medium
3		C											ML		2.5, same as above but slight layering visible, more pronounced at 4.8 ft Some H_2S odor
4	Sp4	D													4.7 very dark layer w stronger H_2S odor
5		E											ML		4.8 medium, very dark gray (3/1 2.5Y) ~~reddish/orange~~ Brown (4/3 10YR) spotty layers, ~~Poorly Graded~~ Bg ~~SAND (SP)~~ ML non plastic, slight cohesive SILT WITH SAND ML Organics (roots?)
6	Sump	F											ML		
7		G											SP ML		6.5 2° layer of poorly graded SAND (SP)
8	Sp4	H											GP		7.0 Moist, ~~Dense~~, Dark greenish gray (4/1 10Y Gley 1), Poorly Graded Gravel with SAND (GP)

* corrected Depth

Project Name: Mill Pond	Client: SCL	Sheet 1 of 1	
Boring Number: MP-SC03	Site Manager: Steve Negri	Date/Time Started: 5/6/09	
Logged By: B. Graham	Drilling Contractor: T+SC	Date/Time Completed: 5/6/09	
OFS Number: 106-3414	Drilling Method: Vibra core	Total Depth: –	
Location: Mill Pond North Delta	Sampling System: ~~Vibra~~ SS spun	Water Depth: –	

DEPTH (ft)	Sample #	Moisture/ Water Prod.	Cobbles/ Boulders	Crs. Gravel	Fine Gravel	Crs. Sand	Med. Sand	Fine Sand	Silt/Clay	USCS Symbol	Graphic Log	Description
												8 ft core / 6.8 recovery
												0 – 0.3, woody organic debris, some mill fal
												0.3 very dark greenish gray (3/1 10Y Gley 1)
												fine grained, wet, cohesive, low plasticity
1	A									ML		(ML) Silt w/ sand, heavy organics
2	B									ML		
3	C									ML		plasticity increases
4	D									ML		
5	E									ML		color change to dark greenish gray
												(4/1 10Y Gley 1)
6	F									SD		5.5 same color as above, wet, fine grained,
												cohesive, non plastic organics, 6.0 ~~5.0~~
	G									SD		Poorly Graded SAND ~~with SILT~~ BG
7	H											6.8 TD. 6.0 Two thin black layers
8												organic layers
												* Corrected Depth

Project Name: Mill Pond	Client: SCL	Sheet 1 of 1	
Boring Number: MP-SC-09	Site Manager: Steve Negri	Date/Time Started: 5/7/09	
Logged By: B. Graham	Drilling Contractor: JTEC	Date/Time Completed: 5/7/09	
OFS Number: 106-3414	Drilling Method: Vibra Core	Total Depth: —	
Location: Mill Pond	Sampling System: Split spoon	Water Depth: —	

DEPTH (ft)	Sample #				Moisture/ Water Prod.	Size Fractions % Cobbles/ Boulders	Crs. Gravel	Fine Gravel	Crs. Sand	Med. Sand	Fine Sand	Silt/Clay	USCS Symbol	Graphic Log	Description
1					W							100	ML		7ft push, 5.7 ft recovery 81% recovery 0-1.0 very soft, very dark gray (3/1 10YR), non plastic, non cohesive, SILT (ML)
2	B				W							100	ML		1.0 Density increases to soft
3	C				W							100	ML		Density increases slightly w/depth
4	D				W							100	ML		
5	E				W						T	100	ML		low plasticity
6	F				W						T	100	ML		
7	G				W		15	45	25	10	5		GP SW		same as above; slightly more dense 6.2 some thin blacker layers 6.5 3½ chunk of subrounded gravel, dense, non plastic non cohesive, more gravel / sand, thin organic layer wrapping large gravel at surface 6.5 Well GRADED SAND WITH GRAVEL (SW)

Project Name: MM Pond	Client: SCL	Sheet 1 of 1	
Boring Number: MP-SC-07	Site Manager: Steve Negri	Date/Time Started: 5/7/09	
Logged By: B. Graham	Drilling Contractor: T&C	Date/Time Completed: 5/7/09	
OFS Number: 106-3414	Drilling Method: Vibracor	Total Depth: –	
Location: East of Dam	Sampling System: SS spoon	Water Depth: –	

DEPTH (ft)	Sample #				Moisture/ Water Prod.	Cobbles/	Boulders Crs. Gravel	Fine Gravel	Crs. Sand	Med. Sand	Fine Sand	Silt/Clay	USCS Symbol	Graphic Log	Description
						Size Fractions %									8ft core / 7ft push / 5.5 ft recovery 79%
1	A	fringed			W							100	ML		0-0.1 very soft, light olive brown (5/6 2.5Y) fine grained, non plastic, non cohesive, organics SILT (ML)
												100	ML		
												100	ML		
												100	ML		0.1 - 1.0, soft, Black (2.5/N Gley 1), low plasticity, cohesive, SILT (ML), slight odor
2	B				W			35	30	25	10		SW		1.0 - 1.2ft color change to Dark Gray (4/1 Gley 1) Same as above, more organics
3	C				W										1.2 Medium, Dark brown (3/3 10YR), cohesive non plastic, no apparent structure, coarse grained well graded, sand slightly more than gravel, minor organics < 1%, WELL GRADED SAND WITH GRAVEL (SW)
4	D				W										Gravel size increases with depth Subangular to subrounded
5	E				M		25	40	20	10	5		GW		4.0 gravel > sand WELL GRADED GRAVEL WITH SAND (GW)
6	F				M										2" - 3½ gravel
7															
8															Depth corrected interval
															SW sand from 1.2 squeezed in from 0-1.2 interval.

Project Name: Mill Pond	Client: SCL	sheet 1 of 1	
Boring Number: MP-SC-07 Attemp #1	Site Manager: Steve Negri	Date/Time Started: 5/7/09	
Logged By: B. Graham	Drilling Contractor: TYEC	Date/Time Completed: 5/7/09	
OFS Number: 106-3414	Drilling Method: Vibra core	Total Depth: –	
Location: Mill Pond	Sampling System: Spl spoon	Water Depth: –	

* DEPTH (ft)	Sample #				Moisture/ Water Prod.	Size Fractions % Cobbles/ Boulders	Crs. Gravel	Fine Gravel	Crs. Sand	Med. Sand	Fine Sand	Silt/Clay	USCS Symbol	Graphic Log	Description
1					W							100	ML		1st Attempt. 4.7 ft recovery of 8 ft 57% Different from core used for samples 0 - Very soft, Dark greenish gray (4/1 10Y Gley 1), fine grade, SILT (ML) Non-plastic, non cohesive, organics
2					W						5	95	ML		1.0 Density changes to soft, minor sand
3	Sample Loss				W						5	95	ML		
4	No				W						5	95	ML		3'-4' Two bands ~ 0.1 ft of greenish gray (5/1 10Y Gley 1) SILT
5															TD
															30 ft away from Keeper

* Uncorrected Depth

Project Name: Mill Pond	Client: SCL	Sheet 1 of 1	
Boring Number: MP-SC-08	Site Manager: Steve Negri	Date/Time Started: 5/8/09	
Logged By: Bryan Graham	Drilling Contractor: THEC	Date/Time Completed: 5/8/09	
OFS Number: 06-3414	Drilling Method: Vibra Core	Total Depth: —	
Location: Mill Pond	Sampling System: SS sp w/	Water Depth: —	

DEPTH (ft)	Sample #				Moisture/ Water Prod.	Size Fractions % Cobbles/	Boulders Crs. Gravel	Fine Gravel	Crs. Sand	Med. Sand	Fine Sand	Silt/Clay	USCS Symbol	Graphic Log	Description
															7 ft push / 3.5 ft recovery ~ 50% Refusal at 3.5 - Geoprobe slowed ~ 5 ft sd
1	A				W							100	ML		0.0 very soft, dark greenish gray (4/1 10Y Gley 1), non plastic, non cohesive, SILT (ML) dark grayish brown (4/2 10YR) silt; organics
2	B				W							100	ML		
3	C				W							100	ML		2.5 color change to very dark greenish gray (3/1 5GY Gley 1), soft, SILT (ML)
4	D				W							100	ML		
5	E				M						0	100	ML		4.5 color change to greenish black (2.5/1 10Y Gley 1)
6	F				M						5	95	ML		5.5 color change to brown (4/3 10YR), sand content increases slightly
7	G						20	25	35	20	15	5	SW		6.0 dense, brown mottled (4/3 10YR), non cohesive, non plastic, sub angular gravel Well GRADED SAND WITH GRAVEL (SW)

Depth corrected

Project Name: Mill Pond	Client: SCL	Sheet 1 of 1	
Boring Number: MP-SC-10	Site Manager: Steve Negri	Date/Time Started: 5/8/09	
Logged By: Bryan Graham	Drilling Contractor: TTEC	Date/Time Completed: 5/8/09	
OFS Number: 106-3414	Drilling Method: Vibracore	Total Depth: –	
Location: Mill Pond	Sampling System: SS sparon	Water Depth: –	

* DEPTH (ft)	Sample #				Moisture/ Water Prod.	Size Fractions % Cobbles/	Boulders/ Crs. Gravel	Fine Gravel	Crs. Sand	Med. Sand	Fine Sand	Silt/Clay	USCS Symbol	Graphic Log	Description
															7 ft push / 12 ft core / 5.8 recovery = 83 %
1	A				W						T	100	ML		0.0 soft, very dark greenish gray (3/1 10Y Gley1), low plasticity, low cohesive, wet, SILT (ML) trace of sand, minor organics
2	B				V						T	100	ML		0.1' thick band of gray silt (6N Gley1)
3	C				W						T	100	ML		
4	D SW				W M					20	70	10	~~SW~~ SW		3.0, color change to greenish black (2.5/1 10Y Gley1) Black layer at 3.5 3.5" by 3/4" piece of tree branch, ~~form~~ 3.8-4.0 Dark greenish gray (4/1 10Y Gley1), non plastic, slight cohesive, SAND, some fines, WELL GRADED SAND (SW)
5	E				M		20	50	15	10	5	T	GW		4.0 Dense, Dark greenish gray matrix (4/1 10Y Gley1), non cohesive, non plastic, moist, Gravels, sub angular, qtz, metamorphics, organics (roots?) Well Graded Gravel (GW)
6	F						15	55	15	10	5				
7	G						~~15~~ 10	~~60~~ 35 45	~~20~~ ~~15~~	~~20~~ ~~15~~ 10	~~10~~ ~~5~~	~~10~~	GW-GM		Silt content increases Gravel 55% / SAND 35% / SILT 10% WELL GRADED GRAVEL WITH SILT (GW-GM)
8															Add sample interval 3.8-4.0 SW sand metals, TOC, SVOCs may be pesticides / PCBs

* corrected depth

Project Name: MILL POND
Boring Number: MP-SC-11
Logged By: Bryan Graham

Client: SCL
Site Manager: Steve Nagy
Drilling Contractor: TIEC
Drilling Method: Vibracore
Sampling System: SS spoon

Sheet 1 of 1
Date/Time Started: 5/8/09
Date/Time Completed: 5/8/09
Total Depth: 7.0
Water Depth: -

OFS Number: 106-3414
Location: West end of Pond

DEPTH (ft)	Sample #				Moisture/ Water Prod.	Size Fractions % Cobbles/	Boulders/ Crs. Gravel	Fine Gravel	Crs. Sand	Med. Sand	Fine Sand	Silt/Clay	USCS Symbol	Graphic Log	Description
															SS 12' tube bent @ 7ft 7' push, 6.4 ft recovery = 91% Refusal @ 7ft
1	A				W							100	ML		0 Soft, Dark greenish gray (4/1 10Y Gley 1) low plastic, slight cohesive, fine grained SILT (ML), minor organics, slight H_2S odor
2	B				W							100	ML		1.0 color change to greenish black (2.5/1 10Y Gley 1) 1.5, color change to greenish gray (5/1 10Y Gley 1) Black layers @ 1.7 - 1.9
3	C				W							100	ML		2.2 Black layer Density increases slightly, low plasticity irregular black layers (organics)
4	D				W										Black layer at 3.9, H_2S odor Density Δ to loose
5	E				W						30	70	ML		Color change, Greenish gray (6/1 10Y Gley 1) core of sample has black (as above) plus brown (4/3 10YR) ~~silty sand~~ SILT WITH SAND (ML)
6	F				W						10	90	ML		Color change to ~~dark~~ greenish gray (5/1 10Y Gley 1) (SILT) ML
					M						7	90	SM		SILTY SAND (SM) non plastic
7	G				M	10	90	15	15	10	10 T		ML GRAVEL		6.8-6.9 SILT WITH SAND (ML) 6.9-7.0 ~~SI~~ WELL GRADED GRAVEL WITH SILT (GW-GM)

Large chunk of wood in sample at 6.5 ft obviously punctured by core catcher due to rounded step

Appendix 3: Site Photographs

Appendix 3 Site Photographs

The following pages include select photographs with descriptions. Additional photographs including photographs of each sediment core, are included on the attached CD.

Subbottom and bathymetry vessel on the left, coring raft on the right

Coring raft near the log boom by Mill Pond dam

Looking south at coring raft on log boom

Looking north across remains of wooden crib dam on Mill Pond

Looking north across remains of wooden crib dam on Mill Pond, concrete spill way on the left

Looking south across concrete spill way

Looking east across Mill Pond. Survey control stations in foreground on left.

Van used for processing, sample core on the left, sample containers on the right

Core MP-SC-11 and typical silt material found in cores

Gravels and sands of MP-SC-10

Gravels of MP=SC-07

Looking west across Mill Pond after completion of field work and site clean up.

Appendix 4: Geophysical Electronic Files (CD Only)

Appendix 5: Analytical Data (CD Only)

Appendix 6: Data Validation

Appendix 6 Data Validation

1 DATA QUALITY ASSESSMENT

This data quality assessment was prepared to evaluate the implementation of the sampling and analytical procedures for the Mill Pond project. Samples were analyzed by Analytical Resources, Inc. (ARI) for chemical analysis. The following sections describe the evaluation of the field quality control (QC) sampling objectives and analytical data quality objectives for this project.

1.1 FIELD QUALITY CONTROL SAMPLING OBJECTIVES

Field QC sampling objectives for this project were met with the analysis of matrix spike and matrix spike duplicates (MS/MSDs), a source blank, and a rinsate blank. The results of the field QC sampling are described in the following sections.

1.1.1 Matrix Spike and Duplicate

MS/MSD samples are prepared for chemical analysis by spiking the sample with a known amount of a target analyte. Once the spike is added to the MS/MSD sample, the sample is carried through the complete sample preparation process along with the other samples in the batch. The percent recoveries (%R) for the MS/MSD samples are compared against each other and against the known amount of the spike to measure the accuracy of the analytical method. Relative percent difference (RPD) values from the MS/MSD samples are calculated to evaluate the analytical precision of the method. One MS/MSD sample is routinely collected for every 20 samples. The %R and RPDs were within the specified QC limits for the MS/MSDs collected for this project except for the following:

Sample ID	%R or RPD Outlier	Analysis
MP-SC-02-G	%R	Aroclor 1016 Aroclor 1260
MP-SS-03-A	%R	Antimony
MP-SC-11-F	%R	Aroclor 1016 Aroclor 1260
MP-SC-01C	%R	Antimony
MP-SS-01A	%R	Sulfide

1.1.2 Source Blank

A source blank consists of analyte-free, reagent-grade water provided by the laboratory to be used for the collection of rinsate blank samples. The source blank collected for this project had no detected analytes except for copper, nickel, and zinc.

1.1.3 Rinsate Blank

The rinsate blank sample evaluates the effectiveness of the decontamination procedure and is required to be collected at a frequency of one per piece of non-disposal sampling equipment used. Rinsate blank samples are analyte-free water collected from the final rinse during the decontamination process and analyzed for the same analytes as the original samples. The rinsate blank sample collected for this project had no detected analytes.

1.2 ANALYTICAL DATA QUALITY OBJECTIVES

The following sections describe the fulfillment of the analytical data quality objectives in terms of precision, accuracy, representativeness, completeness, and comparability parameters for the sample results for this project.

1.2.1 Precision and Accuracy

In accordance with the analytical methods specifications, the following parameters were assessed as applicable to analyses:

- Technical holding times and preservation
- Instrument performance checks
- Initial and continuing calibration verifications
- Method blanks
- Surrogates
- Laboratory control samples
- Internal standards
- ICP Serial Dilution and Post-digestion Spike
- Target compound identification
- Compound quantitation
- System performance

1.2.1.1 Technical Holding Times and Preservation

Analysis holding times and preservation requirements were checked against QC criteria, and all QC requirements were met except for all samples analyzed for polybrominated diphenyl ethers (PBDE). Samples were collected on May 6, 2009 through May 8, 2009 and analysis was performed on June 2, 2009, which is outside of technical holding time for this analytical method.

1.2.1.2 Instrument Performance Checks

Instrument performance checks were completed, and all QC requirements were met.

1.2.1.3 Initial and Continuing Calibration Verifications

Percent relative standard deviations and relative response factors of the initial calibration and percent differences of the continuing calibration met the QC requirement for all samples except for PCB analysis.

1.2.1.4 Method Blanks

Sample concentrations were compared to concentrations detected in the method blanks. For sample concentrations either not detected or less than 5 times blank contaminant concentrations, associated sample results are considered not detected. For sample concentrations detected but greater than 5 times blank contaminant concentrations, sample results are not affected. For this project, there were no method blank concentrations that affected associated sample results.

1.2.1.5 Surrogates

Surrogate recovery applies to organic analyses only. Surrogate percent recoveries were within QC limits for all samples except for semivolatile organic compound analysis for sample MP-RB.

1.2.1.6 Laboratory Control Samples

Laboratory control samples were within QC limits for all analyses except for PCB analysis.

1.2.1.7 Internal Standards

Internal standard area counts and retention times were within QC limits.

1.2.1.8 ICP Serial Dilution and Post-digestion Spike

ICP serial dilutions and post-digestion spikes (applicable to metals analysis only) were within QC limits.

1.2.1.9 Target Compound Identification

All target analytes were correctly identified.

1.2.1.10 Compound Quantitation

All compound quantitation was within calibration range.

1.2.1.11 System Performance

System performance met all QC requirements, and no discrepancies were reported.

1.2.2 Representativeness

Representative data were obtained through selection of sampling locations and analytical parameters to meet the data quality objectives of this project. Proper collection and handling of samples, and the use of established field and laboratory procedures were followed.

1.2.3 Completeness

The percent completeness is defined as the percentage of measurements that are judged to be valid. The completeness goal is to generate a sufficient amount of valid data to meet project objectives. Completeness is calculated and reported for each method, matrix, and analyte combination. The number of valid results divided by the number of possible individual analyte results, expressed as a percentage, determines the completeness of the data set. For this project, all results are considered valid thereby meeting the completeness goal of 100%.

1.2.4 Comparability

Comparability is a qualitative parameter expressing the confidence with which one data set can be compared with another. Sample data should be comparable with other measurements for similar samples and sample conditions. The objective is to produce data with the greatest possible degree of comparability. The number of matrices that are sampled and the range of field conditions encountered are considered in determining comparability. Comparability was achieved for this project by using standard methods for sampling and analysis, reporting data in standard units, normalizing results to standard conditions, and using standard and comprehensive reporting formats.

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

APPENDIX E.3-1
1994 AND 1996 POPUD WATER QUALITY DATA

TEMPERATURE MODELING OF SULLIVAN CREEK

1. INTRODUCTION

This report updates and replaces the stream temperature modeling analysis presented in the Sullivan Creek Hydroelectric Project Application for Amendment of License. Agency comments on the license application requested additional temperature modeling. The modeling reported in the license application relied upon synthesized climate data since monitoring instruments for project studies were vandalized. Subsequent to submission of the license application, the Public Utility District No. 1 of Pend Oreille County (District) has continued to monitor temperatures in Sullivan Creek. The agencies requested that modeling be done based upon the additional available monitoring data to determine changes in water temperatures from existing flow regimes to recommended flows. Concerns on water temperature relate to potential exceedence of state water quality standards and temperature tolerance ranges for rearing salmonids, particularly bull trout juvenile and fry. Delays in bull trout spawning due to high water temperatures were stated by the agencies to be a concern. The agencies also commented that reduced water temperatures in the winter could increase incubation periods for bull, brown and brook trout. Effects of ice formation have also been expressed as a concern.

This updated analysis incorporates additional water and air temperature data collected for the project area. Summer temperatures and stream temperatures prior to the onset of autumn salmonid spawning are addressed.

Winter water temperature issues were discussed in the draft license application. Monitoring for anchor ice formation is recommended during initial operation of project in the months of December and January. Monitoring would not be necessary if surface ice covers more than 90% of the stream. Monitoring can be accomplished by either visual inspection or remote instrument detection. It is important to distinguish that the presence of anchor ice would not necessarily demonstrate a cause and effect relationship to project operation. The potential for anchor ice formation naturally exists. A monitoring program would need to identify several locations where conditions are favorable for anchor ice formation; then document if reduced flow levels correlate with either the duration or extent of anchor ice formation. The specific location of anchor ice formation would also need to coincide with suitable winter fish habitat for an impact to be possible.

1.1 Background

Stream temperature is an important environmental variable affecting fish and other aquatic life. Both the physiology and activity of salmonids are partially a function of water temperature. Extremely high temperatures can be lethal to salmonids. Other recent findings suggest that alterations to tissue and blood chemistry may occur in association with prolonged exposure to elevated temperatures (Thomas et al. 1986). Time of spawning depends on water temperature as well as other variables (Hickman and Raleigh 1982) with preferred water temperatures during spawning for several trout species being between 43 - 63°F (Reiser & Bjornn 1979). Incubation and emergence timing are also temperature dependent. Aho (1977 thesis, quoted in Nicholas 1978) found fry emerging earlier in an unshaded section of Mack Creek (tributary to McKenzie River, Oregon) than in a shaded section, probably due to warmer water temperatures in the unshaded section.

Stream temperature also affects water quality (particularly dissolved oxygen) and possibly productivity of primary trophic levels. Studies have shown contrasting results in algal and periphyton production with changes in stream temperature (Bisson and Davis 1976; Stockner and Shortreed 1978). While temperature may affect productivity, the extent and direction of that affect varies widely dependent upon the community type, nutrient availability, and sunlight.

Physical Factors Influencing Temperature

Stream temperature has been widely studied and the physics of heat transfer is one of the better understood processes in natural watershed management. Changes in water temperature regimes in streams can arise from climatic changes or from human activities. Stream temperature is best thought of as an energy balance. A stream's temperature is constantly adjusting to maintain an equilibrium with its surrounding environment. Six primary heat transfer processes occur simultaneously, some of which add heat energy to the stream while others dissipate heat (TVA 1972, Brown 1969, Theurer 1984, Adams 1988). The net heat flux determines the stream's temperature. Once a stream achieves this equilibrium temperature regime (typically occurring within a stream reach length of 2,000 feet or less for most streams), it will continue to follow the same daily temperature pattern until the channel or climatic variables affecting the heat transfer processes change. While there are many specific climatic and stream variables accounted for in the stream heat energy balance, a sensitivity analysis of stream heating processes performed by Adams and Sullivan (1989) showed that four primary environmental variables regulate heat input and output and thereby determine stream temperature. These are riparian canopy, stream depth, local air temperature, and groundwater inflow.

Stream depth is the only one of these variables to be significantly affected by the project's operation. Unlike the other variables which affect the magnitude of temperature, depth alters the rate of temperature change but not the final equilibrium temperature regime. In other words, shallow streams heat up and cool on a daily basis faster than deeper streams. However, maximum and minimum equilibrium temperatures generally remain the same.

2.0 METHODS

2.1 Monitoring

Unidata[tm] multiple channel continuous recording thermographs are being used to monitor water and air temperatures in Sullivan Creek. Monitoring was initiated in May 1993 at the powerhouse and in February 1993 just downstream of Mill Pond. Calibration of the instruments and probes was done for the range 0°F - 90°F prior to their deployment. An additional calibrated air probe was added to instrumentation for monitoring sub-freezing air temperatures. The water probes have been anchored in the main channel flow near but not in contact with the stream bed. The probes have been positioned so as not to be dewatered at low flow. The air probes are located as near the stream as practicable but raised to an elevation to avoid burial by snowpack.

The thermographs are programmed to read the temperature every 10 seconds; recording an average hourly value to the nearest 0.1°F. Unfortunately, substantial gaps occurred in the early part of the

record due to chronic vandalism and occasional instrument malfunction. Complete hourly temperature data were recorded during 1994 with minimal data gaps.

2.2 Temperature Modeling

The model TEMPEST, developed in Washington by Dr. K. Sullivan and Dr. Terry Adams was used for modeling. This model was initially developed to analyze forest practices effects on stream temperature and has been tested in 92 streams in the Pacific Northwest with exceptionally good results. Documentation on the model can be found in Adams and Sullivan (1989) and Sullivan, et al. (1990).

2.2.1 Selection of Model Input Values

The data requirements and the source of data used in this analysis are shown in Table 1.

TABLE 1
DATA REQUIREMENTS FOR TEMPEST MODEL

VARIABLE	DATA SOURCE
Hourly Air Temperatures	Synthesized from nearby NOAA data
Solar Radiation	USFWS SRSOLAR Model
Cloud Factor	Assumed zero
Riparian Shade	On site data collection
Wind Speed	Estimated
Relative Humidity	NOAA data adjusted to local air temperature and modified as appropriate for ambient conditions
Stream Depth	IFIM data
Groundwater Inflow Rate	Synthesized stream flow record
Groundwater Temperature	Regional data
Initial Water Temperatures	On site data collection

The TEMPEST model requires data on several climatic variables. Wind speed and relative humidity data are only available regionally for the National Oceanographic and Atmospheric Administration (NOAA) climate station located in Spokane. Regional NOAA data for relative humidity was reviewed as an initial point to begin calibration. Adjustment for local project area air temperatures and ambient conditions are necessary to reflect relative humidity for a forested stream environment. The TEMPEST model was revised to allow independent, user specified relative humidity values for daytime (7 am - 6 pm) and nighttime (7pm - 6 am). The daytime relative humidity specified by the user is the estimated relative humidity at 1 pm. The model adjusts the hourly relative humidity to compensate for hourly air temperature changes when making heat exchange calculations. The model

was also revised to allow the user to independently specify daytime and nighttime average wind speeds. During model calibration, wind speed was adjusted within a reasonable range based on anecdotal observations and regional hourly data .

Sullivan and others (1990) report model sensitivities for the TEMPEST model. Predicted water temperatures are most sensitive to air temperature profiles followed by relative humidity. Both air temperature and relative humidity are positively correlated to summer water temperature. Solar insolation affects maximum water temperature predictions for medium sized streams such as Sullivan Creek but minimum daily water temperature predictions are insensitive to solar insolation. Model sensitivity to starting water temperature (the midnight temperature on the initial day of modeling) was minimized by modeling multiple days. Maximum daily temperature predictions are only weakly sensitive to groundwater accretion rates. Riparian canopy closure affects predictions of maximum and minimum water temperature more than the mean daily temperature. Stream depth is a less sensitive input parameter than air temperature, relative humidity and solar insolation but influences model predictions more than shade input values. Based on prediction of diurnal temperature fluctuation, the TEMPEST model was considered much more sensitive to user provided stream depth data than the USFWS stream temperature model SSTEMP (Sullivan et al. 1990).

Several assumptions are necessary for modeling stream temperatures. It is assumed that stream temperature is a site specific phenomena controlled by localized environmental variables and does not function in a cumulative manner. Equilibrium temperature regimes are assumed to be established within a 2,000 foot stream reach, i.e. the water temperature is in equilibrium with the surrounding environmental conditions. Previous studies (Adams and Sullivan 1989, Sullivan and others 1990, Caldwell and others 1991) support the validity of this assumption.

A third assumption is that IFIM data sufficiently describes the relationship between stream flow and average depth for specified habitat types. Stream discharge was assumed constant for any single day period. Stream discharge data for the dates used in model calibration were available from the USGS gaging station near the powerhouse. Streamflow measurements done by CES confirmed stage rating curves for the powerhouse gaging station.

Model predictive results are best viewed with an understanding of the model's accuracy. In a test of 91 sites located throughout Washington State the average error in prediction of daily maximum stream temperatures between July 15 and August 15 by the TEMPEST model was 1.5°C (2.7°F). Error is likely primarily a function of estimating climatic variables such as relative humidity.

Modeling consisted of:

- identification of critical modeling periods,
- field data collection on relevant channel characteristics,
- compilation of published data,
- model calibration,
- predicting temperatures without the project,
- predicting temperatures with the project, and
- comparing pre-project and project stream temperatures.

Any potential difference in stream temperature due to project operation is more apt to occur during seasons when climatic conditions most strongly affect maximum and minimum stream temperatures. Previous investigations on other streams have identified the period of July 15 through August 15 as being the time when streams are most likely to experience their highest temperatures (Sullivan, et. al. 1990). Subsequently, stream temperature modeling focussed on this period.

Three stream reaches were selected for modeling. Thermograph data have been collected for two of these reaches; 1,000 feet upstream of the powerhouse and 2,000 feet downstream of the Mill Pond outlet. (Note: Actual thermograph location was less than 500 ft. downstream of Mill Pond. Channel characteristics used in modeling are representative of the channel downstream of this thermograph.) The third modeling stream reach is characterized by IFIM transect 4 of study site 2; a wide riffle area whose shallowness makes it susceptible to temperature impacts. Sullivan Creek downstream of Mill Pond is characterized by riffles and runs with few pools. The stream passes through a steep sided canyon upstream of the powerhouse. Numerous pools occur in this lower section. Within each modeling reach riparian shade was measured from the center of the wetted channel at 100 foot intervals using a densiometer. Riparian shade level is 65% for both the stream reaches where thermograph data are available; below Mill Pond and upstream of the powerhouse. The canopy is more open at study site 2 transect 4.

Accretion was estimated for the calibration reach by calculating the difference in synthesized daily stream flows between the Mill Pond and Metaline Falls (powerhouse). Mean monthly flow at Mill Pond for the summer modeling period has been estimated at 75 cfs with a corresponding flow of 79 cfs at the powerhouse. The groundwater temperature (44.6°F) used in modeling is based on the average annual air temperature (available from the NOAA long term record 1965 to present for Boundary Dam station no. 4500844).

The IFIM hydraulic model was used to calculate stream depths within the diversion at different flow regimes modeled. A weighted mean for average stream depths at each transect was calculated for each stream flow modeled. Transect weighting was according to habitat frequency. The stream depths used in temperature modeling are reported in Table 2.

TABLE 2
SUMMARY OF STREAM DEPTHS

Instream flow diversion/powerhouse	Depth (feet)		
	75/79 cfs	50/59 cfs	25/29 cfs
Below Mill Pond: transects 8, 9	1.31	1.11	0.81
Above powerhouse: transects 1,2,3,6	2.50	2.16	1.65
IFIM SS2 transect 4: wide riffle	0.93	0.79	0.64

2.2.2 Model Calibration

Hourly recorded water temperature data were used to calibrate the TEMPEST model by comparing predicted to actual water temperatures. The day with the hottest instantaneous water temperature was identified excluding days with only partial records. The hourly air temperature profile for this day was used in model calibration. Other model input values were selected as described above. Wind speed, relative humidity and solar insolation values were adjusted during calibration so that predicted daily maximum and minimum water temperatures were within 0.2°C of recorded water temperatures. Incremental hourly changes in water temperature for predicted and actual were also compared to confirm that the pattern of incremental change was approximately similar.

2.2.3 Winter Stream Temperature

Winter temperatures were not modeled due to limitations of existing models to realistically predict water temperatures in the appropriate range. Neither validation of the TEMPEST model nor published validation of other models for winter stream conditions in Washington are known to be available. Calibration of the model for winter conditions is also difficult due to more widely varying daily climate and stream flow conditions. Project effects on winter stream temperature were discussed in the initial draft of the license application.

3.0 Results

3.1 Monitoring

Monthly summary statistics and hourly air and water temperature data collected in 1993 through June, 1995, are reported in Appendix A of this report. More recent temperature data have not yet been processed.

Maximum daily air temperatures during July through August 1994 (the modeling period used in this analysis) were significantly above normal based on a 25 year record at the nearby Boundary Dam NOAA climate station (No. 450844). The mean of the monthly average of the daily maximum air temperature (1965-1963) for the nearby NOAA station is 79.63°F and 81.6°F for July and August, respectively. In 1994 the corresponding temperature statistics were 88.26°F and 86.10°F. July and August 1994 had the second highest maximum air temperatures on record. This allows for a conservative modeling approach when interpreting modeled impacts to normally expected impacts.

The hourly temperature record for the period July 15 through August 15, 1994 was searched for the days with the hottest hourly water temperatures. Two days (July 25 and August 3, 1994) were rejected since hourly records were incomplete due to temporary instrument removal during data downloading. (The hottest recorded water temperature just upstream of the powerhouse on each of these two days, 67.9°F, may be an artifact of electronic error during disconnect and redeployment.). The hottest daily maximum water temperature upstream of the powerhouse for days with a complete record was 67.4°F: recorded on July 23, 24, 26, August 2, 4, 1994. Daily water temperatures at the powerhouse peaked between 3 pm and 5 pm.

A 1994 annual maximum recorded water temperature in Sullivan Creek downstream of Mill Pond was recorded on July 25, 1994. The hourly temperature data for the upper monitoring site (downstream of Mill Pond) showed an unusual pattern in hourly temperature data. Values for the model calibration date of July 24, 1994 are shown in Figure 1. Summer daily maximum water temperatures downstream of Mill Pond were not reached until 9 PM to midnight; several hours later than the peak in daily air temperatures and the peak in water temperature at the powerhouse. Summer stream temperatures for our region typically occur in mid to late afternoon as typified by the pattern observed at the powerhouse. The upper monitoring site daily maximum temperature stayed constant for three hours and then dropped precipitously in the following hour. This pattern in hourly temperature suggests that temperatures in Sullivan Creek at the upper monitoring site (less than 500 feet downstream of Mill Pond Dam) are influenced by Mill Pond water temperatures. Insufficient travel time has occurred for temperature regimes to reach equilibrium with channel conditions. The larger water body of Mill Pond is slower to heat on a daily cycle. Once a maximum temperature is reached it remains constant as the larger mass of Mill Pond can effectively store heat energy. The sharp drop in temperature following the peak suggests that heated surface waters in Mill Pond are drained and replaced by incoming cooler water from Sullivan Creek in approximately three hours during summer low flow periods. Mill Pond is not known to stratify during the summer. Modeling for the stream reach below Mill Pond and the mid-diversion reach at SS2 transect 4 used the measured air temperature profile for July 24, 1995 from the Mill Pond thermograph. Model calibration for other input climate data were the same as that used for modeling the powerhouse site. A correction for relative humidity was applied to compensate for differences in the air temperature profiles for the different sites.

3.2 Model Calibration

The recorded hourly temperature for July 24, 1994 was used to calibrate the TEMPEST model for modeling maximum annual temperatures in Sullivan Creek. The gaged streamflow at the powerhouse was 79 cfs. The input values for the calibrated model are listed in Appendix B. The uncalibrated and calibrated model hourly data are also provided in Appendix B. Table 3 and Figure 2 compare predicted and actual temperature regimes for the calibrated model.

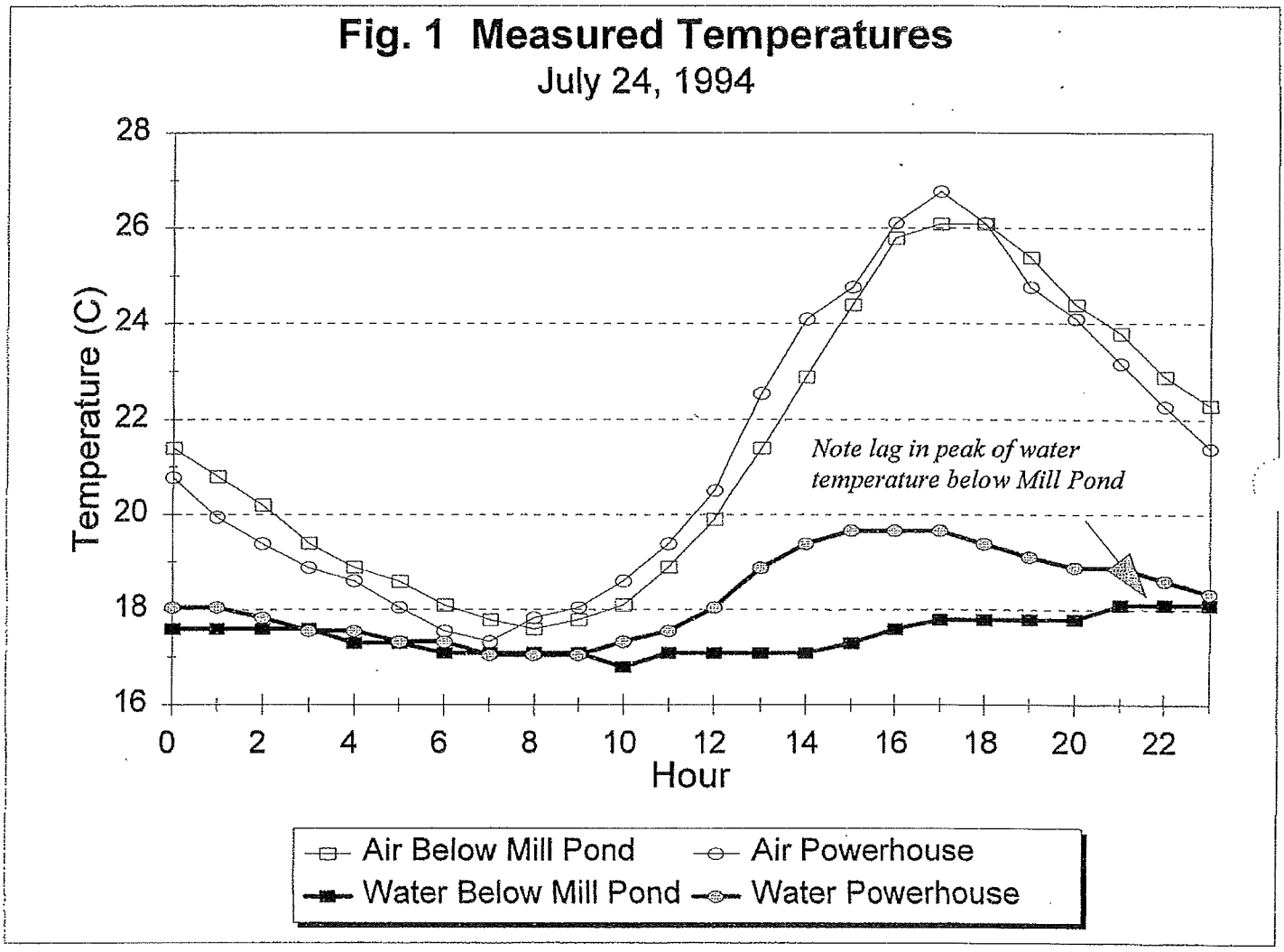
Fig. 1 Measured Temperatures
July 24, 1994
Temperature (C)
28
26
24
22
20
18
16
0
2
4
6
8
10
12
14
16
18
20
22
Hour
Note lag in peak of water temperature below Mill Pond
Air Below Mill Pond
Air Powerhouse
Water Below Mill Pond
Water Powerhouse

Fig. 2 Tempest Calibration Results

July 24, 1994

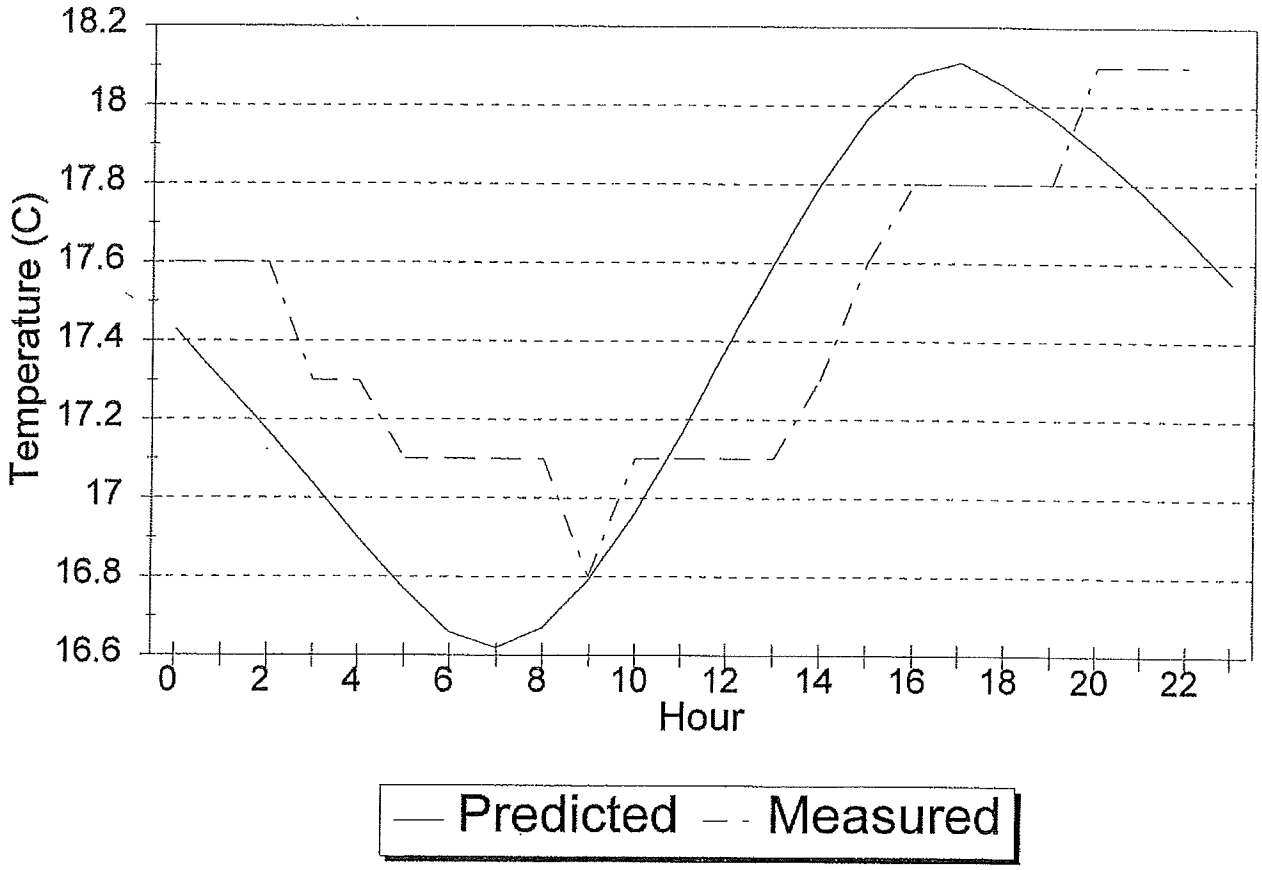

TABLE 3
CALIBRATED MODEL RESULTS

Upstream of Powerhouse Hourly Water Temperature °F				
		Maximum	Minimum	Mean
7/24/94	Predicted	67.3	62.9	65.0
	Measured	67.5	62.8	64.9
	Difference	-0.2	0.1	0.1
7/23/94	Predicted	67.3	62.2	64.7
	Measured	67.5	62.2	64.3
	Difference	-0.2	0	0.4

3.3 Model Results

The calibrated model was used to predict daily water temperature regimes at normal stream flows with and without project operation. Predicted water temperature regimes for the diversion reach during hot summer days are reported in Table 4.

TABLE 4
Predicted Daily Summer Water Temperatures for the Hottest Days.

	Discharge (cfs)	Maximum (°F)	Minimum (°F)	Mean (°F)
Upstream of powerhouse	79	67.3	62.9	65.0
	55	67.6	62.5	65.0
	27	68.3	61.8	65.0
downstream of Mill Pond	75	68.3	60.5	64.4
	50	68.7	60.0	64.4
	25	69.5	59.1	64.3
IFIM SS2 T4 wide riffle	75	69.2	59.4	64.4
most temperature sensitive	50	69.6	59.0	64.3
	25	69.9	58.5	64.2

The potential for point source temperature effects at the powerhouse tailrace was also analyzed. Stream temperatures below the powerhouse could differ from those just above the powerhouse. The temperature component of the WDFW gas saturation model (developed by Mr. Ken Bates) was used

to predict the tailrace temperature. Initial temperature of water entering the buried penstock was set at 62.6°F ; the mean daily water temperature at Mill Pond for July 15 - August 15, 1994: modeling period. Using an average ambient ground temperature of 44.6°F the gas saturation model predicts the tailrace water exiting the 16,340 foot buried 90 inch diameter steel pipeline/penstock will be 44.6.°F. The predicted maximum stream temperature above the diversion was used. Assuming an instream flow of 55 cfs or 27 cfs upstream at the powerhouse (assume 25 or 50 cfs instream flow + accretion) and a tailrace flow of 50 or 25 cfs the resulting temperature of the downstream mixed water can be calculated using a weighted average.

$$T_3 = \frac{Q_1 * T_1 + Q_2 * T_2}{Q_1 + Q_2}$$

where: Q_1 = instream flow above tailrace = 55 or 27 cfs (instream flow + accretion)
Q_2 = tailrace discharge = 25 or 50 cfs
T_1 = instream temperature above tailrace
T_2 = tailrace water temperature
T_3 = downstream water temperature

The predicted summer daily stream temperatures downstream of the diversion are listed in Table 5.

Table 5. Predicted Stream Temperatures downstream of the Powerhouse.

Instream flow	Maximum	Mean	Minimum
79 cfs	67.3°F	65.0°F	62.9°F
55 cfs	60.4°F	58.6°F	56.9°F
27 cfs	52.9°F	51.8°F	50.6°F

4.0 Conclusions and Mitigation Measures

Sullivan Creek within the diversion reach is a Class AA stream for State water quality standards. The maximum temperature standard for Class AA streams is 16.0°C (60.8°F). When natural conditions exceed 16.0°C, no temperature increases will be allowed due to human activities which will raise the receiving water temperature greater than 0.3°C (0.6°F). Three instream flows were analyzed including the monthly average stream flow (75/79 cfs: below Mill Pond/powerhouse). An instream flow of 50 cfs below Mill Pond (55 cfs at the powerhouse) does not result in a temperature prediction that exceeds water quality standards. An instream flow of 25 cfs below Mill Pond (27 cfs at the powerhouse) does result in a temperature prediction that exceeds the incremental increase criteria for a new activity; i.e., predicted maximum temperature increase of 1.0°F. Predicted minimum daily temperatures are slightly cooler with reduced instream flows. Shallower water cools faster so lower minimum daily summer water temperatures are expected with diversion. Mean daily stream temperatures are essentially unchanged with diversion.

The effect of the return flow at the tailrace will be to cool the downstream waters in the summer and warm the water in the winter. Maximum water temperatures downstream of the tailrace in the summer are predicted to be 60.4°F when the project is operating (at an instream flow of 50 cfs with total stream flow above diversion of 75 cfs) compared to 67.3°F were the project not operating. Return flow from the tailrace in the winter would be at ambient ground temperature which is warmer than the upstream water temperature; the latter being near freezing during cold periods. The temperature effects of the tailrace flow would diminish downstream as the water temperature returns to equilibrium condition. The effect would not extend as far as the mouth of the stream.

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APPENDIX A
STREAM TEMPERATURE MONITORING DATA

Sullivan Creek Air & Water Temperatures At Mill Pond

Monthly Summaries

	Water			Air		
Date	Min	Avg	Max	Min	Avg	Max
Mar-93	33.6	35.7	38.2	16.8	31.6	40.1
Apr-93	37.9	40.1	43.0	30.6	38.1	44.4
May-93	Data not available					
Jun-93	Data not available					
Jul-93	56.7	57.1	57.5	46.5	52.3	58.8
Aug-93	56.7	57.1	57.5	44.1	55.2	66.9
Sep-93	50.1	53.9	60.5	40.1	50.1	62.2
Oct-93	50.8	52.3	53.5	34.5	45.4	58.8
Nov-93	39.1	43.8	50.4	16.0	31.9	45.4
Dec-93	34.2	37.8	40.1	18.6	30.0	36.6
Jan-94	33.3	34.3	35.1	19.1	30.0	34.6
Feb-94	30.9	33.8	35.7	-0.8	25.7	33.0
Mar-94	35.4	37.1	40.1	22.7	32.9	43.7
Apr-94	38.5	39.9	42.7	33.0	40.4	51.2
May-94	39.5	43.2	48.2	35.7	45.3	56.7
Jun-94	44.7	50.4	57.9	40.7	52.0	69.4
Jul-94	53.9	59.9	66.0	47.5	62.9	79.6
Aug-94	57.5	61.6	65.0	45.4	62.3	81.5
Sep-94	54.7	56.8	60.0	41.4	54.4	70.5
Oct-94	47.5	52.3	55.5	34.8	43.6	54.7
Nov-94	37.2	41.6	47.5	19.1	31.4	38.5
Dec-94	32.7	34.9	38.5	7.3	26.1	35.7
Jan-95	30.6	32.9	34.5	5.2	23.9	31.6
Feb-95	31.8	34.1	35.1	6.7	27.8	35.1
Mar-95	33.6	35.9	39.5	16.9	31.9	45.9
Apr-95	38.5	40.1	43.4	30.6	39.1	53.1
May-95	39.5	42.3	46.1	36.0	45.5	55.9
Jun-95	43.7	50.9	57.1	43.4	51.6	63.5
Jul-95	53.9	58.0	61.8	48.6	59.9	74.3
Aug-95	54.7	57.3	62.2	45.2	56.2	75.5
Sep-95	52.3	56.3	59.2	40.1	54.4	69.0
Oct-95	48.6	49.9	52.3	35.7	43.2	49.5

Sullivan Creek Air & Water Temperatures At Mill Pond

	Water			Air		
Date	Min	Avg	Max	Min	Avg	Max
02-25-93				16.0	20.6	24.4
02-26-93				16.0	18.9	24.9
02-27-93				16.2	22.0	27.7
02-28-93				16.2	22.9	29.5
03-01-93	33.6	33.8	33.9	16.8	24.9	30.9
03-02-93	33.9	34.0	34.2	28.0	29.1	30.3
03-03-93	33.9	34.0	34.2	20.0	27.4	31.8
03-04-93	33.9	34.1	34.2	29.7	31.1	32.1
03-05-93	34.2	34.2	34.5	32.1	32.4	32.7
03-06-93	34.5	34.5	34.5	32.4	32.7	33.3
03-07-93	34.5	34.8	35.1	32.1	33.0	34.8
03-08-93	34.8	35.0	35.4	30.9	32.6	33.9
03-09-93	34.8	35.1	35.4	25.8	30.1	33.6
03-10-93	34.8	35.2	35.4	22.7	28.5	33.9
03-11-93	34.8	35.1	35.4	21.9	27.6	33.0
03-12-93	34.8	35.1	35.1	21.9	27.7	33.0
03-13-93	35.1	35.2	35.4	20.3	27.6	33.9
03-14-93	35.1	35.3	35.4	28.6	31.0	32.7
03-15-93	35.1	35.4	35.7	30.9	32.9	33.9
03-16-93	35.4	35.5	35.7	24.1	29.6	33.0
03-17-93	35.4	35.7	36.0	30.0	31.7	33.3
03-18-93	35.7	36.1	36.3	32.4	33.0	35.4
03-19-93	36.0	36.3	36.6	30.3	32.4	34.5
03-20-93	36.3	36.5	36.6	31.8	32.6	33.3
03-21-93	36.3	36.5	36.9	31.8	32.9	33.9
03-22-93	36.6	36.7	36.9	32.1	33.0	33.9
03-23-93	36.6	36.8	36.9	33.3	34.3	36.0
03-24-93	36.3	36.3	36.6	32.7	33.6	35.4
03-25-93	36.3	36.3	36.3	31.5	33.3	35.1
03-26-93	36.3	36.3	36.6	31.5	33.3	36.0
03-27-93	36.3	36.7	36.9	31.2	33.6	36.9
03-28-93	36.6	37.0	37.2	31.5	34.0	36.9
03-29-93	36.9	37.3	37.6	32.4	34.6	37.9
03-30-93	37.2	37.5	37.9	31.2	33.7	36.6
03-31-93	37.2	37.8	38.2	31.2	35.1	40.1
04-01-93	37.9	38.3	38.8	31.2	35.8	42.1
04-02-93	38.2	38.4	38.8	34.8	36.9	39.5
04-03-93	38.5	38.9	39.1	35.4	37.6	40.7
04-04-93	38.8	39.0	39.5	35.4	37.1	38.8
04-05-93	38.8	39.1	39.5	33.0	35.8	38.2
04-06-93	38.8	39.3	39.5	30.6	35.1	41.7
04-07-93	39.1	39.5	40.1	36.0	38.8	43.7
04-08-93	39.5	39.9	40.1	36.0	39.4	43.4
04-09-93	39.8	40.2	41.1	36.9	39.4	44.4
04-10-93	40.1	40.4	40.4	33.9	37.0	39.8
04-11-93	40.1	40.5	41.7	34.5	37.3	41.4
04-12-93	40.4	40.6	40.7	36.3	37.9	39.8
04-13-93	40.4	40.5	40.7	36.3	38.8	41.4
04-14-93	40.4	41.1	41.7	35.4	38.9	41.7
04-15-93	40.7	40.9	41.1	32.4	37.2	41.1
04-16-93	40.7	41.2	41.7	35.7	40.3	43.4
04-17-93	41.4	41.5	41.7	39.1	41.4	43.4
04-18-93	41.4	41.7	42.1	37.9	40.2	42.1
04-19-93	41.4	41.7	43.0	35.1	39.0	43.7
06-26-93	51.9	53.4	56.3	50.1	54.2	57.5
06-27-93				51.9	54.0	55.1
06-28-93				47.9	50.0	51.6
06-29-93				49.0	50.5	51.9
06-30-93				50.1	51.5	52.7
07-01-93				48.2	51.3	53.5
07-02-93				49.7	51.3	53.1
07-03-93				49.3	51.5	53.5
07-04-93				50.8	52.8	54.3

Sullivan Creek Air & Water Temperatures At Mill Pond

	Water			Air		
Date	Min	Avg	Max	Min	Avg	Max
07-05-93				51.9	53.4	55.1
07-06-93				50.4	52.5	54.7
07-07-93				50.1	52.3	54.3
07-08-93				50.4	53.1	55.5
07-09-93				52.3	53.8	55.1
07-10-93				50.4	52.5	53.9
07-11-93				49.7	52.1	53.1
07-12-93				47.5	49.3	50.8
07-13-93				46.5	49.6	51.9
07-14-93				47.9	50.2	51.9
07-15-93				48.2	50.1	51.9
07-16-93				49.0	50.2	51.2
07-17-93				48.2	49.8	50.8
07-18-93				50.1	51.6	53.5
07-19-93				49.0	51.8	53.9
07-20-93				51.9	52.4	53.1
07-21-93				51.2	51.9	52.3
07-22-93				49.3	51.6	52.7
07-23-93				51.9	53.4	55.1
07-24-93				52.7	54.0	55.5
07-25-93				52.3	53.5	54.7
07-26-93				52.3	54.6	56.7
07-27-93				53.5	55.2	57.1
07-28-93				53.5	56.4	58.8
07-29-93				54.3	55.9	57.5
07-30-93				49.7	52.1	53.9
07-31-93				48.2	52.1	54.7
08-01-93				49.3	53.4	56.3
08-02-93				51.2	55.1	57.9
08-03-93				53.1	56.5	58.8
08-04-93				53.1	56.8	59.6
08-05-93				54.3	57.6	60.0
08-06-93				53.9	57.7	60.5
08-07-93				54.7	57.6	59.2
08-08-93				52.7	56.4	59.2
08-09-93				51.2	55.3	59.2
08-13-93	56.7	57.1	57.5	57.9	60.8	66.9
08-14-93	55.5	56.6	58.3	51.6	56.7	62.2
08-15-93	55.9	56.3	57.5	56.7	57.4	58.8
08-16-93	55.1	55.3	55.9	55.1	56.0	57.1
08-17-93	54.7	54.7	55.1	55.1	55.7	56.7
08-18-93	54.3	55.5	57.1	54.7	57.0	60.5
08-19-93	55.5	57.1	59.6	53.1	57.7	63.2
08-20-93	56.3	57.3	58.3	55.1	58.7	61.4
08-21-93	56.3	57.0	57.9	57.9	58.5	59.2
08-22-93	55.9	56.8	57.9	54.7	57.3	60.0
08-23-93	56.3	56.9	57.5	54.3	57.1	59.6
08-24-93	55.5	56.3	57.5	47.2	50.4	53.1
08-25-93	53.9	54.6	55.1	44.1	49.1	54.7
08-26-93	53.5	54.8	56.3	45.8	51.1	57.5
08-27-93	53.9	54.6	55.9	50.4	52.7	56.3
08-28-93	53.1	53.9	54.7	45.4	49.5	52.3
08-29-93	52.7	53.9	55.5	45.1	49.9	55.5
08-30-93	52.7	54.1	55.5	46.5	51.2	56.3
08-31-93	53.1	54.0	55.5	47.2	51.2	55.1
09-01-93	53.1	54.2	55.5	49.7	53.9	58.3
09-02-93	54.3	55.6	57.1	50.1	54.5	59.6
09-03-93	54.7	56.0	57.9	50.8	55.5	60.5
09-04-93	55.5	56.6	58.3	52.3	56.3	59.6
09-05-93	55.1	56.7	57.9	51.9	55.7	60.0
09-06-93	55.5	56.8	58.3	51.2	55.5	60.5
09-07-93	55.9	57.1	58.8	51.2	55.7	60.5
09-08-93	55.9	57.5	59.2	51.2	56.0	60.9
09-09-93	56.3	57.5	59.2	51.9	56.2	60.9
09-10-93	56.3	58.0	60.5	52.3	56.9	62.2

Sullivan Creek Air & Water Temperatures At Mill Pond

	Water			Air		
Date	Min	Avg	Max	Min	Avg	Max
09-11-93	55.5	56.6	58.3	50.8	53.4	57.5
09-12-93	54.7	55.3	56.3	47.9	50.1	51.9
09-13-93	53.9	54.8	55.5	44.4	48.0	51.6
09-14-93	53.1	53.8	55.1	46.5	48.3	49.7
09-15-93	52.7	53.3	54.3	46.8	48.4	50.1
09-16-93	51.9	52.8	53.5	42.4	46.4	50.8
09-17-93	51.9	52.9	53.9	42.4	46.4	50.1
09-18-93	51.6	52.8	53.9	43.0	47.0	50.8
09-19-93	51.9	52.6	53.5	45.8	48.0	50.8
09-20-93	51.6	52.0	52.7	44.7	46.3	47.5
09-21-93	50.8	51.6	51.9	44.4	46.0	48.6
09-22-93	50.4	51.4	51.9	40.1	44.0	47.9
09-23-93	50.4	51.4	52.3	41.1	44.8	48.2
09-24-93	50.1	51.0	51.9	41.7	45.3	47.9
09-25-93	50.1	50.9	51.6	42.4	45.8	49.0
09-26-93	50.1	51.2	52.7	42.1	45.5	49.0
09-27-93	50.1	51.3	52.7	43.4	47.0	50.4
09-28-93	50.4	51.5	52.7	45.4	48.5	51.6
09-29-93	51.2	52.3	53.9	44.7	48.9	53.1
09-30-93	51.6	52.1	52.7	47.2	49.5	51.9
10-01-93	50.8	51.9	52.7	43.4	48.3	56.3
10-02-93	51.2	52.0	53.1	40.4	47.9	55.9
10-03-93	50.8	51.8	53.1	41.1	49.0	58.8
10-04-93	50.8	52.0	53.1	42.4	49.4	57.1
10-05-93	51.6	52.6	53.5	43.0	50.0	57.9
10-06-93	52.7	53.2	53.5	48.2	51.1	54.7
10-07-93	52.7	52.9	53.5	44.4	46.2	47.9
10-08-93	52.3	53.1	53.5	41.1	45.8	50.8
10-09-93	52.3	53.0	53.5	36.9	42.5	47.9
10-10-93	51.9	52.3	52.7	37.2	43.1	49.3
10-11-93	51.6	52.0	52.3	39.5	44.9	50.8
10-12-93	51.9	52.3	52.7	43.7	47.4	51.2
10-13-93	52.3	52.5	52.7	47.5	49.0	50.4
10-14-93	52.7	53.0	53.5	48.6	49.4	50.4
10-15-93	52.7	52.9	53.1	47.2	48.3	49.3
10-16-93	53.1	53.2	53.5	46.8	48.2	49.3
10-17-93	53.1	53.4	53.5	44.7	46.5	48.6
10-18-93	52.7	52.8	53.1	40.1	44.4	47.2
10-19-93	52.3	52.7	52.7	39.8	44.7	46.8
10-20-93	51.9	52.4	52.7	34.5	39.4	44.4
10-21-93	51.9	52.2	52.7	38.5	42.2	45.8
10-22-93	51.9	52.1	52.3	38.5	43.2	47.5
10-23-93	52.3	52.5	52.7	47.2	48.0	48.6
10-24-93	52.3	52.6	52.7	42.7	46.1	48.6
10-25-93	51.9	52.3	52.7	38.2	42.2	46.5
10-26-93	51.6	51.7	51.9	36.0	40.2	44.4
10-27-93	51.2	51.2	51.6	36.9	40.6	44.7
10-28-93	51.2	51.3	51.6	41.4	44.2	47.2
10-29-93	50.8	51.2	51.2	36.9	41.3	44.7
10-30-93	50.8	50.9	51.2	36.3	40.5	44.4
10-31-93	50.8	50.8	50.8	39.8	43.2	45.8
11-01-93	50.1	50.4	50.4	35.7	39.7	43.0
11-02-93	50.1	50.1	50.4	40.1	42.0	43.7
11-03-93	49.7	49.9	50.1	38.8	41.9	45.4
11-04-93	49.3	49.4	49.7	36.3	39.7	42.7
11-05-93	48.2	48.6	49.0	31.8	35.4	39.1
11-06-93	46.8	47.6	48.2	33.0	34.6	36.6
11-07-93	45.8	46.4	46.8	33.3	34.8	36.9
11-08-93	45.4	45.6	45.8	33.3	34.8	37.2
11-09-93	45.8	45.8	46.1	30.6	33.7	36.6
11-10-93	45.8	46.0	46.1	31.5	34.5	37.9
11-11-93	45.8	45.8	45.8	30.3	33.2	36.6
11-12-93	45.1	45.4	45.8	29.5	32.8	36.6
11-13-93	43.7	44.5	44.7	30.9	33.0	35.7
11-14-93	42.7	43.1	43.7	25.2	29.2	31.5

Sullivan Creek Air & Water Temperatures At Mill Pond

	Water			Air		
Date	Min	Avg	Max	Min	Avg	Max
11-15-93	42.1	42.4	42.7	31.2	32.8	34.8
11-16-93	41.4	41.6	42.1	28.6	31.7	33.9
11-17-93	40.7	41.2	41.7	31.2	33.0	34.8
11-18-93	41.7	42.3	42.7	31.8	34.0	36.0
11-19-93	42.4	42.6	43.0	29.7	32.7	35.1
11-20-93	42.7	42.7	43.0	33.0	34.1	34.8
11-21-93	42.7	42.8	43.0	34.5	35.6	36.6
11-22-93	41.7	42.2	42.7	21.6	28.2	36.0
11-23-93	40.1	40.8	41.7	16.0	17.6	21.1
11-24-93	39.5	39.8	40.1	16.0	17.3	20.5
11-25-93	39.5	39.5	39.5	16.0	17.6	21.3
11-26-93	39.1	39.5	39.5	16.0	19.3	23.5
11-27-93	39.5	39.5	39.5	21.6	25.8	29.2
11-28-93	39.5	39.6	39.8	29.2	30.9	32.1
11-29-93	39.5	39.7	39.8	32.4	33.5	34.8
11-30-93	39.8	39.8	39.8	33.6	34.5	35.1
12-01-93	39.8	39.8	39.8	33.6	34.6	35.1
12-02-93	39.5	39.7	39.8	34.5	34.8	35.1
12-03-93	39.5	39.8	39.8	34.8	35.1	35.4
12-04-93	39.8	39.8	40.1	33.0	35.4	36.6
12-05-93	39.1	39.5	39.8	24.9	29.6	32.4
12-06-93	38.8	39.1	39.1	21.1	24.6	28.0
12-07-93	38.8	39.0	39.1	28.0	29.3	31.2
12-08-93	38.8	38.8	39.1	30.9	32.3	34.2
12-09-93	38.8	39.0	39.1	33.9	34.5	35.1
12-10-93	39.1	39.3	39.5	34.8	35.4	36.0
12-11-93	39.5	39.5	39.5	35.4	35.7	36.3
12-12-93	39.1	39.5	39.5	32.4	34.9	36.0
12-13-93	39.1	39.1	39.5	31.8	33.0	33.9
12-14-93	39.1	39.1	39.1	33.9	34.3	34.8
12-15-93	39.1	39.1	39.1	31.8	33.5	34.8
12-16-93	38.5	38.7	39.1	24.9	28.0	32.1
12-17-93	38.5	38.5	38.5	22.7	26.3	28.9
12-18-93	38.5	38.5	38.5	27.7	28.4	29.2
12-19-93	38.5	38.5	38.5	28.6	29.4	30.0
12-20-93	38.5	38.5	38.5	29.5	30.3	31.2
12-21-93	38.2	38.5	38.5	28.6	29.5	30.6
12-22-93	36.0	37.5	38.5	25.8	28.4	30.6
12-23-93	35.4	35.7	36.0	24.3	25.8	27.8
12-24-93	35.4	35.5	35.7	23.1	25.8	27.8
12-25-93	34.8	35.2	35.4	18.6	22.0	25.6
12-26-93	35.1	35.3	35.4	21.6	24.0	26.5
12-27-93	35.1	35.3	35.4	20.3	24.2	27.3
12-28-93	34.8	34.8	35.1	22.7	24.4	26.5
12-29-93	34.5	34.8	34.8	23.3	26.3	29.2
12-30-93	34.8	34.9	35.1	27.7	29.3	31.1
12-31-93	34.5	34.8	34.8	29.7	30.4	31.1
01-01-94	34.2	34.5	34.5	29.7	30.7	31.6
01-02-94	34.2	34.3	34.5	30.9	31.5	32.0
01-03-94	34.2	34.3	34.5	31.2	31.8	32.5
01-04-94	34.2	34.2	34.2	31.5	31.9	33.0
01-05-94	34.2	34.2	34.2	29.2	31.6	32.5
01-06-94	33.3	33.8	34.2	23.1	25.8	28.9
01-07-94	33.3	33.6	33.6	24.6	27.7	30.6
01-08-94	33.6	33.7	33.9	29.2	30.1	31.1
01-09-94	33.9	33.9	33.9	30.3	31.0	32.0
01-10-94	33.9	33.9	33.9	29.5	30.8	32.0
01-11-94	33.9	33.9	34.2	30.9	31.6	32.5
01-12-94	34.2	34.2	34.2	31.5	32.1	33.0
01-13-94	34.2	34.4	34.5	31.8	32.4	33.0
01-14-94	34.5	34.5	34.5	32.4	32.9	33.6
01-15-94	34.8	34.8	34.8	31.5	32.8	34.6
01-16-94	34.8	34.8	34.8	30.3	31.8	33.6
01-17-94	34.8	34.8	34.8	30.3	31.8	33.0
01-18-94	34.8	34.8	34.8	30.9	31.7	33.0

Sullivan Creek Air & Water Temperatures At Mill Pond

	Water			Air		
Date	Min	Avg	Max	Min	Avg	Max
01-19-94	34.5	34.7	34.8	26.9	30.0	31.6
01-20-94	33.6	34.1	34.5	22.3	25.7	29.2
01-21-94	33.6	33.9	34.2	22.7	26.1	30.1
01-22-94	33.9	34.1	34.5	27.7	30.0	31.6
01-23-94	34.2	34.4	34.5	29.5	30.7	32.0
01-24-94	34.5	34.6	34.8	30.9	31.7	33.0
01-25-94	34.5	34.8	34.8	29.5	30.8	32.0
01-26-94	34.8	34.8	35.1	30.9	31.8	32.5
01-27-94	34.8	35.0	35.1	27.3	31.2	33.0
01-28-94	34.2	34.5	34.8	22.3	26.7	31.1
01-29-94	34.2	34.4	34.5	25.5	28.4	30.1
01-30-94	33.9	34.1	34.5	22.7	25.4	28.7
01-31-94	33.6	33.9	34.2	19.1	23.2	28.2
02-01-94	33.3	33.7	33.9	18.8	23.0	26.9
02-02-94	33.3	33.6	33.9	17.7	22.5	24.7
02-03-94	32.4	33.1	33.6	13.1	19.5	24.3
02-04-94	33.3	33.5	33.6	21.9	23.5	25.6
02-05-94	33.3	33.3	33.6	23.3	24.3	26.0
02-06-94	33.0	33.2	33.3	22.7	24.0	26.0
02-07-94	32.1	32.6	33.0	6.1	18.3	23.5
02-08-94	30.9	31.6	32.1	-0.8	12.1	16.9
02-09-94	32.1	32.1	32.4	14.1	16.7	19.9
02-10-94	32.1	32.3	32.4	12.7	19.2	25.2
02-11-94	32.1	32.3	32.4	17.8	20.7	24.3
02-12-94	32.4	32.5	32.7	22.2	24.9	27.8
02-13-94	32.7	32.9	33.0	26.6	29.2	31.1
02-14-94	32.7	32.9	33.0	25.2	28.4	30.6
02-15-94	33.0	33.0	33.0	28.0	29.7	31.1
02-16-94	33.0	33.1	33.3	30.0	30.6	31.6
02-17-94	35.1	35.2	35.4	31.8	32.2	32.4
02-18-94	35.4	35.4	35.4	31.8	32.3	33.0
02-19-94	35.1	35.3	35.4	30.0	31.1	31.8
02-20-94	35.1	35.2	35.4	29.5	30.8	31.8
02-21-94	35.1	35.3	35.4	31.8	31.9	32.1
02-22-94	35.4	35.4	35.4	29.5	31.0	31.8
02-23-94	35.1	35.4	35.7	23.5	30.5	32.1
02-24-94	34.5	34.9	35.1	16.2	20.3	23.8
02-25-94	34.5	34.7	34.8	20.3	22.9	25.8
02-26-94	34.5	34.9	35.1	25.5	27.8	30.0
02-27-94	34.8	35.1	35.4	30.0	30.9	31.5
02-28-94	35.1	35.3	35.4	31.5	31.6	31.8
03-01-94	35.4	35.6	35.7	31.8	32.4	33.3
03-02-94	35.7	35.7	35.7	32.1	33.0	34.2
03-03-94	35.7	35.8	36.0	32.4	33.2	34.2
03-04-94	36.0	36.0	36.3	31.8	33.9	36.3
03-05-94	36.0	36.1	36.3	28.3	30.7	32.1
03-06-94	35.7	36.0	36.3	23.0	27.5	31.5
03-07-94	35.7	35.8	36.3	23.0	27.4	31.2
03-08-94	35.4	35.7	36.0	22.7	27.7	31.5
03-09-94	35.4	35.7	36.0	25.2	29.4	32.7
03-10-94	36.0	36.0	36.0	30.6	32.1	33.9
03-11-94	36.0	36.3	36.3	32.1	32.9	34.8
03-12-94	36.3	36.6	36.9	30.6	32.6	35.1
03-13-94	36.6	36.8	36.9	33.0	33.9	35.7
03-14-94	36.9	37.0	37.2	33.0	34.8	37.2
03-15-94	36.9	37.4	37.9	31.5	34.9	39.1
03-16-94	37.6	37.7	37.9	33.6	35.9	39.1
03-17-94	37.6	37.9	37.9	35.1	35.7	36.9
03-18-94	37.9	37.9	37.9	34.8	35.6	37.2
03-19-94	37.6	37.8	37.9	31.2	32.7	34.2
03-20-94	37.2	37.4	37.6	28.9	31.1	32.4
03-21-94	37.2	37.3	37.6	31.2	32.8	33.6
03-22-94	37.2	37.5	37.6	28.3	30.6	32.4
03-23-94	36.9	37.3	37.6	24.9	29.7	33.0
03-24-94	36.9	37.1	37.2	25.2	30.8	35.1

Sullivan Creek Air & Water Temperatures At Mill Pond

	Water			Air		
Date	Min	Avg	Max	Min	Avg	Max
03-25-94	37.2	37.5	37.6	26.6	31.5	36.3
03-26-94	37.6	37.9	38.2	29.7	33.9	39.8
03-27-94	37.9	38.3	38.5	30.9	34.9	39.5
03-28-94	38.2	38.7	39.1	32.7	37.6	43.7
03-29-94	38.8	39.1	39.5	32.1	36.7	41.7
03-30-94	39.1	39.6	39.8	32.4	37.4	42.7
03-31-94	39.8	39.8	40.1	33.3	38.0	43.7
04-01-94	39.5	39.8	40.1	35.1	38.5	42.7
04-02-94	39.1	39.4	39.8	35.4	39.1	43.7
04-03-94	39.1	39.4	39.8	37.9	38.7	39.5
04-04-94	39.1	39.1	39.1	37.6	38.5	40.1
04-05-94	38.8	39.2	39.5	34.5	37.5	39.1
04-06-94	38.8	39.0	39.1	34.5	35.8	37.6
04-07-94	38.5	38.8	39.1	35.4	36.7	38.2
04-08-94	39.1	39.1	39.1	35.7	37.1	38.5
04-09-94	39.1	39.2	39.5	36.6	38.3	41.1
04-10-94	39.1	39.5	39.8	37.9	40.4	43.7
04-11-94	39.8	40.7	41.4	36.6	41.4	46.1
04-12-94	40.7	41.0	41.1	39.5	41.4	43.0
04-13-94	39.5	40.2	41.1	37.2	38.5	40.7
04-14-94	38.8	39.1	39.5	33.0	36.3	39.1
04-15-94	39.5	39.9	40.7	35.7	40.2	45.8
04-16-94	40.4	41.0	42.1	39.1	44.2	50.8
04-17-94	41.1	41.7	42.7	42.7	46.6	51.2
04-18-94	40.7	41.7	42.7	41.1	45.5	49.3
04-19-94	40.1	40.7	41.7	42.4	43.8	46.1
04-20-94	38.8	39.9	40.4	40.4	42.8	45.4
04-21-94	38.8	39.8	40.7	40.1	42.4	46.1
04-22-94	38.5	39.5	40.1	39.5	40.9	42.1
04-23-94	38.8	39.6	40.4	38.5	41.0	43.4
04-24-94	38.8	39.4	40.1	37.2	40.0	42.1
04-25-94	39.1	39.5	39.8	39.8	40.7	42.4
04-26-94	38.8	39.7	40.4	36.3	40.5	43.7
04-27-94	39.1	39.9	40.4	36.0	40.8	44.7
04-28-94	39.8	40.5	41.4	37.9	41.6	45.1
04-29-94	40.1	40.9	42.1	35.7	41.8	48.2
04-30-94	40.4	40.7	41.4	39.8	41.5	43.0
05-01-94	39.8	40.0	40.4	36.6	39.3	41.1
05-02-94	39.5	39.9	40.4	36.6	40.3	43.4
05-03-94	39.5	40.3	41.4	35.7	41.6	47.5
05-04-94	40.4	40.8	41.1	41.4	42.4	43.4
05-05-94	40.4	41.2	43.0	38.5	43.6	49.3
05-06-94	41.4	42.6	44.1	39.5	46.1	52.7
05-07-94	42.4	43.8	45.4	43.4	48.8	54.3
05-08-94	42.7	43.9	44.7	43.7	48.4	53.1
05-09-94	42.4	43.4	44.4	43.7	47.8	52.7
05-10-94	42.1	43.1	44.1	44.1	46.5	49.7
05-11-94	42.1	42.8	43.4	43.0	45.9	49.0
05-12-94	42.1	42.9	43.7	43.7	45.6	48.2
05-13-94	41.7	42.5	43.4	41.7	43.9	46.5
05-14-94	41.4	42.2	42.7	39.8	43.8	46.8
05-15-94	41.7	42.1	42.7	43.0	43.3	44.1
05-16-94	41.1	41.7	42.1	41.4	42.9	45.1
05-17-94	41.1	41.9	43.0	37.6	43.0	47.5
05-18-94	42.4	42.9	43.7	43.4	45.2	48.2
05-19-94	42.4	42.9	43.4	40.7	44.1	47.5
05-20-94	42.4	42.8	43.4	43.4	44.4	46.5
05-21-94	42.7	43.1	43.7	43.0	44.7	46.5
05-22-94	42.7	43.5	44.7	41.1	45.2	48.6
05-23-94	43.4	44.6	46.1	42.4	47.7	52.3
05-24-94	44.7	46.0	47.5	45.4	50.7	56.3
05-25-94	45.8	47.2	48.2	47.2	51.0	56.7
05-26-94	46.5	47.1	47.5	48.2	50.7	53.5
05-27-94	46.1	46.7	47.5	45.4	48.3	51.2
05-28-94	45.1	45.6	46.5	42.4	45.9	49.3

Sullivan Creek Air & Water Temperatures At Mill Pond

	Water			Air		
Date	Min	Avg	Max	Min	Avg	Max
05-29-94	44.4	44.5	44.7	42.4	44.3	45.1
05-30-94	43.4	44.2	45.4	38.5	43.7	49.0
05-31-94	43.7	44.6	45.4	39.5	46.0	51.2
06-01-94	45.1	45.4	45.8	46.8	48.6	50.8
06-02-94	44.7	46.2	47.5	41.1	49.6	56.7
06-03-94	46.5	47.9	49.7	45.1	52.8	60.9
06-04-94	47.5	48.4	49.3	47.9	50.5	53.1
06-05-94	46.1	47.1	48.2	43.7	48.7	53.1
06-06-94	46.5	47.1	47.9	46.1	48.6	50.1
06-07-94	45.4	45.9	46.5	43.4	45.0	47.2
06-08-94	45.1	45.7	46.5	43.0	45.6	49.3
06-09-94	45.1	45.7	46.8	43.0	47.2	50.8
06-10-94	45.4	46.4	47.5	43.7	49.1	53.5
06-11-94	46.8	47.5	48.2	47.9	51.6	55.9
06-12-94	47.5	48.1	49.0	48.2	51.7	55.1
06-13-94	47.9	48.4	49.3	45.8	49.4	50.4
06-14-94	46.8	47.8	48.6	40.7	44.8	48.6
06-15-94	46.8	47.5	48.2	43.7	47.1	51.6
06-16-94	46.5	47.4	48.6	44.1	47.1	50.8
06-17-94	48.6	49.6	51.2	46.5	49.9	54.7
06-18-94	49.7	50.3	50.8	44.7	48.4	52.3
06-19-94	49.7	50.9	52.3	43.4	50.1	57.5
06-20-94	51.2	52.5	53.9	45.4	53.3	60.9
06-21-94	52.7	54.1	55.9	49.7	57.6	65.5
06-22-94	54.3	55.6	57.1	53.1	60.3	67.9
06-23-94	55.5	56.0	56.7	55.5	59.7	69.4
06-24-94	55.9	56.8	57.5	55.9	58.7	61.8
06-25-94	55.1	56.3	57.5	50.4	57.9	64.5
06-26-94	54.7	55.5	56.7	53.5	55.3	59.6
06-27-94	53.1	54.2	55.5	49.3	54.5	60.5
06-28-94	53.9	55.3	57.5	50.4	58.5	67.4
06-29-94	54.7	55.5	56.3	53.9	56.0	58.8
06-30-94	55.5	56.8	57.9	56.7	62.3	66.9
07-01-94	55.9	56.7	57.5	55.1	59.1	63.2
07-02-94	55.1	55.7	56.3	49.0	52.5	57.1
07-03-94	54.7	55.0	55.5	48.2	52.0	55.9
07-04-94	53.9	54.7	55.5	47.5	53.2	57.9
07-05-94	53.9	55.1	56.3	47.9	55.6	63.2
07-06-94	55.1	56.1	57.5	51.6	57.5	64.5
07-07-94	56.3	56.7	57.5	53.5	56.8	63.6
07-08-94	57.9	58.7	59.6	63.2	66.7	70.0
07-09-94	57.1	58.2	59.2	54.7	61.9	70.0
07-10-94	57.5	58.4	59.6	51.9	60.1	69.4
07-11-94	57.5	58.7	59.2	52.7	61.1	70.0
07-12-94	57.5	58.6	59.6	52.7	60.5	68.9
07-13-94	57.9	59.1	60.0	53.5	61.5	70.5
07-14-94	58.8	59.4	60.0	58.8	62.7	69.4
07-16-94	58.3	59.6	60.5	55.5	63.5	72.1
07-17-94	59.2	60.0	60.9	57.9	64.5	71.0
07-18-94	59.6	59.9	60.5	58.8	62.9	66.9
07-19-94	58.8	59.8	60.9	53.1	61.3	70.0
07-20-94	59.6	60.6	62.2	55.5	64.7	74.8
07-21-94	60.5	61.7	62.7	59.2	68.0	77.1
07-22-94	61.4	62.4	64.1	60.5	69.3	79.0
07-23-94	61.8	63.0	64.1	62.2	70.0	79.0
07-24-94	62.2	63.4	64.5	63.6	70.5	79.0
07-25-94	63.2	64.4	66.0	66.4	72.2	79.6
07-26-94	63.2	64.4	65.5	63.2	70.2	77.7
07-27-94	63.2	64.0	65.0	58.8	67.5	76.0
07-28-94	62.7	63.3	64.5	57.9	63.6	70.0
07-29-94	61.8	62.8	64.5	56.7	66.4	78.4
07-30-94	62.2	63.1	64.5	59.6	67.2	76.0
07-31-94	61.8	62.8	63.6	57.1	65.5	74.3
08-01-94	61.8	62.7	63.6	57.9	66.4	76.6

Sullivan Creek Air & Water Temperatures At Mill Pond

	Water			Air		
Date	Min	Avg	Max	Min	Avg	Max
08-02-94	62.2	63.3	64.5	61.4	68.9	76.6
08-03-94	62.7	63.9	65.0	62.7	70.8	81.5
08-04-94	63.2	63.7	64.5	61.8	68.1	74.3
08-05-94	63.2	63.9	64.5	60.5	66.7	73.2
08-06-94	62.7	63.4	64.5	55.5	62.2	68.9
08-07-94	62.2	62.9	63.6	53.9	62.8	72.6
08-08-94	61.8	62.4	63.2	58.8	61.4	64.5
08-09-94	60.9	61.8	62.7	53.1	58.7	66.4
08-10-94	60.5	61.4	62.2	50.8	60.4	72.1
08-11-94	60.9	61.7	62.2	53.1	64.2	74.8
08-12-94	60.9	62.0	63.2	55.1	65.6	77.7
08-13-94	61.8	62.6	63.6	57.9	67.6	79.6
08-14-94	61.8	62.9	63.6	57.9	67.5	80.8
08-15-94	61.8	62.8	63.6	58.8	65.6	72.6
08-16-94	61.8	62.7	63.6	55.9	63.7	72.6
08-17-94	61.8	62.4	63.2	55.5	62.0	70.0
08-18-94	60.9	61.8	62.7	52.3	62.0	72.6
08-19-94	61.4	61.9	62.7	54.3	64.0	75.4
08-20-94	61.4	61.8	62.2	56.3	64.4	73.7
08-21-94	60.9	61.7	62.2	54.3	62.2	70.0
08-22-94	60.9	61.3	62.2	53.5	58.7	63.6
08-23-94	59.6	60.3	60.9	51.6	58.2	66.4
08-24-94	59.2	59.9	60.5	49.7	58.2	67.9
08-25-94	59.2	59.7	60.0	51.2	59.2	66.4
08-26-94	58.8	58.9	59.2	53.5	56.4	60.5
08-27-94	57.5	58.4	59.2	45.4	54.7	65.5
08-28-94	57.9	58.7	59.6	48.2	57.6	68.9
08-29-94	58.3	59.0	59.6	51.9	56.8	62.2
08-30-94	57.9	58.9	60.0	49.7	57.4	66.9
08-31-94	58.3	59.3	60.5	50.4	60.0	70.0
09-01-94	58.3	59.1	60.0	50.1	59.2	70.0
09-02-94	58.8	59.3	60.0	51.6	58.9	68.9
09-03-94	57.9	58.5	59.6	50.4	53.2	57.5
09-04-94	57.1	57.6	57.9	46.8	50.8	55.5
09-05-94	56.7	57.5	57.9	44.7	52.0	60.5
09-06-94	56.7	57.7	58.3	46.8	55.1	65.5
09-07-94	57.1	58.0	58.8	49.3	57.2	67.4
09-08-94	57.5	58.2	59.2	53.9	60.2	70.5
09-09-94	57.1	57.8	58.8	49.0	53.8	59.6
09-10-94	56.3	56.5	57.1	45.8	48.8	51.9
09-11-94	55.5	55.9	56.3	45.1	49.2	54.3
09-12-94	55.1	55.7	55.9	41.4	48.3	56.3
09-13-94	54.7	55.6	56.3	42.1	50.2	59.6
09-14-94	55.5	55.7	55.9	50.1	53.8	58.8
09-15-94	55.5	56.0	56.7	52.7	56.1	62.2
09-16-94	55.5	56.3	57.1	49.0	55.5	63.2
09-17-94	55.9	56.9	57.5	50.1	57.2	66.0
09-18-94	56.3	56.9	57.5	50.1	57.0	65.0
09-19-94	56.3	56.7	57.5	48.6	51.8	56.7
09-20-94	56.3	56.9	57.1	53.9	58.8	63.2
09-21-94	55.9	56.6	57.1	47.5	53.3	59.2
09-22-94	55.9	56.5	57.1	46.5	53.0	60.5
09-23-94	55.5	56.3	56.7	47.5	54.0	60.9
09-24-94	55.5	56.3	56.7	48.2	54.8	61.4
09-25-94	55.5	56.2	56.7	48.6	55.2	63.2
09-26-94	55.5	56.1	56.7	49.0	55.1	61.8
09-27-94	55.5	56.1	56.7	49.0	55.1	62.7
09-28-94	55.5	55.9	56.3	49.7	55.0	59.6
09-29-94	55.1	55.7	55.9	49.7	54.8	61.4
09-30-94	55.5	55.6	55.9	51.6	54.2	56.7
10-01-94	55.1	55.2	55.5	49.7	52.1	54.7
10-02-94	53.9	54.4	55.1	42.1	45.6	49.3
10-03-94	53.5	53.9	54.3	42.1	46.1	52.3
10-04-94	53.1	53.5	53.9	39.8	44.6	49.7
10-05-94	52.7	53.3	53.5	38.8	44.3	50.1

Sullivan Creek Air & Water Temperatures At Mill Pond

	Water			Air		
Date	Min	Avg	Max	Min	Avg	Max
10-06-94	52.7	53.1	53.5	40.1	45.2	50.8
10-07-94	52.7	53.1	53.5	39.5	44.9	50.1
10-08-94	52.7	53.4	53.9	40.7	45.6	51.6
10-09-94	53.5	53.9	54.3	42.1	47.4	52.7
10-10-94	53.9	54.4	54.7	47.5	50.0	53.5
10-11-94	54.3	54.6	55.1	47.5	50.2	54.3
10-12-94	54.3	54.5	54.7	42.1	46.6	51.6
10-13-94	53.9	54.1	54.3	40.1	44.8	49.3
10-14-94	53.5	54.0	54.3	41.4	43.6	47.2
10-15-94	53.5	53.5	53.5	40.7	43.1	46.8
10-16-94	53.1	53.2	53.5	38.2	42.1	46.5
10-17-94	52.7	52.8	53.1	37.6	41.6	45.8
10-18-94	52.3	52.4	52.7	39.5	41.5	44.7
10-19-94	51.9	51.9	52.3	37.2	40.1	43.4
10-20-94	51.9	51.9	51.9	41.4	43.3	45.8
10-21-94	51.6	51.8	51.9	40.4	43.1	45.8
10-22-94	50.8	51.2	51.6	34.8	38.5	41.4
10-23-94	50.8	51.0	51.2	40.1	42.0	44.7
10-24-94	50.4	50.6	50.8	35.7	39.6	43.7
10-25-94	50.1	50.3	50.4	36.0	39.6	43.7
10-26-94	50.4	50.6	50.8	41.7	45.4	48.2
10-27-94	50.4	50.5	50.8	44.4	45.7	46.8
10-28-94	49.7	49.9	50.4	39.1	42.0	44.4
10-29-94	49.0	49.1	49.3	37.2	38.3	39.5
10-30-94	48.2	48.3	48.6	35.1	36.4	38.5
10-31-94	47.5	47.7	48.2	36.6	37.0	37.6
11-01-94	47.2	47.4	47.5	34.8	37.2	38.5
11-02-94	46.1	46.8	47.2	29.5	34.0	36.0
11-03-94	45.4	45.8	46.5	25.5	30.1	34.8
11-04-94	44.7	45.1	45.4	31.6	33.4	34.6
11-05-94	44.4	44.5	44.7	26.0	30.7	33.6
11-06-94	43.7	44.1	44.4	28.2	31.0	34.1
11-07-94	44.1	44.1	44.1	32.5	34.0	34.6
11-08-94	44.1	44.2	44.4	34.6	35.2	36.2
11-09-94	43.7	43.8	44.1	34.6	34.9	35.1
11-10-94	43.7	43.7	43.7	35.1	36.0	37.3
11-11-94	43.4	43.7	43.7	35.1	35.7	36.2
11-12-94	43.0	43.4	43.4	34.1	35.7	37.3
11-13-94	42.4	42.5	43.0	26.0	30.2	33.0
11-14-94	42.4	42.4	42.4	31.1	33.6	35.1
11-15-94	42.1	42.2	42.4	33.0	34.2	34.6
11-16-94	41.4	41.8	42.1	33.0	34.1	34.6
11-17-94	40.7	41.2	41.4	26.0	31.8	33.0
11-18-94	40.1	40.3	40.7	23.9	27.3	29.2
11-19-94	40.1	40.1	40.1	28.7	29.7	30.6
11-20-94	39.5	39.8	40.1	25.2	29.5	30.6
11-21-94	38.2	38.6	39.1	19.5	22.0	24.7
11-22-94	37.9	38.1	38.2	19.1	22.7	25.6
11-23-94	37.9	38.2	38.5	23.9	27.3	29.6
11-24-94	38.2	38.5	38.5	29.6	30.4	31.1
11-25-94	38.5	38.5	38.5	31.1	31.3	32.0
11-26-94	38.5	38.6	38.8	30.6	32.0	33.0
11-27-94	38.2	38.3	38.5	28.2	29.8	30.6
11-28-94	37.6	37.9	38.2	25.6	28.5	30.1
11-29-94	37.2	37.3	37.6	25.2	28.2	30.6
11-30-94	37.2	37.6	37.9	30.6	32.4	36.2
12-01-94	37.2	37.5	37.9	31.6	32.9	35.7
12-02-94	36.9	37.4	38.5	30.6	31.9	33.0
12-03-94	35.7	36.5	36.9	19.9	24.9	30.6
12-04-94	34.5	34.8	35.7	10.4	13.7	18.8
12-05-94	34.2	34.5	34.8	7.3	10.9	14.8
12-06-94	34.5	34.8	35.1	12.1	16.1	19.9
12-07-94	35.1	35.1	35.1	19.1	21.1	23.1
12-08-94	34.8	34.9	35.1	21.9	23.0	24.7
12-09-94	34.8	34.8	34.8	24.7	25.4	26.0

Sullivan Creek Air & Water Temperatures At Mill Pond

	Water			Air		
Date	Min	Avg	Max	Min	Avg	Max
12-10-94	34.5	34.8	34.8	22.7	24.3	25.6
12-11-94	34.8	34.8	35.1	25.6	26.6	27.8
12-12-94	34.8	34.8	35.1	26.0	26.9	28.2
12-13-94	34.2	34.4	34.8	19.5	22.4	25.2
12-14-94	34.5	34.5	34.5	23.5	24.6	25.6
12-15-94	34.5	34.5	34.5	25.6	26.6	27.8
12-16-94	34.5	34.8	34.8	27.8	28.5	29.6
12-17-94	34.8	34.8	35.1	29.6	30.1	30.6
12-18-94	34.8	34.8	34.8	30.6	30.6	30.6
12-19-94	34.8	34.8	34.8	30.6	30.6	30.6
12-20-94	34.8	34.8	35.1	30.6	30.9	31.1
12-21-94	35.1	35.1	35.1	31.1	31.1	31.1
12-22-94	35.1	35.1	35.1	30.6	31.0	31.1
12-23-94	35.1	35.1	35.1	30.6	30.6	30.6
12-24-94	34.8	34.9	35.1	26.5	28.7	30.6
12-25-94	34.8	35.0	35.1	29.2	29.7	30.1
12-26-94	34.8	35.0	35.1	30.1	30.4	30.6
12-27-94	34.8	34.8	35.1	30.6	30.6	30.6
12-28-94	34.8	34.9	35.1	30.6	30.9	31.1
12-29-94	34.5	34.8	35.1	26.0	29.6	31.1
12-30-94	33.3	33.8	34.5	17.7	21.2	26.0
12-31-94	32.7	32.9	33.3	12.1	14.5	17.3
01-01-95	31.8	32.3	32.7	8.5	11.4	13.8
01-02-95	31.5	31.8	32.1	7.3	10.4	13.4
01-03-95	31.2	31.5	31.8	7.0	9.8	12.4
01-04-95	30.9	31.1	31.5	5.8	8.6	11.1
01-05-95	30.6	30.8	31.2	5.2	8.2	11.1
01-06-95	30.9	31.1	31.5	8.5	11.9	15.1
01-07-95	30.9	31.1	31.5	10.1	12.9	16.9
01-08-95	31.5	31.8	32.1	17.3	20.1	22.7
01-09-95	32.1	32.5	33.9	22.7	26.6	31.1
01-10-95	32.7	32.9	33.0	30.1	30.5	30.6
01-11-95	33.0	33.0	33.0	30.6	30.6	30.6
01-12-95	33.0	33.1	33.3	30.6	30.7	31.1
01-13-95	33.3	33.3	33.3	30.6	30.7	31.1
01-14-95	33.3	33.5	33.6	30.6	30.7	31.1
01-15-95	33.6	33.6	33.6	30.6	30.9	31.6
01-16-95	33.6	33.8	33.9	30.6	31.0	31.6
01-17-95	33.9	33.9	34.2	30.6	30.8	31.1
01-18-95	34.2	34.2	34.2	30.6	30.6	30.6
01-19-95	34.2	34.2	34.5	30.6	30.6	31.1
01-20-95	33.9	34.0	34.5	26.0	28.7	30.6
01-21-95	33.3	33.5	33.9	21.5	23.8	26.0
01-22-95	33.0	33.2	33.3	19.1	21.7	23.5
01-23-95	32.1	32.6	33.0	13.1	16.9	20.3
01-24-95	31.8	32.4	33.0	12.4	16.9	22.3
01-25-95	32.7	33.0	33.3	22.3	24.8	27.3
01-26-95	33.3	33.3	33.3	27.3	28.6	29.6
01-27-95	33.6	33.6	33.6	29.6	30.3	30.6
01-28-95	33.6	33.6	33.9	29.2	30.4	30.6
01-29-95	33.6	33.7	33.9	29.2	29.9	30.6
01-30-95	33.9	33.9	33.9	30.6	30.6	30.6
01-31-95	33.9	34.1	34.2	30.6	30.9	31.6
02-01-95	34.2	34.2	34.2	31.1	31.2	31.6
02-02-95	34.2	34.2	34.5	31.1	31.2	31.6
02-03-95	34.2	34.5	34.5	30.6	31.2	32.0
02-04-95	34.2	34.4	34.5	29.6	30.4	30.6
02-05-95	34.2	34.5	34.5	30.1	30.5	30.6
02-06-95	34.5	34.7	34.8	30.6	30.9	31.1
02-07-95	34.8	34.9	35.1	30.6	31.2	32.0
02-08-95	34.8	34.8	34.8	30.1	30.5	30.6
02-09-95	34.5	34.7	34.8	26.0	28.8	30.1
02-10-95	34.2	34.5	34.8	23.9	27.2	29.6
02-11-95	33.9	34.5	34.8	21.5	25.8	27.8
02-12-95	33.0	33.2	33.9	13.8	16.1	20.3

Sullivan Creek Air & Water Temperatures At Mill Pond

	Water			Air		
Date	Min	Avg	Max	Min	Avg	Max
02-13-95	32.4	32.7	33.0	12.7	14.9	16.9
02-14-95	31.8	32.4	33.0	6.7	12.6	17.3
02-15-95	32.7	32.8	33.0	16.6	18.5	21.5
02-16-95	33.0	33.2	33.6	21.5	24.3	27.8
02-17-95	33.6	33.6	33.9	27.8	29.5	31.1
02-18-95	33.6	33.7	33.9	30.6	30.6	31.1
02-19-95	33.9	33.9	33.9	31.1	31.6	32.0
02-20-95	33.9	33.9	34.2	31.6	32.4	34.6
02-21-95	33.9	34.0	34.2	31.1	31.9	33.6
02-22-95	33.9	34.1	34.2	30.6	31.4	33.0
02-23-95	33.9	34.2	34.5	30.1	30.6	31.1
02-24-95	34.2	34.4	34.8	30.6	31.3	32.5
02-25-95	34.8	34.9	35.1	31.1	32.5	35.1
02-26-95	34.8	34.9	35.1	29.2	30.5	31.1
02-27-95	34.2	34.6	34.8	24.3	27.3	29.6
02-28-95	33.6	34.3	34.5	19.5	24.2	27.8
03-01-95	33.6	34.2	34.5	18.4	23.4	27.8
03-02-95	33.6	34.0	34.5	16.9	22.7	27.8
03-03-95	33.6	34.1	34.5	18.4	24.3	29.6
03-04-95	34.2	34.4	34.5	28.7	29.3	30.1
03-05-95	34.2	34.3	34.5	25.2	28.3	29.6
03-06-95	33.6	33.9	34.2	18.0	23.0	26.0
03-07-95	33.9	34.1	34.5	23.9	26.6	29.6
03-08-95	34.2	34.2	34.5	26.0	27.7	29.6
03-09-95	34.2	34.5	34.8	29.6	30.7	32.0
03-10-95	34.5	34.8	35.1	31.1	33.3	36.2
03-11-95	34.8	35.0	35.1	32.5	35.0	37.9
03-12-95	34.8	34.9	35.1	31.6	33.1	35.1
03-13-95	34.8	35.2	35.4	31.1	32.5	34.1
03-14-95	35.4	35.7	36.0	33.0	34.2	35.7
03-15-95	36.0	36.2	36.6	34.1	35.2	37.3
03-16-95	36.0	36.3	36.6	30.6	33.5	36.7
03-17-95	36.0	36.5	36.9	30.6	33.0	36.2
03-18-95	36.9	36.9	36.9	33.6	34.3	35.1
03-19-95	36.9	37.1	37.2	34.6	35.3	36.7
03-20-95	37.2	37.2	37.2	33.0	34.3	35.1
03-21-95	37.2	37.3	37.6	33.0	34.3	35.7
03-22-95	36.6	37.0	37.2	31.1	33.2	36.2
03-23-95	36.6	36.9	36.9	32.5	34.0	36.2
03-24-95	36.6	36.8	36.9	31.6	33.5	35.1
03-25-95	36.3	36.7	36.9	30.1	31.0	32.0
03-26-95	36.3	36.6	36.9	30.1	31.7	34.6
03-27-95	36.3	37.1	38.2	30.1	33.9	40.2
03-28-95	36.6	37.4	37.9	30.6	35.0	40.2
03-29-95	37.2	37.9	38.5	30.6	35.8	42.0
03-30-95	37.6	38.4	39.1	32.0	37.1	43.3
03-31-95	38.2	38.7	39.5	32.5	38.8	45.9
04-01-95	38.8	39.2	39.5	36.2	39.6	42.0
04-02-95	38.5	38.8	39.1	33.0	36.6	40.8
04-03-95	38.5	39.0	39.8	32.5	38.5	45.2
04-04-95	38.8	39.2	39.8	35.1	39.9	45.2
04-05-95	38.8	39.3	39.8	33.6	38.3	42.0
04-06-95	39.1	39.4	39.5	36.2	38.8	41.4
04-07-95	38.5	39.1	39.5	34.1	38.1	42.0
04-08-95	39.1	39.2	39.5	34.6	37.7	39.6
04-09-95	38.5	38.9	39.1	33.0	35.8	39.6
04-10-95	38.5	38.9	39.5	30.6	35.4	39.6
04-11-95	39.1	39.4	39.8	34.6	37.8	40.8
04-12-95	39.1	39.4	39.8	31.6	35.0	38.4
04-13-95	39.1	39.3	39.8	36.2	38.3	40.8
04-14-95	38.8	39.2	39.5	33.6	34.9	37.3
04-15-95	38.5	39.2	39.8	33.6	34.9	37.3
04-16-95	38.5	39.3	40.1	30.6	35.0	40.2
04-17-95	38.8	39.3	39.8	31.1	36.0	40.2
04-18-95	39.1	39.5	40.1	35.1	38.5	41.4

Sullivan Creek Air & Water Temperatures At Mill Pond

	Water			Air		
Date	Min	Avg	Max	Min	Avg	Max
04-19-95	39.5	39.7	39.8	34.6	37.5	39.0
04-20-95	38.8	39.5	39.8	32.0	36.1	40.8
04-21-95	39.1	39.8	40.4	32.0	37.9	43.9
04-22-95	39.8	40.3	40.7	33.0	40.1	46.6
04-23-95	40.4	41.1	42.1	34.6	42.1	49.5
04-24-95	41.4	42.1	42.4	39.0	43.5	48.0
04-25-95	41.7	42.6	43.4	37.9	44.0	49.5
04-26-95	42.4	42.9	43.4	41.1	45.5	51.6
04-27-95	42.1	42.8	43.4	38.5	45.6	53.1
04-28-95	42.4	42.8	43.4	39.1	45.7	50.4
04-29-95	42.1	42.6	43.0	37.6	44.0	49.0
04-30-95	41.7	42.4	43.0	33.9	41.9	49.7
05-01-95	41.4	42.4	43.0	36.3	45.1	53.9
05-02-95	42.1	42.3	42.7	43.7	44.7	46.5
05-03-95	41.7	42.0	42.4	40.4	43.0	44.7
05-04-95	41.1	41.7	42.4	37.6	42.6	48.6
05-05-95	41.7	42.0	42.1	42.4	45.1	48.2
05-06-95	41.4	41.9	42.1	43.0	45.6	48.6
05-07-95	41.4	41.8	42.1	43.4	45.7	49.0
05-08-95	41.1	41.9	42.7	42.1	46.7	51.9
05-09-95	41.1	41.7	42.1	42.7	46.5	50.1
05-10-95	41.1	41.6	42.1	43.4	46.2	51.6
05-11-95	40.4	41.0	41.7	42.4	43.2	44.4
05-12-95	40.1	40.4	41.1	41.1	41.8	42.4
05-13-95	39.5	40.6	42.1	36.3	41.8	46.5
05-14-95	40.4	41.5	43.0	38.5	44.6	50.8
05-15-95	41.4	42.5	43.4	43.7	47.0	51.6
05-16-95	41.1	42.1	43.0	41.1	45.9	50.1
05-17-95	41.1	41.6	42.4	43.0	45.1	48.2
05-18-95	40.4	41.3	42.1	41.4	43.2	45.1
05-19-95	39.8	41.3	42.4	36.0	41.3	48.6
05-20-95	40.4	41.4	42.7	37.6	42.9	47.2
05-21-95	40.7	41.9	43.0	38.5	43.4	47.5
05-22-95	41.1	42.2	43.4	38.5	44.5	50.1
05-23-95	41.7	42.6	43.4	40.7	46.7	51.9
05-24-95	42.1	42.8	43.4	42.7	47.2	51.2
05-25-95	42.1	43.0	43.7	44.4	46.8	50.1
05-26-95	41.4	42.5	43.7	37.6	44.2	50.4
05-27-95	42.1	43.2	44.7	40.7	47.2	53.1
05-28-95	43.0	44.3	45.8	44.1	49.9	55.5
05-29-95	43.7	45.0	46.1	46.5	51.2	55.9
05-30-95	43.7	45.1	46.1	46.1	50.9	55.5
05-31-95	43.7	45.0	46.1	46.1	50.0	54.3
06-01-95	43.7	45.0	46.1	45.1	50.1	55.5
06-02-95	44.4	45.2	46.1	46.8	47.9	49.7
06-03-95	45.8	46.9	48.6	46.1	49.9	53.9
06-04-95	48.2	49.2	50.4	49.3	52.5	55.5
06-05-95	49.0	49.6	50.4	48.6	50.3	53.1
06-06-95	48.6	48.8	49.3	44.7	46.1	48.2
06-07-95	47.5	49.0	50.4	44.1	47.2	50.8
06-08-95	49.0	49.9	50.4	43.4	47.8	51.6
06-09-95	49.0	49.7	50.4	44.7	49.0	52.7
06-10-95	49.3	50.4	51.6	46.5	51.0	54.7
06-11-95	51.2	51.9	52.7	50.1	51.7	53.1
06-12-95	50.8	51.6	52.3	44.4	50.1	54.7
06-13-95	50.4	50.8	51.6	49.3	50.9	52.3
06-14-95	49.3	49.6	50.4	48.6	49.7	50.4
06-15-95	48.6	49.5	50.4	48.2	51.3	54.7
06-16-95	50.1	51.1	52.7	50.4	53.9	57.9
06-17-95	51.6	52.0	52.7	50.4	52.8	54.7
06-18-95	50.4	51.1	51.6	46.5	50.0	52.3
06-19-95	50.4	50.7	51.2	47.9	50.1	55.0
06-20-95	49.0	49.7	50.4	47.9	48.7	49.5
06-21-95	48.6	48.9	49.3	48.2	49.8	51.9
06-22-95	49.3	49.9	50.8	49.3	51.9	55.9

Sullivan Creek Air & Water Temperatures At Mill Pond

	Water			Air		
Date	Min	Avg	Max	Min	Avg	Max
06-23-95	50.1	51.3	53.1	49.3	53.6	57.9
06-24-95	52.3	53.4	55.1	51.6	55.9	59.6
06-25-95	53.9	55.2	56.7	52.5	57.2	60.9
06-26-95	54.7	55.9	56.7	52.3	56.8	60.9
06-27-95	54.7	55.4	56.3	48.7	53.6	56.7
06-28-95	53.5	54.2	54.7	48.7	54.0	58.8
06-29-95	53.5	54.6	56.3	49.7	56.4	63.5
06-30-95	54.7	55.5	57.1	52.7	58.3	62.4
07-01-95	54.7	55.8	56.7	53.5	59.6	65.6
07-02-95	55.1	55.8	56.7	55.9	57.3	60.4
07-03-95	54.7	54.9	55.1	53.3	55.9	58.5
07-04-95	53.9	54.6	55.1	50.1	55.2	59.5
07-05-95	54.3	55.0	56.3	50.8	57.0	63.5
07-06-95	54.7	55.5	56.3	51.2	58.2	64.5
07-07-95	55.1	55.8	56.7	55.9	59.9	63.6
07-08-95	55.5	56.5	58.3	55.9	61.3	67.9
07-09-95	57.1	58.1	59.2	59.2	62.6	66.4
07-10-95	57.5	58.2	58.8	58.3	60.3	62.4
07-11-95	56.7	57.7	58.3	51.2	57.5	64.5
07-12-95	56.3	57.4	58.3	49.3	57.3	65.6
07-13-95	56.3	57.6	58.8	50.8	58.9	66.7
07-14-95	56.7	57.8	59.2	53.3	60.4	67.9
07-15-95	57.5	58.3	59.6	55.5	59.7	64.1
07-16-95	57.5	58.7	59.6	51.6	60.0	69.0
07-17-95	57.9	58.9	60.0	52.5	62.1	71.5
07-18-95	58.3	59.4	60.0	55.0	63.1	70.5
07-19-95	58.8	59.8	60.9	55.9	64.3	73.7
07-20-95	59.6	60.5	61.8	56.7	65.6	74.3
07-21-95	59.6	60.2	60.9	60.9	62.7	66.7
07-22-95	58.8	59.6	60.9	53.3	60.9	67.9
07-23-95	59.2	60.0	60.9	56.7	63.0	69.0
07-24-95	59.2	59.7	60.5	56.3	61.6	66.7
07-25-95	58.8	59.5	60.5	55.9	62.5	69.0
07-26-95	58.8	59.4	60.0	57.1	59.7	62.4
07-27-95	57.9	58.9	60.0	50.8	56.2	61.4
07-28-95	57.9	59.0	60.0	49.0	58.3	70.3
07-29-95	58.3	59.0	59.6	55.5	58.8	62.4
07-30-95	57.9	58.6	59.2	48.6	55.9	62.7
07-31-95	57.9	59.0	60.5	51.9	59.7	69.0
08-01-95	58.3	59.1	59.6	53.9	61.6	69.0
08-02-95	58.8	59.2	60.0	56.3	62.0	66.9
08-03-95	58.8	59.6	60.5	55.5	62.0	69.0
08-04-95	59.2	60.0	61.4	55.5	64.0	73.2
08-05-95	60.0	61.0	62.2	57.6	66.5	75.5
08-06-95	59.6	60.6	61.8	56.7	60.8	67.9
08-07-95	58.8	59.3	59.6	55.5	57.1	59.5
08-08-95	57.9	58.2	58.8	51.6	54.5	58.5
08-09-95	57.1	57.9	58.8	47.5	54.8	63.5
08-10-95	57.5	58.1	58.8	48.6	56.3	64.1
08-11-95	57.5	58.0	58.3	55.1	57.6	60.5
08-12-95	57.1	57.4	57.9	47.2	53.2	58.5
08-13-95	55.9	56.5	56.7	45.4	49.9	55.9
08-14-95	55.9	56.4	56.7	46.1	52.0	57.1
08-15-95	55.9	56.3	56.7	50.4	54.7	59.5
08-16-95	55.9	56.3	56.7	50.8	53.6	57.6
08-17-95	55.5	56.0	56.3	47.9	50.6	53.3
08-18-95	55.1	55.4	55.9	48.2	51.4	55.9
08-19-95	54.7	55.5	56.3	48.2	53.7	60.5
08-20-95	55.1	55.9	57.1	48.6	56.3	65.6
08-21-95	55.5	56.7	57.9	49.3	58.8	69.0
08-22-95	56.3	57.3	58.3	51.0	59.4	69.0
08-23-95	56.3	57.2	57.9	48.7	56.6	66.7
08-24-95	55.9	56.7	57.1	48.6	55.4	62.4
08-25-95	55.5	56.5	57.1	45.2	54.0	63.5
08-26-95	55.9	56.7	57.5	48.0	56.0	65.6

Sullivan Creek Air & Water Temperatures At Mill Pond

	Water			Air		
Date	Min	Avg	Max	Min	Avg	Max
08-27-95	55.5	56.3	56.7	47.3	55.0	61.4
08-28-95	55.5	56.3	56.7	48.0	55.1	61.8
08-29-95	55.9	56.2	56.7	51.2	53.9	56.7
08-30-95	55.1	55.7	56.3	46.5	51.8	57.6
08-31-95	55.1	55.8	56.7	45.8	52.8	60.0
09-01-95	55.5	56.3	57.1	46.5	54.7	63.5
09-02-95	55.9	56.9	57.9	48.2	56.9	66.7
09-03-95	56.3	57.0	57.9	49.5	57.7	65.0
09-04-95	56.7	57.7	59.2	53.3	60.1	69.0
09-05-95	57.1	57.7	58.8	54.3	57.9	61.4
09-06-95	56.7	57.3	57.9	48.2	53.9	60.5
09-07-95	56.7	57.0	57.5	51.2	55.9	61.8
09-08-95	56.7	57.2	57.9	49.0	55.4	60.9
09-09-95	56.7	57.3	57.9	49.3	56.3	63.6
09-10-95	56.7	57.6	58.3	50.1	57.3	65.6
09-11-95	57.5	58.1	59.2	52.5	59.2	66.7
09-12-95	57.1	58.0	58.8	51.6	58.6	66.7
09-13-95	57.1	57.8	58.3	50.1	58.1	67.4
09-14-95	57.5	57.9	58.3	50.2	57.8	65.6
09-15-95	57.1	57.9	58.8	50.2	58.4	67.9
09-16-95	57.1	57.7	58.3	51.0	58.1	66.0
09-17-95	57.1	57.7	58.3	49.5	56.8	64.5
09-18-95	57.1	57.6	57.9	51.6	57.6	64.5
09-19-95	57.1	57.4	57.9	52.5	56.3	61.4
09-20-95	56.3	56.8	57.5	48.7	52.2	58.5
09-21-95	55.5	56.0	56.7	40.1	48.0	56.3
09-22-95	54.7	55.3	55.9	40.1	47.8	56.3
09-23-95	54.3	54.9	55.1	42.0	49.8	59.2
09-24-95	53.9	54.6	55.1	42.6	50.6	59.6
09-25-95	53.5	54.3	54.7	42.0	50.1	58.8
09-26-95	53.5	53.7	54.3	45.4	48.6	51.0
09-27-95	53.1	53.1	53.1	46.1	48.4	50.4
09-28-95	52.7	52.8	53.1	49.3	50.4	52.5
09-29-95	52.7	52.8	53.1	47.5	49.4	51.7
09-30-95	52.3	52.7	52.7	44.1	48.2	50.2
10-01-95	51.6	51.8	52.3	37.9	42.1	45.9
10-02-95	50.8	51.2	51.6	40.1	42.0	43.9
10-03-95	50.4	50.6	50.8	43.0	44.4	46.1
10-04-95	50.1	50.3	50.4	41.1	43.2	46.6
10-05-95	49.3	49.8	50.4	35.7	40.5	45.4
10-06-95	49.3	49.6	49.7	40.2	43.1	46.8
10-07-95	49.3	49.3	49.7	40.7	43.1	45.4
10-08-95	49.0	49.2	49.3	41.7	43.2	45.9
10-09-95	48.6	49.0	49.3	39.1	42.6	45.9
10-10-95	49.3	49.6	50.1	44.4	45.9	48.0
10-11-95	50.1	50.1	50.1	44.7	46.1	47.3
10-12-95	49.7	49.8	50.1	40.2	42.4	44.6
10-13-95	49.3	49.6	49.7	38.2	40.9	43.3
10-14-95	49.3	49.3	49.7	38.5	41.0	43.4
10-15-95	49.3	49.5	49.7	40.4	43.9	48.7
10-16-95	49.7	49.9	50.4	45.1	47.1	49.5
10-17-95	49.7	50.0	50.1	42.1	43.6	45.9
11-18-95	43.0	43.0	43.0	37.9	41.7	43.9
11-19-95	42.1	42.4	43.0	33.0	35.6	37.9
11-20-95	41.1	41.4	42.1	30.6	32.1	33.0
11-21-95	40.7	41.0	41.1	31.1	33.0	34.6
11-22-95	41.1	41.2	41.4	34.1	35.4	36.7
11-23-95	41.4	41.5	41.7	36.2	38.0	40.2
11-24-95	41.7	41.9	42.1	40.2	41.1	42.0
11-25-95	41.7	42.1	42.1	38.4	41.2	42.6
11-26-95	41.4	41.5	41.7	36.2	37.4	39.0
11-27-95	40.7	41.1	41.4	34.6	35.1	36.2
11-28-95	40.4	40.6	40.7	34.6	34.8	35.1
11-29-95	40.4	40.6	41.1	35.1	39.7	43.3

Sullivan Creek Air & Water Temperatures At Mill Pond

	Water			Air		
Date	Min	Avg	Max	Min	Avg	Max
11-30-95	40.7	41.0	41.1	39.0	40.5	42.6
12-01-95	40.7	41.0	41.1	34.1	38.9	40.2
12-02-95	39.8	40.2	40.4	32.5	34.6	36.2
12-03-95	39.1	39.3	39.8	30.6	32.1	33.6
12-04-95	38.5	38.8	39.1	30.6	31.6	34.1
12-05-95	37.6	38.2	38.5	23.5	27.9	30.6
12-06-95	37.2	37.2	37.6	21.1	24.2	26.5
12-07-95	36.3	36.9	37.2	16.6	22.6	26.5
12-08-95	35.4	35.7	36.3	10.1	12.7	15.5
12-09-95	35.1	35.4	35.7	8.2	13.1	18.4
12-10-95	35.7	35.7	35.7	18.8	21.6	24.7
12-11-95	35.7	35.9	36.0	24.7	28.6	30.6
12-12-95	36.0	36.2	36.3	30.6	30.7	31.1
12-13-95	36.3	36.3	36.3	31.6	34.0	35.7
12-14-95	36.3	36.7	36.9	32.5	33.0	33.6
12-15-95	36.9	37.1	37.2	33.0	33.3	34.1
12-16-95	37.2	37.4	37.6	32.5	32.8	33.0
12-17-95	37.2	37.6	37.6	30.6	32.4	33.0
12-18-95	36.9	37.1	37.2	30.6	30.7	31.1
12-19-95	37.2	37.2	37.2	31.1	32.0	32.5
12-20-95	37.2	37.2	37.2	32.0	32.5	33.0
12-21-95	36.9	37.2	37.2	30.6	31.5	32.5
12-22-95	36.3	36.7	36.9	27.3	29.9	30.6
12-23-95	35.7	35.9	36.3	23.1	24.9	26.9
12-24-95	34.8	35.1	35.7	19.5	21.7	23.9
12-25-95	34.5	34.5	34.5	17.7	20.1	23.1
12-26-95	33.9	34.1	34.2	15.8	18.8	21.5
12-27-95	33.6	33.9	34.2	15.5	18.7	21.5
12-28-95	33.9	34.0	34.2	20.3	23.2	25.6
12-29-95	34.2	34.2	34.2	25.6	27.1	28.7
12-30-95	34.2	34.2	34.2	28.2	29.4	30.1
12-31-95	34.2	34.5	34.5	30.1	30.6	30.6
01-01-96	34.5	34.6	34.8	29.2	29.8	30.6
01-02-96	34.8	34.8	34.8	29.2	29.9	30.6
01-03-96	34.8	35.0	35.1	30.6	30.6	30.6
01-04-96	34.2	34.6	35.1	19.1	24.7	30.6
01-05-96	33.3	33.6	33.9	12.1	15.6	18.8
01-06-96	33.6	33.6	33.6	16.9	20.0	23.5
01-07-96	33.6	33.8	33.9	23.9	26.3	28.2
01-08-96	33.9	34.0	34.2	28.7	29.6	30.6
01-09-96	34.2	34.2	34.2	30.6	30.6	30.6
01-10-96	34.2	34.3	34.5	30.6	30.6	30.6
01-11-96	34.5	34.5	34.5	30.6	30.6	30.6
01-12-96	34.5	34.5	34.5	28.7	29.9	30.6
01-13-96	34.2	34.4	34.5	27.8	29.0	30.1
01-14-96	34.5	34.5	34.8	30.1	30.6	30.6
01-15-96	34.8	34.8	34.8	30.6	30.8	31.1
01-16-96	34.8	34.9	35.1	30.6	31.2	31.6
01-17-96	33.6	34.3	34.8	16.6	24.4	30.6
01-18-96	33.0	33.3	33.6	12.1	16.4	19.5
01-19-96	33.3	33.4	33.6	18.8	20.2	21.5
01-20-96	33.0	33.1	33.3	19.9	21.5	23.1
01-21-96	33.0	33.0	33.0	23.1	23.5	24.3
01-22-96	32.7	32.8	33.0	21.1	21.9	23.1
01-23-96	32.7	32.8	33.0	22.7	23.8	25.2
01-24-96	32.7	32.8	33.0	22.3	24.0	25.2
01-25-96	32.4	32.7	32.7	20.3	21.9	23.5
01-26-96	32.4	32.5	32.7	19.5	21.0	21.5
01-27-96	32.1	32.3	32.4	17.3	19.3	21.1
01-28-96	31.8	32.0	32.4	15.1	17.7	20.7
01-29-96	30.9	31.1	31.5	6.7	9.9	14.4
01-30-96	30.0	30.3	30.6	-0.8	2.9	6.1
01-31-96	29.7	30.1	30.3	-1.6	2.5	5.8
02-01-96	29.5	29.9	30.3	-0.2	3.5	6.7
02-02-96	29.5	29.9	30.3	0.3	4.1	7.6
02-03-96	29.5	29.9	30.3	1.4	5.4	9.8
02-04-96	30.3	30.7	30.9	10.1	14.4	18.8

Sullivan Creek Air & Water Temperatures At Mill Pond

	Water			Air		
Date	Min	Avg	Max	Min	Avg	Max
02-05-96	31.2	31.3	31.5	18.8	21.8	25.6
02-06-96	31.5	31.8	31.8	26.0	27.9	28.7
02-07-96	31.8	32.0	32.1	28.7	29.6	30.1
02-08-96	32.1	32.2	32.4	30.1	30.4	30.6
02-09-96	32.1	32.2	32.4	30.6	30.6	30.6
02-10-96	31.5	31.7	31.8	24.7	27.2	30.1
02-11-96	31.2	31.5	31.8	20.3	23.4	25.2
02-12-96	31.5	31.8	32.1	22.7	25.3	27.3
02-13-96	32.1	32.2	32.4	26.0	27.7	29.2
02-14-96	32.1	32.5	32.7	26.0	27.8	29.2
02-15-96	32.4	32.6	32.7	25.6	27.7	29.2
02-16-96	32.7	32.8	33.0	25.6	27.9	29.2
02-17-96	33.0	33.1	33.3	28.7	29.7	30.6
02-18-96	33.3	33.5	33.6	30.6	30.6	30.6
02-19-96	33.6	33.7	33.9	30.6	30.6	30.6
02-20-96	33.9	34.0	34.2	30.6	31.0	32.0
02-21-96	34.2	34.2	34.2	30.6	31.5	32.5
02-22-96	34.2	34.2	34.2	30.6	30.6	31.1
02-23-96	34.2	34.2	34.2	30.1	30.5	30.6
02-24-96	33.9	34.0	34.2	26.0	28.4	30.1
02-25-96	33.0	33.4	33.9	17.7	21.7	25.2
02-26-96	32.4	32.7	33.0	12.4	17.4	21.9
02-27-96	32.1	32.4	32.7	12.7	16.1	18.8
02-28-96	31.5	32.1	32.4	9.2	15.6	21.5
02-29-96	31.8	32.1	32.4	12.7	18.4	23.5
03-01-96	32.1	32.4	32.7	16.9	22.1	27.3
03-02-96	32.1	32.5	33.0	19.1	24.7	30.1
03-03-96	32.4	32.8	33.0	23.5	27.0	30.1
03-04-96	32.7	32.8	33.0	26.0	27.6	29.6
03-05-96	32.7	32.8	33.0	23.1	24.6	26.5
03-06-96	32.7	32.7	32.7	23.9	24.1	24.7

Sullivan Creek Air & Water Temperatures at Powerhouse
Monthly Summaries

Date	Water Min	Water Avg	Water Max	Air Min	Air Avg	Air Max
May-93	43.4	46.5	49.7	43.0	53.8	68.9
Jun-93	Data not available					
Jul-93	Data not available					
Aug-93	51.6	55.4	59.2	49.3	55.9	62.2
Sep-93	48.6	53.2	58.8	44.4	51.7	60.5
Oct-93	Data not available					
Nov-93	Data not available					
Dec-93	35.7	36.7	37.9	21.9	29.4	33.6
Jan-94	27.5	35.6	37.2	23.5	31.8	35.4
Feb-94	23.3	33.1	36.9	3.7	27.4	34.5
Mar-94	33.3	37.1	42.1	23.8	33.8	50.1
Apr-94	39.8	41.7	44.1	35.1	42.8	50.2
May-94	38.2	45.1	54.7	36.6	46.5	59.5
Jun-94	45.8	51.6	58.8	42.1	53.2	69.4
Jul-94	53.9	60.7	67.4	48.6	63.5	81.6
Aug-94	55.5	61.8	67.4	46.5	63.2	80.0
Sep-94	53.1	56.8	61.8	42.1	55.2	73.2
Oct-94	47.9	52.5	56.3	36.0	44.6	57.6
Nov-94	37.6	42.6	48.2	21.9	33.7	39.8
Dec-94	32.1	35.8	39.1	14.4	29.0	34.1
Jan-95	27.5	33.4	36.3	8.5	26.1	33.6
Feb-95	32.1	35.2	36.9	8.5	29.5	36.7
Mar-95	33.6	37.4	41.7	16.6	32.9	46.6
Apr-95	39.1	41.5	45.8	32.0	40.3	52.5
May-95	40.7	43.7	47.2	36.3	46.1	55.1
Jun-95	44.7	51.5	57.5	44.1	52.5	66.9
Jul-95	54.3	58.8	64.1	47.5	60.7	75.5
Aug-95	53.9	57.9	64.5	46.1	57.1	79.0
Sep-95	51.6	56.4	60.5	38.5	55.1	70.0
Oct-95	48.2	50.1	52.7	36.3	45.1	51.6

Sullivan Creek Air & Water Temperatures at Powerhouse

Date	Water Min	Water Avg	Water Max	Air Min	Air Avg	Air Max
05-19-93	45.10	45.52	46.80	51.90	57.78	68.90
05-20-93	44.40	44.87	45.40	50.10	53.40	61.40
05-21-93	44.10	44.81	45.40	48.60	52.23	58.80
05-22-93	44.40	44.80	45.40	47.20	50.28	55.10
05-23-93	43.40	44.47	45.10	43.00	49.47	56.30
05-24-93	43.70	45.17	46.50	43.70	51.94	63.20
05-25-93	45.10	46.48	47.90	45.40	53.50	62.20
05-26-93	46.50	47.83	49.30	52.70	57.63	67.90
05-27-93	47.20	48.19	49.30	50.40	56.03	64.10
05-28-93	47.50	48.69	49.70	53.10	57.04	64.50
05-29-93	48.20	48.79	49.70	53.10	55.48	61.80
05-30-93	47.50	47.88	48.60	47.90	51.33	55.90
06-25-93	53.50	54.39	55.10	55.10	57.56	66.40
06-26-93	51.90	54.18	56.30	51.60	55.14	59.20
06-27-93	53.50	54.73	55.90	54.30	56.32	58.30
06-28-93	52.30	53.53	55.10	50.10	52.74	55.50
06-29-93	51.90	52.83	53.90	51.20	52.31	54.30
08-14-93	55.10	56.83	57.90	55.10	58.46	62.20
08-15-93	55.50	56.43	57.50	57.50	58.42	59.20
08-16-93	55.10	55.60	55.90	56.30	57.13	57.90
08-17-93	54.70	54.98	55.50	56.30	56.72	57.50
08-18-93	54.30	55.55	57.10	55.90	57.59	59.60
08-19-93	54.70	56.92	59.20	55.50	58.33	61.40
08-20-93	55.90	57.40	58.80	56.70	59.25	61.40
08-21-93	56.70	57.18	57.90	58.30	59.23	60.50
08-22-93	56.30	57.08	57.90	57.50	58.87	60.50
08-23-93	55.90	57.06	58.80	57.10	58.91	61.80
08-24-93	54.70	55.72	56.70	52.70	54.82	57.10
08-25-93	52.70	54.20	55.50	49.30	52.55	54.70
08-26-93	52.30	54.22	56.30	50.80	52.98	55.50
08-27-93	53.50	54.55	55.90	52.70	53.98	55.90
08-28-93	51.90	53.38	55.10	50.10	52.05	53.90
08-29-93	51.60	53.35	55.10	49.70	52.00	54.30
08-30-93	51.90	53.63	55.50	50.10	52.47	54.70
08-31-93	52.30	53.60	54.30	50.80	52.76	54.70
09-01-93	52.70	54.20	55.90	51.90	54.13	55.90
09-02-93	53.50	55.10	57.10	52.70	54.62	56.70
09-03-93	53.90	55.68	57.50	53.10	55.69	58.80
09-04-93	54.70	56.37	57.90	54.70	56.59	58.80
09-05-93	54.30	56.35	57.90	53.90	56.00	57.50
09-06-93	54.70	56.18	57.50	53.90	55.80	57.90
09-07-93	54.70	56.55	57.90	53.90	56.15	58.30
09-08-93	54.70	56.85	58.30	54.30	56.69	59.60
09-09-93	55.10	56.98	58.30	54.70	56.93	59.20
09-10-93	55.50	57.24	58.80	55.10	57.37	60.50
09-11-93	54.70	55.95	57.50	54.70	55.75	57.90
09-12-93	53.50	54.70	55.90	52.70	53.68	54.70
09-13-93	51.90	53.73	55.10	49.30	51.68	53.10
09-14-93	52.30	53.05	54.30	50.40	51.23	51.90
09-15-93	51.90	52.82	53.90	50.10	51.21	51.90
09-16-93	50.40	51.90	53.50	47.20	49.14	51.20
09-17-93	50.10	51.83	53.50	46.80	48.80	50.80
09-18-93	50.10	51.82	53.50	46.80	48.94	50.80
09-19-93	50.80	51.95	53.10	47.90	49.26	50.40
09-20-93	50.40	51.21	51.90	47.90	48.50	49.30
09-21-93	50.10	50.83	51.90	47.50	48.29	49.30
09-22-93	48.60	50.16	51.90	44.40	46.49	48.60
09-23-93	48.60	50.29	51.90	44.70	46.64	48.60
09-24-93	49.00	50.41	51.90	45.10	47.19	49.00
09-25-93	48.60	50.15	51.60	45.40	47.33	49.30
09-26-93	48.60	50.18	51.90	45.10	47.21	49.70
09-27-93	49.00	50.63	51.90	45.80	48.40	51.20
09-28-93	49.70	51.16	52.70	47.90	49.65	52.30

Sullivan Creek Air & Water Temperatures at Powerhouse

Date	Water Min	Water Avg	Water Max	Air Min	Air Avg	Air Max
09-29-93	49.70	51.51	53.10	47.50	50.11	53.90
09-30-93	50.40	51.60	52.70	49.00	50.25	51.60
12-23-93	36.9	37.2	37.6	27.8	29.7	30.6
12-24-93	36.9	37.0	37.2	26.5	29.2	30.9
12-25-93	36.0	36.5	36.9	21.9	25.9	28.3
12-26-93	36.3	36.7	36.9	26.5	28.1	29.2
12-27-93	36.3	36.7	36.9	26.0	28.3	29.7
12-28-93	36.0	36.4	36.9	27.3	28.4	29.2
12-29-93	35.7	36.4	36.6	27.8	29.8	31.2
12-30-93	36.0	36.4	36.9	31.1	31.8	32.5
12-31-93	36.0	36.4	36.6	32.1	32.4	32.5
01-01-94	35.1	36.0	36.3	32.0	32.4	33.0
01-02-94	36.0	36.2	36.3	32.4	32.9	33.6
01-03-94	35.4	36.0	36.3	32.4	33.1	34.2
01-04-94	35.7	36.0	36.3	32.4	32.7	33.6
01-05-94	35.7	36.0	36.3	32.0	33.1	34.2
01-06-94	34.2	34.9	35.7	25.2	28.2	31.8
01-07-94	34.2	35.1	35.7	27.2	30.3	32.0
01-08-94	34.5	35.4	36.0	31.5	32.0	32.5
01-09-94	35.7	35.9	36.3	32.0	32.7	34.1
01-10-94	35.4	35.7	36.0	32.0	32.5	33.0
01-11-94	35.4	35.9	36.3	32.0	33.3	34.6
01-12-94	36.0	36.1	36.3	33.3	33.9	34.6
01-13-94	36.0	36.2	36.6	33.0	33.6	34.2
01-14-94	36.3	36.5	36.9	33.6	33.9	35.1
01-15-94	36.3	36.5	36.9	33.0	33.9	35.4
01-16-94	36.0	36.5	36.9	32.5	33.9	35.1
01-17-94	36.0	36.4	36.9	32.5	33.5	34.6
01-18-94	36.0	36.4	37.2	32.0	33.2	35.1
01-19-94	35.1	35.9	36.6	28.7	31.7	33.3
01-20-94	34.2	34.8	35.1	25.6	28.1	30.3
01-21-94	34.2	34.9	36.0	25.6	28.6	31.6
01-22-94	35.1	35.8	36.6	29.6	31.7	33.3
01-23-94	35.7	36.0	36.6	31.5	32.5	33.6
01-24-94	36.0	36.5	37.2	32.4	33.1	34.8
01-25-94	35.7	36.2	36.9	31.5	32.3	34.1
01-26-94	36.0	36.6	36.9	32.5	33.4	34.2
01-27-94	35.7	36.4	36.6	30.6	32.5	33.6
01-28-94	34.5	35.3	36.0	26.5	29.2	31.6
01-29-94	35.1	35.7	36.3	28.7	30.8	32.5
01-30-94	28.6	32.2	35.7	26.0	27.6	30.3
01-31-94	27.5	30.1	33.0	23.5	26.0	29.2
02-01-94	29.7	31.8	34.2	23.1	25.9	29.6
02-02-94	30.6	31.7	33.6	21.1	25.3	28.7
02-03-94	28.9	30.3	31.8	17.3	22.7	26.6
02-04-94	31.8	32.8	33.9	23.9	26.3	28.6
02-05-94	33.0	33.5	34.2	26.9	27.7	29.5
02-06-94	32.1	32.7	33.3	24.3	27.3	29.2
02-07-94	23.3	28.3	31.8	10.4	18.7	23.1
02-08-94	23.3	30.4	31.8	3.7	11.9	19.9
02-09-94	31.5	31.7	31.8	17.7	20.5	23.1
02-10-94	31.5	31.6	31.8	21.1	23.1	25.2
02-11-94	31.2	31.4	31.5	22.7	24.8	26.9
02-12-94	31.5	32.1	32.7	26.5	28.6	30.1
02-13-94	32.7	32.9	33.3	29.6	30.9	31.6
02-14-94	32.7	33.0	33.3	28.7	30.7	31.6
02-15-94	33.0	33.2	33.3	31.1	31.8	32.5
02-17-94	35.4	35.6	36.0	32.1	32.1	32.1
02-18-94	35.1	35.7	36.6	32.1	32.8	34.2
02-19-94	34.8	35.4	36.3	30.3	32.0	32.7
02-20-94	34.2	35.3	36.6	30.0	31.7	33.9

Sullivan Creek Air & Water Temperatures at Powerhouse

Date	Water Min	Water Avg	Water Max	Air Min	Air Avg	Air Max
02-21-94	34.5	35.5	36.9	32.1	32.8	34.5
02-22-94	34.5	35.4	36.6	30.6	32.0	32.4
02-23-94	33.6	35.0	35.7	24.4	31.2	33.0
02-24-94	32.1	32.3	33.3	16.0	21.0	24.9
02-25-94	32.1	32.2	32.4	20.8	24.2	27.2
02-26-94	32.7	34.3	35.7	26.9	29.1	31.2
02-27-94	34.5	35.5	36.3	30.6	31.7	32.7
02-28-94	34.8	35.5	36.0	32.1	32.3	33.0
03-01-94	35.7	36.1	36.6	32.4	32.7	33.3
03-02-94	36.0	36.4	37.2	32.4	33.3	34.8
03-03-94	36.0	36.6	37.6	32.7	33.9	35.4
03-04-94	35.7	36.5	37.6	32.1	34.3	37.6
03-05-94	35.1	35.7	36.6	28.3	30.9	35.7
03-06-94	33.9	35.0	36.0	23.8	28.1	34.2
03-07-94	33.9	35.3	36.9	24.4	28.6	33.6
03-08-94	33.3	34.6	36.0	23.8	28.6	36.0
03-09-94	33.6	35.0	36.9	25.8	30.3	36.0
03-10-94	35.4	36.5	38.2	31.2	34.1	38.8
03-11-94	35.7	36.7	38.2	32.1	33.9	38.8
03-12-94	35.4	36.8	38.8	30.6	33.4	38.5
03-13-94	36.6	37.4	38.5	33.0	34.7	39.5
03-14-94	36.6	37.8	39.8	32.7	35.0	40.1
03-15-94	36.0	37.5	39.5	31.5	35.1	43.7
03-16-94	36.9	38.0	39.8	32.7	36.4	43.4
03-17-94	37.2	38.2	39.5	34.5	36.5	40.7
03-18-94	37.6	38.3	39.5	34.2	36.2	39.5
03-19-94	36.6	37.5	38.8	31.5	33.2	36.9
03-20-94	36.0	37.0	38.2	29.7	32.6	35.4
03-21-94	36.6	37.4	38.8	31.8	34.5	39.8
03-22-94	35.7	36.8	38.2	28.3	32.1	37.9
03-23-94	35.1	36.4	38.2	25.5	30.9	38.8
03-24-94	35.1	36.5	38.5	26.3	31.9	43.0
03-25-94	35.4	36.9	39.1	27.7	32.9	43.0
03-26-94	36.0	37.7	40.1	30.3	35.2	46.1
03-27-94	36.6	38.3	40.7	31.5	36.4	46.5
03-28-94	37.2	38.9	41.4	32.7	37.9	48.2
03-29-94	37.2	39.1	41.4	32.1	37.3	48.2
03-30-94	37.9	39.5	42.1	32.7	38.3	49.3
03-31-94	38.5	39.8	42.1	33.0	39.0	50.1
04-14-94	39.8	40.6	41.7	37.3	39.3	40.8
04-15-94	40.4	41.6	43.0	38.4	41.4	44.6
04-16-94	41.4	42.7	44.1	41.4	44.5	48.7
04-17-94	42.4	43.3	44.1	43.3	46.2	49.5
04-18-94	42.4	43.1	43.7	43.3	45.9	48.0
04-19-94	41.7	42.2	42.7	43.7	45.0	46.6
04-20-94	40.4	41.4	42.1	42.0	43.5	45.2
04-21-94	40.4	41.3	42.1	41.4	43.3	45.4
04-22-94	40.4	41.0	41.7	40.7	42.2	43.4
04-23-94	40.4	41.1	42.1	40.1	42.0	43.9
04-24-94	40.4	40.8	41.4	40.1	41.5	42.6
04-25-94	40.4	41.0	41.4	41.4	42.3	43.4
04-26-94	40.1	41.2	42.1	36.3	41.4	45.9
04-27-94	40.4	41.3	42.1	35.7	41.5	46.6
04-28-94	41.1	42.1	43.0	39.1	43.2	48.7
04-29-94	41.1	42.3	43.4	35.1	42.3	50.2
04-30-94	42.1	42.2	42.7	39.5	42.9	45.2
05-01-94	41.1	41.6	41.7	39.1	41.5	43.3
05-02-94	40.7	41.5	42.1	37.9	41.8	45.2
05-03-94	40.7	41.9	43.0	36.6	43.3	51.7
05-04-94	42.1	42.3	42.4	43.0	44.1	45.2
05-05-94	41.7	42.8	44.1	39.5	44.9	50.2
05-06-94	42.7	44.0	45.1	41.1	46.5	52.5
05-07-94	43.7	45.0	46.1	44.4	49.4	57.6

Sullivan Creek Air & Water Temperatures at Powerhouse

Date	Water Min	Water Avg	Water Max	Air Min	Air Avg	Air Max
05-08-94	44.1	45.2	45.8	45.2	49.2	53.3
05-09-94	43.7	44.7	45.4	44.4	49.0	55.0
05-10-94	43.4	44.4	45.1	45.9	49.2	55.9
05-11-94	43.4	44.1	44.7	44.6	47.3	49.5
05-12-94	43.4	44.3	45.1	45.8	47.4	49.7
05-13-94	43.0	43.8	44.4	43.3	45.5	47.3
05-14-94	42.7	43.5	44.1	40.1	44.7	47.3
05-15-94	43.0	43.4	43.7	44.4	45.2	46.8
05-16-94	42.7	43.2	43.7	43.3	45.4	49.5
05-17-94	42.4	43.3	44.4	38.2	44.0	48.7
05-18-94	43.7	44.3	45.4	45.1	46.7	49.5
05-19-94	43.7	44.2	44.7	41.7	45.1	47.3
05-20-94	43.7	44.2	44.7	45.1	46.2	48.7
05-21-94	44.1	44.5	45.1	45.1	46.6	48.7
05-22-94	43.7	44.9	45.8	41.7	46.3	50.1
05-23-94	44.7	46.0	47.2	43.0	48.0	52.7
05-24-94	45.8	47.2	48.2	45.8	50.1	54.7
05-25-94	46.8	48.2	49.0	47.5	51.9	59.5
05-26-94	47.5	48.1	48.6	49.0	51.6	55.0
05-27-94	46.8	47.6	48.2	46.8	49.5	51.7
05-28-94	45.8	46.5	46.8	44.1	47.4	49.5
05-29-94	45.4	45.8	46.5	44.4	46.4	48.0
05-30-94	44.4	45.5	46.8	39.5	45.0	49.7
05-31-94	44.4	45.8	46.8	40.7	46.5	51.0
06-01-94	46.1	46.6	47.2	47.9	49.4	51.2
06-02-94	45.8	47.6	48.6	42.1	49.9	57.6
06-03-94	47.2	49.6	51.2	46.5	53.8	60.0
06-04-94	47.2	48.6	49.3	44.1	49.6	51.9
06-05-94	46.8	48.4	49.0	44.7	50.8	53.9
06-06-94	46.5	47.6	48.2	43.7	48.2	50.4
06-07-94	46.1	46.8	47.9	44.4	46.6	49.0
06-08-94	45.8	46.6	47.5	44.1	47.4	51.0
06-09-94	46.5	47.1	47.9	45.4	48.7	52.3
06-10-94	47.2	48.0	48.6	48.0	50.6	53.5
06-11-94	48.2	48.9	50.1	49.5	51.9	55.9
06-12-94	48.6	49.2	49.7	50.2	52.2	56.3
06-13-94	47.9	49.2	50.8	42.1	48.5	54.7
06-14-94	47.5	48.5	49.7	45.2	47.7	51.2
06-15-94	47.5	48.3	49.3	45.2	48.5	52.5
06-16-94	48.2	49.4	50.8	47.9	49.7	53.3
06-17-94	50.1	51.2	52.3	45.8	51.2	59.5
06-18-94	50.1	51.1	52.3	44.7	49.5	54.7
06-19-94	51.6	52.7	53.9	45.9	52.3	58.8
06-20-94	53.1	54.1	55.5	50.8	56.3	61.4
06-21-94	54.7	55.9	57.1	53.3	59.1	65.6
06-22-94	55.9	57.0	57.9	56.3	60.9	66.4
06-23-94	55.9	57.4	58.8	50.8	59.8	68.4
06-25-94	55.1	56.9	57.9	50.1	59.1	64.5
06-26-94	53.9	55.3	56.3	50.4	54.8	58.5
06-27-94	53.5	55.3	56.7	49.7	56.3	63.5
06-28-94	53.9	56.4	58.8	49.7	59.5	69.4
06-29-94	55.5	57.3	58.8	53.9	60.4	65.6
06-30-94	57.9	57.9	57.9	60.5	61.0	61.4
06-30-94	55.5	57.8	58.8	55.5	61.3	65.5
07-01-94	56.3	57.3	57.9	56.3	59.9	63.5
07-02-94	55.1	56.3	57.5	51.2	54.8	59.5
07-03-94	54.3	55.6	56.3	50.1	54.4	57.6
07-04-94	53.9	55.4	57.1	48.6	54.7	58.5
07-05-94	53.9	56.1	58.3	49.3	57.0	66.7
07-06-94	55.5	57.1	59.2	53.9	59.8	67.9
07-07-94	56.3	57.8	60.5	54.7	58.9	66.7
07-09-94	57.1	59.2	61.4	53.9	63.1	77.0
07-10-94	56.7	59.3	61.8	51.9	61.5	72.8

Sullivan Creek Air & Water Temperatures at Powerhouse

Date	Water Min	Water Avg	Water Max	Air Min	Air Avg	Air Max
07-11-94	57.1	59.6	62.7	51.9	62.3	75.5
07-12-94	57.1	59.6	62.2	52.7	62.2	74.1
07-13-94	57.5	60.0	62.7	53.9	62.3	71.5
07-14-94	58.8	60.3	63.2	60.0	63.4	72.1
07-15-94	57.9	60.4	62.7	53.5	62.2	70.5
07-16-94	58.3	60.7	63.6	55.9	63.4	72.8
07-17-94	59.2	61.1	63.2	56.7	64.6	72.8
07-18-94	59.6	61.0	62.7	59.2	65.3	74.1
07-19-94	57.9	60.6	63.6	52.5	62.5	74.1
07-20-94	58.8	61.6	64.5	55.5	65.2	78.4
07-21-94	60.0	63.0	66.0	58.8	67.7	79.0
07-22-94	60.9	63.7	66.4	60.5	68.9	80.0
07-23-94	62.2	64.4	67.4	62.2	69.8	80.0
07-24-94	62.7	64.9	67.4	63.2	70.6	81.6
07-26-94	63.2	65.3	67.4	63.6	71.0	80.0
07-27-94	62.2	64.6	66.9	60.0	67.9	77.0
07-28-94	61.8	63.5	65.5	58.8	64.9	70.3
07-29-94	60.5	63.4	66.4	57.1	66.9	81.6
07-30-94	61.8	63.9	66.0	60.9	69.3	81.6
07-31-94	60.9	63.4	66.0	58.3	66.9	77.0
08-01-94	60.9	63.6	66.4	58.3	67.1	80.0
08-02-94	62.2	64.5	67.4	62.7	69.2	77.1
08-04-94	62.7	65.1	67.4	62.4	68.8	77.0
08-05-94	62.7	64.6	66.4	60.0	68.2	77.0
08-06-94	61.4	63.5	65.5	56.3	65.1	75.5
08-07-94	60.5	63.1	66.0	54.7	63.7	75.5
08-08-94	61.8	62.9	63.6	59.5	63.8	70.3
08-09-94	59.6	61.7	63.6	52.5	60.8	71.5
08-10-94	58.8	61.6	64.5	50.8	60.7	72.8
08-11-94	59.2	62.3	65.0	53.9	63.9	74.3
08-12-94	59.6	62.6	65.5	56.3	65.1	74.8
08-13-94	60.5	63.5	66.4	58.8	67.2	77.1
08-14-94	61.4	63.7	66.9	59.2	67.6	78.4
08-15-94	61.4	63.4	65.0	61.4	68.4	75.5
08-16-94	60.5	62.9	65.5	56.7	66.2	77.0
08-17-94	60.0	62.3	64.1	56.7	63.7	70.3
08-18-94	59.2	61.9	65.0	54.3	62.8	74.1
08-19-94	59.6	62.2	65.0	56.7	64.3	73.2
08-20-94	60.0	62.3	64.5	58.3	65.9	77.0
08-21-94	59.6	61.8	63.6	55.5	64.3	72.8
08-22-94	59.2	60.9	62.2	54.3	60.8	65.0
08-23-94	58.3	60.2	62.2	51.9	59.8	69.0
08-24-94	57.5	59.7	61.8	50.8	59.3	67.9
08-25-94	57.9	59.8	61.4	52.3	60.2	65.0
08-26-94	57.9	59.0	60.0	53.9	58.5	63.2
08-27-94	55.5	58.3	61.4	46.5	55.5	66.9
08-28-94	56.7	58.8	61.4	49.3	57.8	66.9
08-29-94	57.5	59.3	60.9	53.1	58.9	63.6
08-30-94	57.1	59.1	61.4	50.4	57.5	64.5
08-31-94	57.1	59.6	61.8	52.3	60.5	72.1
09-01-94	56.7	59.3	61.8	50.4	59.6	72.1
09-02-94	57.5	59.5	61.8	53.1	61.3	73.2
09-03-94	57.5	58.2	60.0	51.2	56.0	60.4
09-04-94	55.9	57.6	59.6	48.2	52.9	58.8
09-05-94	55.1	57.3	59.6	46.5	52.7	60.9
09-06-94	55.5	57.8	60.0	48.6	55.3	64.1
09-07-94	56.3	58.2	60.0	49.3	57.0	64.5
09-08-94	57.1	58.9	60.5	54.3	60.4	67.9
09-09-94	56.7	57.8	59.2	50.4	56.3	61.4
09-10-94	55.1	56.2	57.5	46.5	50.8	56.3
09-11-94	54.3	55.9	57.5	46.1	50.9	58.3
09-12-94	53.1	55.1	57.1	42.1	48.9	57.5

Sullivan Creek Air & Water Temperatures at Powerhouse

Date	Water Min	Water Avg	Water Max	Air Min	Air Avg	Air Max
09-13-94	53.1	55.2	57.5	43.4	50.2	57.9
09-14-94	55.1	56.3	57.5	51.9	54.8	59.2
09-15-94	55.5	56.7	57.9	53.9	57.1	62.2
09-16-94	55.1	56.6	58.3	50.1	55.4	62.7
09-17-94	55.5	57.2	58.8	51.2	56.9	64.1
09-18-94	55.5	57.1	58.8	50.8	56.6	64.1
09-19-94	55.1	56.1	57.5	50.4	52.6	55.5
09-20-94	55.5	57.3	58.8	54.2	58.3	62.4
09-21-94	54.3	56.0	57.5	49.5	54.1	59.5
09-22-94	53.9	55.9	57.5	48.0	53.5	59.5
09-23-94	53.9	56.0	57.9	48.7	54.3	60.4
09-24-94	54.3	56.1	57.9	51.0	55.5	61.4
09-25-94	54.3	56.1	57.9	51.0	55.6	61.4
09-26-94	53.9	55.9	57.5	51.0	55.2	60.4
09-27-94	53.9	55.8	57.5	51.0	55.6	61.4
09-28-94	54.3	56.1	57.9	51.0	55.3	58.5
09-29-94	54.3	55.7	57.1	51.7	56.2	65.6
09-30-94	55.1	56.0	57.1	53.3	56.6	59.5
10-01-94	54.3	55.3	56.3	51.7	54.2	57.6
10-02-94	51.9	53.5	54.7	43.9	47.7	52.5
10-03-94	51.6	53.0	54.3	43.9	47.8	53.3
10-04-94	51.6	52.7	53.9	41.4	45.5	51.0
10-05-94	51.2	52.6	53.9	38.4	45.2	51.0
10-06-94	51.2	52.5	53.5	42.0	46.1	51.0
10-07-94	50.8	52.5	53.5	40.2	45.7	51.0
10-08-94	52.3	53.5	54.7	42.0	46.1	51.7
10-09-94	53.1	54.3	55.5	43.3	47.7	52.5
10-10-94	54.3	55.1	55.5	48.7	51.3	55.0
10-11-94	54.7	55.3	55.9	47.5	50.9	55.1
10-12-94	53.9	54.8	55.9	42.4	46.2	49.3
10-13-94	53.5	54.3	55.1	40.1	44.8	49.3
10-14-94	53.9	54.2	54.7	44.1	45.5	47.2
10-15-94	53.5	53.8	54.3	42.4	44.3	47.2
10-16-94	52.7	53.3	53.9	39.1	42.5	47.2
10-17-94	52.7	53.0	53.5	38.5	42.7	46.8
10-18-94	52.3	52.7	53.1	40.7	43.1	46.1
10-19-94	51.9	52.3	52.7	38.5	41.3	44.1
10-20-94	52.3	52.5	52.7	43.0	44.3	45.8
10-21-94	51.9	52.3	52.7	41.1	43.7	45.8
10-22-94	51.2	51.5	51.9	36.0	40.0	42.7
10-23-94	51.2	51.5	51.9	40.7	43.3	45.8
10-24-94	50.4	50.9	51.2	38.2	40.1	43.4
10-25-94	50.4	50.8	51.2	38.2	40.6	44.4
10-26-94	50.8	51.4	51.6	42.1	45.4	47.9
10-27-94	50.8	51.2	51.6	44.4	45.5	46.5
10-28-94	50.1	50.5	50.8	40.4	42.7	44.4
10-29-94	49.3	49.6	50.1	37.6	40.2	41.7
10-30-94	48.6	49.0	49.0	37.2	38.8	40.4
10-31-94	47.9	48.3	48.6	37.9	39.2	40.1
11-01-94	47.9	48.1	48.2	36.3	39.0	39.8
11-02-94	46.8	47.4	47.5	33.6	36.5	38.2
11-03-94	46.1	46.4	46.8	30.6	33.9	37.6
11-04-94	45.4	45.8	46.1	35.7	36.2	37.3
11-05-94	45.1	45.5	45.8	30.6	34.0	36.2
11-06-94	44.7	44.9	45.1	29.6	33.3	36.2
11-07-94	44.7	45.0	45.4	35.1	36.3	36.7
11-08-94	45.1	45.2	45.4	36.2	36.8	37.3
11-09-94	44.7	44.7	44.7	36.2	37.0	37.3
11-10-94	44.7	44.7	44.7	36.7	37.3	37.9
11-11-94	44.4	44.5	44.7	36.7	37.5	37.9
11-12-94	44.1	44.3	44.7	35.7	37.7	39.0
11-13-94	43.4	43.6	43.7	31.1	33.7	35.1
11-14-94	43.4	43.5	43.7	35.1	35.9	36.7
11-15-94	43.0	43.3	43.4	35.7	36.2	36.7

Sullivan Creek Air & Water Temperatures at Powerhouse

Date	Water Min	Water Avg	Water Max	Air Min	Air Avg	Air Max
11-16-94	42.7	42.8	43.0	35.7	36.0	36.2
11-17-94	41.7	42.3	42.7	29.6	34.1	35.7
11-18-94	41.4	41.6	41.7	28.7	30.2	31.6
11-19-94	41.1	41.3	41.4	31.6	32.2	33.0
11-20-94	40.4	41.0	41.4	28.2	31.9	33.6
11-21-94	39.1	39.7	40.1	22.7	24.9	26.9
11-22-94	38.8	39.3	39.8	21.9	25.2	28.7
11-23-94	39.1	39.5	39.8	26.0	29.3	31.1
11-24-94	39.8	40.0	40.4	31.1	32.0	32.5
11-25-94	39.5	39.8	40.1	32.5	33.1	34.1
11-26-94	39.1	39.9	40.4	31.1	32.9	33.6
11-27-94	39.1	39.4	39.5	30.6	31.7	32.5
11-28-94	38.5	38.9	39.1	29.2	30.8	32.0
11-29-94	37.6	38.3	38.5	28.7	30.8	32.5
11-30-94	38.5	38.8	39.1	32.5	33.0	34.1
12-01-94	38.2	38.6	39.1	32.0	32.9	34.1
12-02-94	38.5	38.5	38.5	33.0	33.0	33.0
12-06-94	33.6	34.7	35.4	14.4	19.4	23.1
12-07-94	35.1	35.5	36.0	21.5	24.2	26.0
12-08-94	34.8	35.4	35.7	24.3	25.9	28.2
12-09-94	34.8	35.6	36.0	26.9	27.8	28.7
12-10-94	34.8	35.4	36.0	25.2	27.0	28.2
12-11-94	35.4	35.9	36.3	27.8	29.0	30.6
12-12-94	35.4	35.8	36.6	26.0	28.6	30.6
12-13-94	33.6	34.6	35.1	18.0	23.5	26.5
12-14-94	34.5	35.1	35.7	25.2	26.6	27.8
12-15-94	34.8	35.4	36.0	27.8	29.0	30.6
12-16-94	34.5	35.7	36.6	30.1	30.8	31.6
12-17-94	35.4	36.1	36.3	31.6	31.8	32.0
12-18-94	36.3	36.4	36.6	32.0	32.4	32.5
12-19-94	36.3	36.4	36.6	32.5	32.9	33.0
12-20-94	36.3	36.5	36.9	32.5	32.8	33.0
12-21-94	36.3	36.5	36.6	32.0	32.6	33.0
12-22-94	36.0	36.5	36.9	31.6	32.4	33.0
12-23-94	35.7	36.2	36.9	30.6	31.5	32.5
12-24-94	34.8	35.4	36.0	26.5	29.1	31.1
12-25-94	35.7	36.1	36.6	30.1	31.9	33.6
12-26-94	35.1	35.8	36.3	32.0	32.1	32.5
12-27-94	35.7	36.2	36.6	32.0	32.1	32.5
12-28-94	36.3	36.4	36.9	32.0	32.7	33.6
12-29-94	34.5	35.5	36.3	25.2	29.5	32.5
12-30-94	32.4	33.5	34.5	19.1	22.3	26.0
12-31-94	32.1	32.1	32.4	15.1	17.7	20.7
01-01-95	32.1	32.1	32.1	10.8	15.3	18.4
01-02-95	32.1	32.1	32.1	10.4	15.0	18.8
01-03-95	31.8	32.1	32.1	12.1	14.4	17.7
01-04-95	28.9	30.5	31.8	9.2	12.4	15.8
01-05-95	27.7	28.0	28.9	8.5	12.4	16.2
01-06-95	27.5	27.8	28.3	11.4	15.5	19.1
01-07-95	27.7	28.0	28.6	12.7	16.7	20.7
01-08-95	28.6	29.4	30.0	20.7	22.8	24.7
01-09-95	30.3	30.7	31.2	24.7	27.6	30.1
01-10-95	31.2	31.6	33.6	29.6	31.1	32.0
01-11-95	33.6	34.3	34.8	32.0	32.0	32.5
01-12-95	33.9	34.8	35.1	32.0	32.1	32.5
01-13-95	34.5	35.0	35.1	32.0	32.2	32.5
01-14-95	34.8	35.1	35.4	32.0	32.3	33.0
01-15-95	35.1	35.4	36.0	32.0	32.6	33.6
01-16-95	35.4	35.6	36.3	32.0	32.4	33.0
01-17-95	35.4	35.6	36.0	32.0	32.3	33.0
01-18-95	35.1	35.4	35.7	32.0	32.2	32.5
01-19-95	34.8	35.8	36.3	32.0	32.4	33.0
01-20-95	34.2	35.0	36.0	26.9	29.4	32.0
01-21-95	33.6	33.9	34.2	23.1	25.8	27.8

Sullivan Creek Air & Water Temperatures at Powerhouse

Date	Water Min	Water Avg	Water Max	Air Min	Air Avg	Air Max
01-22-95	33.0	33.6	33.9	21.1	24.4	26.9
01-23-95	32.1	32.4	33.0	15.8	19.7	23.9
01-24-95	32.1	32.6	33.6	14.8	20.3	25.2
01-25-95	33.9	34.4	35.1	25.2	27.2	28.7
01-26-95	34.5	35.1	35.7	28.7	29.8	30.6
01-27-95	35.1	35.4	36.0	30.6	31.1	31.6
01-28-95	34.8	35.4	36.0	31.1	31.6	32.0
01-29-95	34.8	35.2	35.4	31.1	31.6	32.0
01-30-95	35.4	35.8	36.0	32.0	32.0	32.5
01-31-95	35.7	35.9	36.3	32.0	32.3	32.5
02-01-95	35.7	35.9	36.6	32.0	32.7	34.1
02-02-95	35.7	36.0	36.3	32.5	32.8	33.6
02-03-95	35.4	36.1	36.9	31.6	32.6	33.0
02-04-95	34.8	35.5	36.0	29.2	31.1	32.0
02-05-95	35.4	35.8	36.3	31.1	31.9	32.5
02-06-95	36.0	36.3	36.9	32.0	32.4	33.0
02-07-95	36.0	36.3	36.6	32.0	32.5	33.6
02-08-95	35.4	35.8	36.3	30.6	31.5	32.0
02-09-95	35.1	35.6	36.3	27.3	30.1	32.5
02-10-95	34.5	35.4	36.3	25.6	28.8	31.6
02-11-95	34.2	35.4	35.7	25.6	29.4	30.6
02-12-95	32.1	32.6	34.2	18.0	20.4	24.7
02-13-95	32.1	32.2	32.7	14.4	17.7	20.7
02-14-95	32.1	32.2	32.7	8.5	15.5	21.9
02-15-95	32.4	33.1	33.9	18.8	21.2	24.3
02-16-95	33.9	34.5	35.1	24.3	27.3	31.1
02-17-95	34.2	35.1	35.7	31.1	32.0	33.0
02-18-95	35.1	35.4	35.7	32.0	32.5	33.0
02-19-95	35.4	35.8	36.3	32.5	33.0	34.1
02-20-95	35.7	35.9	36.6	32.5	33.7	35.7
02-21-95	35.4	35.8	36.3	32.5	33.3	35.1
02-22-95	35.4	35.7	36.0	31.6	32.6	34.6
02-23-95	35.1	35.6	36.0	28.7	31.4	34.6
02-24-95	35.4	36.1	36.9	31.1	32.7	35.7
02-25-95	36.0	36.5	36.9	32.5	33.6	36.7
02-26-95	35.7	36.2	36.6	28.7	31.3	35.7
02-27-95	34.8	35.5	36.0	22.7	27.4	33.0
02-28-95	34.2	35.0	35.7	18.8	25.1	32.5
03-01-95	33.9	34.8	35.4	19.1	24.5	32.5
03-02-95	33.6	34.6	35.4	16.9	23.8	32.5
03-03-95	33.9	35.1	36.3	19.1	25.6	32.0
03-04-95	35.4	35.9	36.3	29.6	30.8	31.6
03-05-95	35.1	35.8	36.6	25.2	30.0	33.0
03-06-95	33.9	34.9	35.7	16.6	24.2	28.7
03-07-95	34.8	35.6	36.6	26.0	28.9	33.0
03-08-95	35.1	35.5	35.7	28.7	30.5	32.5
03-09-95	35.7	36.2	36.6	31.6	32.2	33.0
03-10-95	36.0	36.6	37.2	32.5	34.0	36.2
03-11-95	36.3	36.6	36.9	33.6	34.9	37.3
03-12-95	36.3	36.6	36.9	33.0	34.1	36.2
03-13-95	36.6	36.9	37.2	32.5	33.5	34.6
03-14-95	36.9	37.5	37.9	33.6	34.5	35.7
03-15-95	37.6	37.8	38.2	34.6	35.3	37.9
03-16-95	37.6	38.0	38.5	33.0	35.0	39.0
03-17-95	37.6	38.2	38.8	30.6	33.6	39.0
03-18-95	38.2	38.5	38.8	33.6	34.9	36.2
03-19-95	38.5	38.8	39.1	34.6	36.2	39.6
03-20-95	38.5	38.8	39.1	33.6	35.2	36.2
03-21-95	38.5	38.9	39.1	33.6	35.5	37.9
03-22-95	37.9	38.6	39.5	32.0	34.3	36.7
03-23-95	38.2	38.6	39.1	33.6	35.2	38.4
03-24-95	38.2	38.5	39.1	32.0	35.0	37.9
03-25-95	37.2	38.2	38.8	29.6	32.0	35.1
03-26-95	36.9	38.2	39.5	29.2	32.7	39.6

Sullivan Creek Air & Water Temperatures at Powerhouse

Date	Water Min	Water Avg	Water Max	Air Min	Air Avg	Air Max
03-27-95	37.2	38.7	39.8	30.6	34.8	42.6
03-28-95	37.9	39.0	40.4	31.6	35.7	43.3
03-29-95	38.2	39.3	40.7	31.6	36.0	44.6
03-30-95	38.5	39.8	41.1	33.0	37.8	46.6
03-31-95	38.8	40.2	41.7	33.0	38.6	45.9
04-01-95	39.8	40.7	41.7	36.7	40.4	48.7
04-02-95	39.5	40.2	41.1	33.6	37.9	43.3
04-03-95	39.1	40.4	41.7	33.6	38.6	45.2
04-04-95	39.8	40.7	42.1	35.7	41.0	49.5
04-05-95	39.5	40.6	41.7	33.0	39.3	47.3
04-06-95	40.1	40.8	41.7	37.3	40.2	45.2
04-07-95	39.8	40.5	41.4	35.1	39.1	42.6
04-08-95	40.1	40.7	41.4	35.1	39.2	42.6
04-09-95	39.8	40.4	41.4	34.6	37.8	44.6
04-10-95	39.1	40.3	41.7	32.5	37.8	43.9
04-11-95	40.4	41.0	42.4	34.6	40.4	48.0
04-12-95	39.8	40.5	41.4	33.6	37.1	40.8
04-13-95	40.4	40.8	41.7	36.7	39.8	43.3
04-14-95	39.8	40.6	42.1	35.1	37.2	42.6
04-15-95	40.1	40.6	41.7	33.6	37.5	43.9
04-16-95	39.5	40.6	41.7	32.0	37.0	46.6
04-17-95	39.5	40.6	41.7	33.0	38.0	42.6
04-18-95	40.4	41.1	42.1	37.3	41.1	48.7
04-19-95	40.4	41.1	41.7	35.1	40.0	44.6
04-20-95	39.5	40.8	42.1	33.0	37.9	43.9
04-21-95	39.8	41.2	42.7	33.6	39.3	46.6
04-22-95	40.1	41.8	43.7	34.6	41.3	51.0
04-23-95	40.7	42.6	44.4	34.6	42.6	52.5
04-24-95	42.4	43.4	44.4	39.6	44.3	50.2
04-25-95	42.4	43.9	45.8	38.4	44.8	51.7
04-26-95	43.0	44.0	44.7	41.7	45.5	50.1
04-27-95	42.7	44.1	45.8	38.8	44.5	52.3
04-28-95	42.7	44.0	45.4	38.8	44.5	50.1
04-29-95	42.4	43.8	45.8	36.6	43.4	52.3
04-30-95	42.1	43.4	44.7	33.9	41.4	50.1
05-01-95	42.1	43.7	45.4	36.3	44.6	55.1
05-02-95	43.4	43.6	44.1	44.4	45.4	46.5
05-03-95	43.0	43.4	44.1	43.0	45.0	47.5
05-04-95	42.4	43.2	44.1	39.1	44.2	50.8
05-05-95	43.0	43.4	44.1	44.1	45.8	47.9
05-06-95	43.0	43.4	43.7	44.1	46.5	50.1
05-07-95	42.7	43.2	43.7	44.7	46.5	49.0
05-08-95	42.4	43.3	44.1	43.7	46.7	52.7
05-09-95	42.4	43.2	43.7	44.1	46.7	50.4
05-10-95	42.4	43.0	43.4	44.7	47.2	51.9
05-11-95	42.4	42.6	43.0	43.7	44.8	46.1
05-12-95	41.7	42.0	42.4	43.0	43.7	44.4
05-13-95	40.7	42.2	43.4	38.2	44.0	49.3
05-14-95	41.7	43.0	44.1	39.5	45.6	51.6
05-15-95	43.0	43.9	44.7	45.1	48.1	52.7
05-16-95	42.4	43.5	44.1	42.7	46.6	51.2
05-17-95	42.7	43.1	43.7	45.1	46.6	49.3
05-18-95	42.1	42.8	43.4	43.0	44.9	46.8
05-19-95	41.7	42.6	43.4	36.9	42.5	50.8
05-20-95	41.7	42.9	43.7	38.8	43.6	47.5
05-21-95	42.4	43.3	44.1	39.8	43.9	47.5
05-22-95	42.4	43.5	44.4	39.1	44.2	48.6
05-23-95	42.7	43.9	44.7	41.4	46.0	50.8
05-24-95	43.4	44.1	44.7	43.4	46.7	49.3
05-25-95	43.4	44.2	44.7	45.8	47.1	49.7
05-26-95	42.7	43.9	44.7	38.8	44.4	49.0
05-27-95	43.0	44.5	45.8	42.1	46.7	50.8
05-28-95	44.1	45.5	46.8	44.7	48.8	53.1
05-29-95	44.7	46.2	47.2	46.8	50.3	54.7

Sullivan Creek Air & Water Temperatures at Powerhouse

Date	Water Min	Water Avg	Water Max	Air Min	Air Avg	Air Max
05-30-95	44.7	46.2	47.2	47.5	50.7	54.3
05-31-95	45.1	46.2	46.8	47.5	50.1	53.1
06-01-95	44.7	46.2	47.2	46.1	49.6	52.7
06-02-95	45.4	46.2	46.8	47.5	48.6	49.7
06-03-95	46.5	47.8	49.3	47.9	50.1	53.1
06-04-95	49.0	49.8	50.8	49.7	51.9	55.1
06-05-95	49.7	50.1	50.8	50.1	51.5	53.5
06-06-95	49.0	49.3	50.1	46.1	47.9	49.7
06-07-95	48.6	49.7	51.2	45.4	48.7	51.9
06-08-95	49.7	50.6	51.2	44.1	48.5	52.7
06-09-95	49.3	50.5	51.2	45.1	49.6	53.9
06-10-95	49.7	51.2	52.3	47.5	51.6	55.1
06-11-95	51.9	52.4	53.1	51.2	53.0	54.3
06-12-95	51.6	52.2	53.1	46.5	51.1	55.5
06-13-95	50.8	51.4	51.9	50.8	52.4	53.5
06-14-95	49.7	50.2	50.8	50.1	51.1	51.6
06-15-95	49.3	50.3	51.6	49.7	52.3	55.1
06-16-95	50.8	51.9	53.1	51.9	54.6	57.9
06-17-95	51.9	52.5	53.1	52.3	53.9	54.7
06-18-95	50.8	51.5	51.9	47.5	51.0	53.1
06-19-95	50.8	51.1	51.6	48.7	51.1	55.5
06-20-95	49.7	50.3	50.8	49.3	50.2	51.0
06-21-95	49.3	49.7	50.1	49.7	51.2	53.1
06-22-95	49.7	50.7	51.9	50.8	52.9	56.3
06-23-95	50.8	52.2	53.9	51.2	54.8	59.6
06-24-95	52.7	54.0	55.5	51.9	56.3	61.8
06-25-95	54.3	55.8	57.1	53.9	58.6	66.9
06-26-95	55.1	56.5	57.5	52.3	57.8	64.1
06-27-95	55.1	55.9	56.7	49.7	55.4	60.0
06-28-95	53.9	54.7	55.5	48.2	55.1	61.8
06-29-95	53.5	55.2	56.7	49.7	56.6	63.6
06-30-95	55.1	56.1	57.1	53.5	58.5	65.5
07-01-95	55.1	56.5	57.5	53.9	59.3	65.0
07-02-95	55.5	56.3	56.7	56.7	58.0	59.5
07-03-95	55.1	55.5	56.3	54.3	57.2	60.9
07-04-95	54.3	55.4	56.7	50.4	57.0	63.2
07-05-95	54.3	55.9	57.5	51.6	58.3	64.5
07-06-95	54.7	56.2	57.5	50.8	58.1	64.5
07-07-95	55.5	56.8	57.9	56.7	60.7	65.6
07-08-95	55.9	57.5	59.6	57.1	61.4	68.4
07-09-95	57.5	58.9	60.5	60.0	62.7	67.4
07-10-95	58.3	58.8	59.6	57.9	61.7	65.0
07-11-95	56.7	58.0	59.2	50.8	58.3	65.6
07-12-95	55.9	57.9	60.0	49.3	57.8	65.0
07-13-95	56.3	58.2	60.0	50.8	59.6	67.9
07-14-95	56.7	58.5	60.5	53.1	61.0	68.4
07-15-95	57.5	59.3	61.4	56.7	61.2	67.9
07-16-95	57.1	59.5	61.8	51.9	60.8	70.0
07-17-95	57.5	59.9	62.7	53.5	61.6	70.5
07-18-95	57.9	60.4	62.7	55.9	63.2	72.1
07-19-95	58.3	60.9	63.6	56.7	64.2	75.5
07-20-95	58.8	61.5	64.1	57.1	65.6	74.8
07-21-95	60.0	60.8	61.8	60.5	63.6	66.7
07-22-95	57.9	60.4	63.2	53.1	61.3	69.0
07-23-95	58.8	61.0	63.2	57.5	63.5	70.0
07-24-95	58.8	60.5	61.8	57.5	62.8	67.4
07-25-95	58.3	60.5	63.2	57.1	63.7	69.4
07-26-95	59.2	60.2	62.7	57.9	61.4	64.5
07-27-95	57.5	59.7	62.2	51.6	58.3	64.1
07-28-95	57.1	59.9	63.2	50.1	59.2	70.0
07-29-95	58.3	59.7	61.4	56.7	61.3	66.7
07-30-95	56.7	59.0	61.8	47.5	57.1	65.0
07-31-95	57.1	59.6	62.7	55.0	61.0	70.5

Sullivan Creek Air & Water Temperatures at Powerhouse

Date	Water Min	Water Avg	Water Max	Air Min	Air Avg	Air Max
08-01-95	57.5	60.0	62.7	53.1	61.8	69.0
08-02-95	58.3	60.4	62.7	56.7	62.5	66.9
08-03-95	58.8	60.7	63.2	55.9	62.3	68.9
08-04-95	58.8	61.2	64.1	55.5	63.7	74.3
08-05-95	60.0	62.1	64.5	57.5	66.4	79.0
08-06-95	59.6	61.0	62.7	57.1	61.9	67.9
08-07-95	58.8	59.5	60.5	55.9	59.2	61.4
08-08-95	57.5	58.5	60.0	53.1	56.7	60.4
08-09-95	55.9	58.3	61.4	46.8	55.8	64.5
08-10-95	56.3	58.5	61.4	48.6	57.0	66.0
08-11-95	57.9	58.9	60.0	55.9	59.0	64.5
08-12-95	56.3	57.4	58.8	48.6	55.3	62.4
08-13-95	55.5	56.7	58.8	47.2	52.6	57.9
08-14-95	55.1	56.7	58.3	47.9	53.6	58.8
08-15-95	55.5	57.2	59.2	52.3	56.3	60.9
08-16-95	55.9	56.9	57.9	52.3	55.6	58.8
08-17-95	55.1	56.0	57.1	48.2	52.5	55.0
08-18-95	54.7	55.9	57.1	49.0	53.7	59.5
08-19-95	54.3	56.1	57.9	48.6	54.3	60.0
08-20-95	54.3	56.5	59.2	49.3	55.9	65.5
08-21-95	55.1	57.4	60.5	48.2	58.1	71.5
08-22-95	55.5	57.8	60.0	51.6	59.0	68.4
08-23-95	55.5	57.4	58.8	47.9	56.3	64.5
08-24-95	55.1	56.9	59.2	48.2	55.7	62.7
08-25-95	54.3	56.6	58.8	46.1	54.2	63.5
08-26-95	55.1	56.9	59.2	48.2	56.2	66.0
08-27-95	54.7	56.6	58.8	47.2	55.6	62.7
08-28-95	54.7	56.8	58.8	48.6	55.7	62.2
08-29-95	55.9	56.7	57.5	53.1	56.0	57.9
08-30-95	54.3	56.2	58.3	47.9	53.7	59.2
08-31-95	53.9	56.2	58.8	47.5	54.2	62.7
09-01-95	54.7	56.8	59.2	48.2	55.8	65.5
09-02-95	55.1	57.4	60.0	50.1	57.2	67.4
09-03-95	55.5	57.5	60.0	50.4	57.8	65.5
09-04-95	56.3	58.4	60.5	54.7	60.5	70.0
09-05-95	57.5	58.8	60.0	54.7	60.1	62.4
09-06-95	55.9	57.6	59.6	49.7	56.2	63.2
09-07-95	56.3	57.7	59.6	53.5	58.3	64.1
09-08-95	55.5	57.5	59.6	49.7	56.6	62.2
09-09-95	55.5	57.6	59.6	49.3	56.7	64.5
09-10-95	55.9	57.9	60.0	50.1	57.6	66.0
09-11-95	56.7	58.5	60.5	52.3	59.3	67.4
09-12-95	56.7	58.4	60.0	50.8	58.6	66.9
09-13-95	55.9	58.0	60.0	51.2	58.1	66.9
09-14-95	56.3	58.0	60.0	51.2	57.8	66.4
09-15-95	55.9	58.0	60.0	49.7	58.0	67.9
09-16-95	56.3	58.0	59.6	52.7	58.5	66.4
09-17-95	55.5	57.5	59.2	50.1	57.1	66.0
09-18-95	56.3	57.7	59.2	51.9	58.1	65.0
09-19-95	56.7	57.4	58.3	52.7	57.3	63.5
09-20-95	55.5	56.3	57.5	49.0	53.7	60.9
09-21-95	52.7	54.6	56.3	38.5	49.1	57.5
09-22-95	52.3	54.3	56.7	38.5	48.3	57.1
09-23-95	52.3	54.1	56.3	41.1	49.8	60.0
09-24-95	51.9	53.6	55.5	41.7	50.0	59.6
09-25-95	51.6	53.5	55.5	43.4	50.3	59.6
09-26-95	52.3	53.2	53.9	45.8	50.2	52.7
09-27-95	52.3	53.0	53.9	46.8	50.0	52.3
09-28-95	53.1	53.5	54.3	50.4	52.1	53.9
09-29-95	52.7	53.3	54.3	49.3	51.4	54.3
09-30-95	51.9	52.9	53.5	45.4	49.9	52.3
10-01-95	50.4	51.5	52.7	37.6	44.5	49.0
10-02-95	50.1	50.7	51.2	41.1	44.3	46.6
10-03-95	50.1	50.7	51.6	44.1	46.5	48.2

Sullivan Creek Air & Water Temperatures at Powerhouse

Date	Water Min	Water Avg	Water Max	Air Min	Air Avg	Air Max
10-04-95	49.3	50.1	50.8	42.4	45.2	49.0
10-05-95	48.2	49.3	50.4	36.3	42.9	48.6
10-06-95	49.0	49.6	50.8	41.7	45.0	49.3
10-07-95	48.6	49.3	50.1	42.7	45.2	48.0
10-08-95	48.6	49.2	50.1	42.7	45.0	47.5
10-09-95	48.2	49.2	50.4	42.4	45.4	48.0
10-10-95	49.7	50.4	51.2	45.8	47.4	49.0
10-11-95	50.8	50.9	51.2	44.4	47.6	48.7
10-12-95	49.7	50.3	50.8	40.7	44.1	47.3
10-13-95	49.3	49.8	50.1	39.5	42.6	45.2
10-14-95	49.3	49.6	50.1	40.7	42.9	45.2
10-15-95	49.3	49.9	50.8	41.1	44.5	49.7
10-16-95	50.1	50.7	51.6	45.8	47.9	51.6
10-17-95	50.1	50.4	50.8	43.7	45.3	46.6
11-18-95	43.7	44.0	44.1	37.3	41.6	43.9
11-19-95	42.7	43.2	43.7	34.1	36.6	39.0
11-20-95	42.1	42.2	42.7	30.1	32.6	35.7
11-21-95	41.7	41.9	42.1	32.5	35.1	36.2
11-22-95	42.1	42.3	42.4	35.7	36.8	37.3
11-23-95	42.4	42.6	42.7	37.3	39.1	41.4
11-24-95	42.7	42.9	43.0	40.8	42.2	43.3
11-25-95	42.7	43.0	43.0	39.6	42.0	42.6
11-26-95	42.4	42.6	42.7	37.9	39.3	40.2
11-27-95	41.7	42.1	42.4	36.2	37.7	38.4
11-28-95	41.4	41.5	41.7	37.3	37.7	37.9
11-29-95	41.4	41.8	42.1	37.9	40.6	43.9
11-30-95	41.7	42.1	42.1	39.6	41.4	43.3
12-01-95	41.4	42.0	42.1	35.1	40.3	42.0
12-02-95	40.4	41.1	41.4	33.6	36.0	37.9
12-03-95	40.1	40.2	40.4	33.0	35.0	36.2
12-04-95	39.5	39.7	40.1	31.1	33.1	36.2
12-05-95	38.2	38.9	39.5	22.3	28.1	31.6
12-06-95	38.2	38.3	38.5	21.1	28.1	30.6
12-07-95	36.9	37.8	38.2	16.9	25.6	30.1
12-08-95	36.3	36.7	36.9	9.2	15.4	23.5
12-09-95	36.0	36.5	36.9	10.8	19.4	24.3
12-10-95	36.3	36.6	36.9	24.7	26.7	28.7
12-11-95	35.7	37.1	37.6	28.7	30.3	31.6
12-12-95	37.2	37.5	37.6	31.6	32.5	33.6
12-13-95	37.6	37.8	38.2	32.5	33.0	33.6
12-14-95	38.2	38.4	38.8	33.0	33.5	33.6
12-15-95	38.5	38.8	38.8	33.0	33.6	34.1
12-16-95	38.8	38.8	38.8	33.6	33.9	34.1
12-17-95	38.2	38.4	38.8	31.6	32.5	34.1
12-18-95	38.2	38.3	38.5	32.5	33.3	34.1
12-19-95	38.5	38.5	38.5	33.6	33.9	34.1
12-20-95	38.2	38.5	38.8	33.0	33.8	34.1
12-21-95	37.9	38.1	38.5	31.6	32.8	34.1
12-22-95	36.6	37.2	37.9	25.6	29.8	32.0
12-23-95	35.7	36.2	36.9	23.9	26.6	29.6
12-24-95	35.1	35.3	36.0	21.1	22.8	28.2
12-25-95	34.5	34.9	35.4	18.4	22.2	26.0
12-26-95	34.2	34.7	35.1	17.7	20.8	24.7
12-27-95	34.8	34.9	35.1	22.7	24.9	27.3
12-28-95	34.8	35.1	35.4	27.8	28.5	30.1
12-29-95	35.1	35.4	35.7	30.1	30.4	31.6
12-30-95	35.4	35.7	36.0	31.6	31.7	32.0
12-31-95	35.7	35.9	36.0	31.1	31.8	32.0
01-01-96	35.7	36.0	36.3	31.1	31.6	32.0
01-02-96	36.3	36.4	36.9	32.0	32.2	33.0
01-03-96	35.4	36.1	36.9	26.0	30.5	32.5
01-04-96	33.3	34.3	35.4	12.4	19.1	27.8
01-05-96	33.6	34.1	34.8	16.2	22.1	25.2
01-06-96	33.3	34.5	35.1	25.2	27.4	29.6
01-07-96	34.8	35.3	35.7	29.6	30.8	32.0

Sullivan Creek Air & Water Temperatures at Powerhouse

Date	Water Min	Water Avg	Water Max	Air Min	Air Avg	Air Max
01-08-96	35.4	35.6	36.0	32.0	32.1	32.5
01-09-96	35.4	35.7	36.0	32.0	32.0	32.0
01-10-96	35.7	35.9	36.0	32.0	32.3	33.0
01-11-96	35.4	35.7	36.3	28.7	31.6	33.0
01-12-96	35.1	35.6	36.0	29.2	31.0	31.6
01-13-96	35.7	36.0	36.0	31.6	32.0	33.0
01-14-96	36.0	36.2	36.6	32.5	32.9	34.6
01-15-96	36.3	36.4	36.9	33.0	33.4	34.6
01-16-96	34.5	35.6	36.9	23.5	28.6	33.0
01-17-96	32.7	33.7	34.8	12.7	19.6	28.7
01-18-96	33.9	34.1	34.2	21.5	22.7	24.7
01-19-96	33.6	34.1	34.5	21.5	25.2	26.5
01-20-96	33.3	34.1	34.5	25.2	27.0	27.8
01-21-96	33.6	33.9	34.5	23.9	26.4	27.8
01-22-96	33.6	33.7	34.2	26.5	27.1	27.8
01-23-96	33.6	34.0	34.5	24.7	27.7	28.7
01-24-96	33.0	33.7	34.2	19.5	26.4	28.2
01-25-96	33.3	33.5	33.9	22.3	25.0	26.9
01-26-96	32.7	33.0	33.6	17.3	20.8	25.2
01-27-96	32.7	33.1	33.6	20.7	23.7	25.6
01-28-96	32.1	32.3	33.0	0.9	12.5	23.1
01-29-96	32.1	32.1	32.1	-5.3	3.9	16.2
01-30-96	32.1	32.1	32.1	-0.5	6.3	11.7
01-31-96	32.1	32.1	32.1	-1.0	6.0	12.4
02-01-96	32.1	32.1	32.1	3.4	7.8	12.1
02-02-96	32.1	32.1	32.1	2.3	7.1	12.1
02-03-96	32.1	32.1	32.1	11.1	15.3	18.8
02-04-96	32.1	32.1	32.1	19.1	21.6	24.7
02-05-96	32.1	32.1	32.1	26.5	30.7	32.0
02-06-96	32.1	32.1	32.1	30.6	31.4	32.0
02-07-96	31.8	32.2	32.7	32.0	32.0	32.0
02-08-96	33.0	33.4	33.6	32.0	32.5	33.0
02-09-96	32.7	33.1	33.6	21.5	27.1	32.0
02-10-96	32.4	32.9	33.6	19.1	25.0	28.7
02-11-96	32.7	33.2	33.9	24.3	26.3	28.2
02-12-96	33.6	33.7	34.2	27.3	29.1	31.1
02-13-96	33.6	34.0	34.5	27.3	29.6	32.0
02-14-96	33.6	34.1	34.5	26.9	29.4	32.0
02-15-96	33.9	34.3	34.8	27.8	29.7	32.0
02-16-96	34.5	34.8	35.4	30.1	31.1	32.0
02-17-96	35.1	35.2	35.7	31.6	32.2	33.6
02-18-96	35.1	35.5	36.0	32.0	32.7	34.1
02-19-96	35.4	35.8	36.3	32.0	32.6	33.6
02-20-96	35.7	36.0	36.3	32.5	32.9	34.1
02-21-96	35.7	36.0	36.3	31.6	32.4	33.6
02-22-96	35.4	35.9	36.3	31.6	32.0	32.0
02-23-96	35.1	35.7	36.3	25.6	30.3	32.0
02-24-96	34.2	35.1	36.0	19.5	25.6	31.6
02-25-96	33.0	34.0	35.1	14.4	20.3	26.9
02-26-96	33.0	33.8	34.5	13.8	20.3	25.6
02-27-96	32.4	33.2	34.2	12.1	19.9	23.5
02-28-96	32.7	33.4	34.2	14.1	20.2	25.2
02-29-96	33.0	33.7	34.2	18.8	23.3	27.8
03-01-96	33.3	33.9	34.5	22.3	25.9	31.6
03-02-96	33.9	34.3	35.1	26.0	28.7	33.0
03-03-96	34.2	34.7	35.4	27.8	29.7	30.6
03-04-96	33.9	34.4	34.8	24.3	27.0	30.1
03-05-96	34.2	34.4	34.8	26.5	28.1	30.1

APPENDIX B
TEMPEST MODEL CALIBRATION DETAIL

July 24, 1994 tempest model results
calibration detail: 79 cfs, air temp profile = 724.txt, input=724cal.txt, starting water temp @ midnigh
TEMPEST2 model results

			air temp			predicted water temp			actual water temp	
	cfs	gwinflow	max	min	mean	max	min	mean	max	min
pow	79	0.000010	26.80	17.30	21.30	19.65	17.21	18.41	19.70	17.10
pow	55	0.000010	26.80	17.30	21.30	19.84	17.03	18.41		
pow	27	0.000010	26.80	17.30	21.30	20.31	16.62	18.41		

			air temp			predicted water temp			actual water temp	
	cfs	gwinflow	max	min	mean	max	min	mean	max	min
pow	79	0.004000	26.80	17.30	21.30	19.62	17.15	18.35	19.70	17.10
pow	55	0.004000	26.80	17.30	21.30	19.79	16.96	18.35		
pow	27	0.004000	26.80	17.30	21.30	20.18	16.53	18.33		

			air temp			predicted water temp			actual water temp	
	cfs	gwinflow	max	min	mean	max	min	mean	max	min
pow	79	0.000010	80.2	63.1	70.3	67.4	63.0	65.1	67.5	62.8
pow	55	0.000010	80.2	63.1	70.3	67.7	62.7	65.1		
pow	27	0.000010	80.2	63.1	70.3	68.6	61.9	65.1		

			air temp			predicted water temp			actual water temp	
	cfs	gwinflow	max	min	mean	max	min	mean	max	min
pow	79	0.004000	80.2	63.1	70.3	67.3	62.9	65.0	67.5	62.8
pow	55	0.004000	80.2	63.1	70.3	67.6	62.5	65.0		
pow	27	0.004000	80.2	63.1	70.3	68.3	61.8	65.0		

			air temp			predicted water temp		
	cfs	gwinflow	max	min	mean	max	min	mean
Blw Mil	75	0.004	26.10	17.60	21.37	20.16	15.84	18.02
Blw Mil	50	0.004	26.10	17.60	21.37	20.41	15.55	18.00
Blw Mil	25	0.004	26.10	17.60	21.37	20.83	15.03	17.95

			air temp			predicted water temp		
	cfs	gwinflow	max	min	mean	max	min	mean
Blw Mil	75	0.004	78.98	63.68	70.47	68.29	60.51	64.44
Blw Mil	50	0.004	78.98	63.68	70.47	68.74	59.99	64.40
Blw Mil	25	0.004	78.98	63.68	70.47	69.49	59.05	64.31

			air temp			predicted water temp		
	cfs	gwinflow	max	min	mean	max	min	mean
T4SS2	75	0.004	26.10	17.60	21.37	20.69	15.21	17.97
T4SS2	50	0.004	26.10	17.60	21.37	20.88	14.97	17.94
T4SS2	25	0.004	26.10	17.60	21.37	21.06	14.73	17.91

			air temp			predicted water temp		
	cfs	gwinflow	max	min	mean	max	min	mean
T4SS2	75	0.004	78.98	63.68	70.47	69.24	59.38	64.35
T4SS2	50	0.004	78.98	63.68	70.47	69.58	58.95	64.29
T4SS2	25	0.004	78.98	63.68	70.47	69.91	58.51	64.24

calibration data for sullivan creek

		Predicted	Measur
0	21.40	17.43	17.60
1	20.80	17.30	17.60
2	20.20	17.17	17.60
3	19.40	17.04	17.60
4	18.90	16.90	17.30
5	18.60	16.77	17.30
6	18.10	16.66	17.10
7	17.80	16.62	17.10
8	17.60	16.67	17.10
9	17.80	16.79	17.10
10	18.10	16.96	16.80
11	18.90	17.16	17.10
12	19.90	17.38	17.10
13	21.40	17.60	17.10
14	22.90	17.80	17.10
15	24.40	17.97	17.30
16	25.80	18.08	17.60
17	26.10	18.11	17.80
18	26.10	18.05	17.80
19	25.40	17.97	17.80
20	24.40	17.88	17.80
21	23.80	17.78	18.10
22	22.90	17.67	18.10
23	22.30	17.55	18.10

Sept 18, 1994 tempest model results
calibration detail: 52cfs air temp profile = 818.txt, input = 918cal.txt, start wat=14.2
tempst2 model results

			air temp			predicted water temp			actual water temp		
	cfs	gwinflow	max	min	mean	max	min	mean	max	min	mean
pow	79	0.003	17.80	10.40	13.60	14.81	13.47	14.16			
pow	52	0.003	17.80	10.40	13.60	14.91	13.36	14.16	14.90	13.10	13.95
pow	27	0.003	17.80	10.40	13.60	15.14	13.11	14.16			
T4SS2	75	0.003	17.80	10.40	13.60	15.84	12.38	14.17			
T4SS2	50	0.003	17.80	10.40	13.60	16.10	12.17	14.18			
T4SS2	25	0.003	17.80	10.40	13.60	16.44	11.88	14.20			

Sept 18 calibrated model reuslt

		Predicte	Measur
0	13.50	14.17	14.20
1	13.10	14.04	14.20
2	12.60	13.90	13.90
3	11.90	13.77	13.70
4	11.50	13.63	13.70
5	11.10	13.50	13.50
6	10.70	13.36	13.50
7	10.40	13.38	13.30
8	10.40	13.46	13.10
9	10.90	13.59	13.10
10	11.30	13.76	13.10
11	11.90	13.96	13.10
12	12.80	14.16	13.30
13	13.90	14.36	13.70
14	15.60	14.56	13.90
15	17.10	14.73	14.40
16	17.80	14.85	14.60
17	17.80	14.91	14.90
18	17.10	14.89	14.90
19	16.30	14.86	14.90
20	15.60	14.72	14.60
21	15.10	14.59	14.60
22	14.40	14.45	14.40
23	13.70	14.31	14.20

APPENDIX C
WATER TEMPERATURE MODELING FOR SEPTEMBER

TEMPERATURE MODELING FOR SEPTEMBER

The agencies requested temperature modeling for September; the onset for spawning of brown trout and, if present, bull trout. Concern had been raised that reduced instream flows could potentially elevate stream temperatures and thereby delay spawning.

The same methods for modeling stream temperatures in July and August were applied for modeling of September water temperatures. Air and water temperature data were available for the project diversion reach for September 1993 and 1994. Daily temperature data are reported in Appendix A. The hottest water temperatures at the powerhouse with a complete 24 hour continuous record were recorded on September 18, 1994 (58.8°F). This date corresponded with unseasonably warm air temperatures. Modeling for September water temperatures used this date for model calibration. Cooler days would show less change in water temperature with reduced flow. The stream flow on September 18, 1994 was 52 cfs at the powerhouse.

Calibration input data are reported in Appendix B. The calibrated hourly temperature regime is compared to measured temperatures in Figure 1. Model calibration results are presented in Table 1.

TABLE 1
CALIBRATED MODEL RESULTS: SEPTEMBER

		Hourly Water Temperature °F		
		Maximum	Minimum	Mean
9/18/94	Predicted	58.8	56.0	57.5
	Measured	58.8	55.6	57.1
	Difference	0	0.4	0.4

The calibrated model was used to predict daily water temperature regimes at normal stream flows with and without project operation. Predicted water temperature regimes for the diversion reach during September (hottest days) are reported in Table 2.

TABLE 2
Predicted Daily Water Temperatures for September (Hottest Days)

	Discharge (cfs)	Maximum (°F)	Minimum (°F)	Mean (°F)
Upstream of powerhouse	79	58.7	56.2	57.5
	52	58.8	56.0	57.5
	27	59.3	55.6	57.5
IFIM SS2 T4 wide riffle	75	60.5	54.3	57.5
most temperature sensitive	50	61.0	53.9	57.5
	25	61.6	53.4	57.6

Predicted water temperatures during current, pre-project stream flows (50 cfs) exceed the maximum temperature standard for Class AA streams (16.0°C = 60.8°F) in the vicinity of Study Site 2 transect 4 (a wide riffle near the North Fork Campground). Water quality standards are not naturally exceeded at any of the modeled stream reaches when stream flows are higher (75/79 cfs: below Mill Pond/at powerhouse). A reduction in stream flow of 25 cfs causes a corresponding increase in predicted water temperature up to but not exceeding 0.6°F. Predicted water temperatures are highest in shallow stream areas typified by Study Site 2 Transect 4. Exceptionally warm conditions were modeled for September. Most days would have cooler water temperatures with less of a response in stream temperature elevation caused by reductions in stream flow within the Sullivan Creek diversion reach.

APPENDIX C

WATER QUALITY MONITORING

Table 1. Summary of Water Quality Parameters for Sullivan Creek Project Vicinity Measurements taken by Pend Oreille PUD *

	Box Canyon		Ione City	Sullivan	Mill
Test	Forebay	Tailbay	Park	Lake	Pond
Water Temp	X	X	X	X	X
Ambient Air	X	X	X	X	X
Discharge	X	X			
Gas pressure					
Before	X	X	X	X	
After	X	X	X	X	
D.O.	X	X	X	X	
pH	X	X	X	X	
Acidity	X	X	X	X	
Alkalinity	X	X	X	X	
CO2	X	X	X	X	
Hardness	X	X	X	X	
Date Sampling	4/88	4/88	4/88	6/88	2/93
# Samples	38	38	38	37	

*Sampling monthly

Table 2a. Water Quality Sampling in Sullivan Creek Drainage, USFS.

	Pass	Thunder	Stony	Mankato	Gypsy	Cascade	Deemer	Leona Cr. Up	Leona Cr. Low	Kinyon	Rocky Fork
Acidity											
Alkalinity				X	X	X		X		X	
CO2											
Coliform							X	X	X		
Color				X	X			X		X	X
Conductivity				X	X	X	X	X	X	X	X
Copper											
Flow (cfs)			X		X		X	X	X		
Hardness											
Calcium						X					
Magnesium						X					
Total				X	X	X		X		X	X
Iron				X	X			X			X
Manganese											
Nitrates						X		X	X		
Nitrites						X					
DO				X						X	
pH				X	X	X	X	X	X	X	X
O-Phosphate					X	X		X			
Susp.Sed.				X	X		X			X	
TDS				X	X	X	X	X	X	X	X
Sulfate						X					
Temperature		X		X	X	X	X	X	X	X	X
Turbidity	X	X	X	X	X	X	X	X	X	X	X

Table 2b. Water Quality Sampling in Sullivan Creek Drainage, USFS.

	Sullivan Cr.					Harvey Cr.					
	Up	II	Bridge	NF	Noisy	MF	MF&NF	Up	Low	Bridge	Jungle
Acidity		X									
Alkalinity		X	X		X						X
CO2		X									
Coliform	X		X	X	X	X	X	X		X	
Color		X	X								
Conductivity	X	X	X	X	X	X	X	X	X	X	X
Copper			X								
Flow (cfs)	X	X	X	X	X	X	X	X		X	
Hardness											
Calcium											
Magnesium											
Total		X	X		X						X
Iron		X	X		X						
Manganese			X								
Nitrates			X		X						
Nitrites			X								
DO	X	X	X	X	X					X	X
pH		X	X	X	X	X	X	X		X	X
O-Phosphate		X	X		X						
Susp.Sed.	X	X	X	X						X	
TDS	X	X	X	X	X	X	X	X		X	
Sulfate			X								
Temperature	X	X	X	X	X	X	X	X		X	X
Turbidity	X	X	X	X	X	X	X	X		X	X

Table 3. Streams sampled for water quality by the USFS in the Sullivan Creek drainage, and frequency of sampling.

Stream	No.	District	Area	Sampler	Dates	# Samples
Pass Cr.	21110216	Sull Lake	Sull. Cr.	USFS	1970-74	19
Thunder Cr.	21110227	Sull Lake	Sull. Cr.	USFS	1971	3
Stony Cr.	21110228	Sull Lake	Sull. Cr.	USFS	1962-80	36
Mankato Cr.	21110211	Sull Lake	Sull. Cr.	USFS	1970-74	5
Gypsy Cr.	21110217	Sull Lake	Sull. Cr.	USFS	1971-92	31
Cascade Cr.	21110223	Sull Lake	Sull. Cr.	USFS	1971-84	5
Deemer Cr.	21110231	Sull Lake	Sull. Cr.	USFS	1971-92	23
Up.Leola Cr.	21110313	Sull Lake	Sull. Cr.	USFS	1974-77	8
Lo. Leola Cr.	21110314	Sull Lake	Sull. Cr.	USFS	1977	5
Kinyon Cr.	21110210	Sull Lake	Sull. Cr.	USFS	1973-74	4
Up. Sull. Cr.	21110218	Sull Lake	Sull. Cr.	USFS	1969-92	24
Sull Cr. II	21110212	Sull Lake	Sull. Cr.	USFS	1971-89	15
Sull-Bridge	21110207	Sull Lake	Sull. Cr.	USFS	1960-92	96
NF Sull.	21110220	Sull Lake	Sull. Cr.	USFS	1962-92	76
Noisy Cr.	21110215	Sull Lake	Harvey Cr.	USFS	1959-92	19
MF Harvey	-	Sull Lake	Harvey Cr.	USFS	1991	1
M&NF Harvey	21110235	Sull Lake	Harvey Cr.	USFS	1925-92	11
Jungle Cr.	21110213	Sull Lake	Harvey Cr.	USFS	1973	1
Rocky Fork	21110214	Sull Lake	Harvey Cr.	USFS	1974	1
Up. Harvey	21110234	Sull Lake	Harvey Cr.	USFS	1990-92	14
Low. Harvey	21110234	Sull Lake	Harvey Cr.	USFS	1989	1
Harvey-Bridge	21110222	Sull Lake	Harvey Cr.	USFS	1968-92	60

APPENDIX

WATER QUALITY DATA SHEETS

SULLIVAN CREEK DRAINAGE

Table 1a. Box Canyon Dam forebay water quality data collected by Pend Oreille PUD.

Date	Temperature Water (F)	Temperature Air (F)	B.Can Flow	Gas Pressure Before	Gas Pressure After	DO	pH	Acidity Free	Acidity Total	Methyl Alkaline	CO2	Total Hardness
4/88	46	76	25000	-7	12	5.6	9	0	2	6	30	7
5/88												
6/88	58	70	28000	-2	-2	4.6	9	0	2	6	25	6
7/88		60	8500	-10	-5	4.8	9.5	0	2	6	30	7
8/88	70	78	6000	-5	5	4.8	9	0	2	5	15	7
9/88	64	60	10000	-7	5	5.2	9	0	3	4	20	6
10/88												
11/88	45		18000	-8	0	5.4	9	0	2	6	25	6
4/89	46	58	42000	0	5	6.2	8.5	0	3	5	20	6
5/89	52	58	35275	-3	10	6	9	0	2	5	20	6
6/89	62	72	31550	-5	2	5.6	9	0	2	4	15	6
7/89	65	85	22000	-5	1	2	9	0	4	4	20	6
8/89	66	82		-10	3	5.6	9.5	0	3	4	20	6
9/89	63	82	16000	-2	5	7	9	0	2	6	20	8
10/89												
11/89												
12/89	44	32	21000	-5	0	7	9	0	3	4	20	7
1/90	36	32	21000	-10	0	8.4	8.5	0	3	5	15	5
3/90	40	45	20600	-15	0	7	8.5	0	3	5	15	6
4/90	48	42	50600	-5	3	6.4	8.5	0	3	4	15	6
6/90	60	70	60840	-10	0	5.2	8.5	0	3	6	25	6
8/90	74	79	11900	-5	5	5	8.5	0	3	5	25	6
10/90	55	42	25600	-5	5	5.6	8.5	0	3	6	25	6
12/90	38	32	21400	-10	0	5.2	8.5	0	3	5	30	8
4/91	44	55	40000	-5	5	8	8.5	0	2	6	20	7
7/91	67	73	33590	-12	0	6	8.5	0	1	5	20	8
8/91	72	85	12500	-5	5	8	8.5	0	2	5	20	6
11/91	40	36	12900	-22	-12	7	8.7	0	0	5	25	7
12/91	40	42	20520	0	5	7.8	8.7	0	0	7	40	7
1/92	38	28	13500	-7	5	10	8.7	0	2	6	10	6
2/92	40	36	14840	-5	7	11.2	8.9	0	1	6	10	7
3/92	46	38	18040	-20	10	10.8	8.8	0	1	6	5	5
4/92	52	45	18200	4	19	10.6	8.8	0	1	6	5	5
5/92	58	44	23960	0	17.5	8.8	9	0	1	6	5	5
6/92	70	97	21801	25	37	9.2	9	0	1	6	5	5
7/92	70	60	17040	0	24	7.4	9	0	1	6	5	4

Table 1a. Box Canyon Dam forebay water quality data collected by Pend Oreille PUD.

Date	Temperature Water (F)	Temperature Air (F)	B.Can Flow	Gas Pressure Before	Gas Pressure After	DO	pH	Acidity Free	Acidity Total	Methyl Alkaline	CO2	Total Hardness
8/92												
9/92	62	56	14080	10	34	4	9	0	1	6	5	5
10/92	56	56	21900	25	29	4.6	9	0	1	6	5	5
11/92	46	38	12570	-5	20	4.6	9	0	1	6	5	5
12/92	34	25	13480	-18	-25	5.4	8.5	0	1	6	5	5
1/93	32	35	20720			6	8.8	0	1	6	5	6
2/93	36	40	10110	9	14	6	8.5	0	1	6	5	6

Table 1b. Box Canyon Dam tailbay water quality data collected by Pend Oreille PUD.

Date	Temperature Water (F)	Temperature Air (F)	B.Can Flow	Gas Pressure Before	Gas Pressure After	DO	pH	Acidity Free	Acidity Total	Methyl Alkaline	CO2	Total Hardness
4/88	46	76	25000	-5	10	6	9	0	2	5	25	6
5/88	55	70	28000	-10	-8	5.6	9	0	2	5	20	5
6/88	67	60	16000	0	10	5.2	8.5	0	2	5	20	5
7/88	72	65	10000	-10	-8		8.5	0	2	5	20	5
8/88	70	75	6000	-7	5		9	0	2	5	15	5
9/88	64	83	10000	-5	0	5	9	0	3	5	25	7
10/88	60		21000	-5	0	5.4	9	0	3	6	25	7
11/88	45	32	21000			5.2	9	0	2	5	15	6
4/89	46	58	42000	0	7	6	8.5	0	3	5	15	5
5/89	52	56	35275	-8	12	6	9	0	2	5	20	5
6/89	62	80	29680	-20	-10		9.5	0	2	5	20	6
7/89	65	82	22000	-10	-5		9	0	3	5	20	5
8/89	66	75	14700	-8	4	7	9	0	3	5	15	4
9/89												
10/89												
11/89												
12/89	44	32	21000	-2	5	6	9	0	4	5	25	6
1/90	36	32	21000	-10	-5	6	8.5	0	4	5	20	6
3/90	40		20600	-20	-5	5.6	8.5	0	3	5	20	6
4/90	49	42	50600	-10	-2	5.6	8.5	0	4	5	25	6
6/90	60	70	60840	-5	3	5.4	8.5	0	3	6	20	5
8/90	74	78	11040	-2	5	5.6	8.5	0	3	6	25	5
10/90	55	46	21880	-10	-5	5.6	8.5	0	4	5	20	6
12/90	39	32	21400	-8	-2	5.6	8.5	0	4	6	25	6
4/91	45	52	40000	-3	7	7	8.5	0	5	5	20	5
7/91	67	73	33590	-18	-10	5.6	8.5	0	3	6	25	7
8/91	68	72	12500	-15	0	6	8.5	0	2	5	20	4
11/91	40	36	12240	-24	-20	7.4	8.8	0	0	5	25	8
12/91	38	29	15000	-10	10	9.2	8.8	0	0	6	20	6
1/92	36	20	5980			11	8.9	0	2	7	10	7
2/92	42	40	11820	-24	-25	11	8.7	0	1	6	5	5
3/92	47	40	17840	10	2.5	10	8.8	0	1	5	5	6
4/92	52	54	25360	5	10	9.4	8.8	0	1	6	5	5
5/92	59	54	23960	4	24	8.8	8.9	0	1	6	5	5
6/92	70	97	21801	25	60	9.2	9	0	1	5	5	5
7/92	68	60	14520	-2	20	9.4	9	0	1	5	5	5

Table 1b. Box Canyon Dam tailbay water quality data collected by Pend Oreille PUD.

Date	Temperature		B.Can	Gas Pressure		DO	pH	Acidity		Methyl	CO2	Total
	Water (F)	Air (F)	Flow	Before	After			Free	Total	Alkaline		Hardness
10/92	56	48	21900	10	18	4.2	9	0	1	6	5	5
11/92	46	37	25640	17	33	4.6	9	0	1	6	5	6
12/92	35	32	12660	-5	15	5.2	8.7	0	1	7	5	5
1/93	32	26	16840			5.6	8.5	0	1	7	5	5
2/93	32	8	9780	-35	-38	6	8.5	0	2	6	10	6

Table 1c. Ione City Park water quality data collected by Pend Oreille PUD.

Date	Temperature Water (F)	Temperature Air (F)	B.Can Flow	Gas Pressure Before	Gas Pressure After	DO	pH	Acidity Free	Acidity Total	Methyl Alkaline	CO2	Total Hardness
4/88	48	70			6.2	9	0	4	6	15	6	
5/88												
6/88	64	80	-15	-3	5.2	8.5	0	4	5	15	6	
7/88	72	70	7	7	4.8	9.5	0	4	6	15	6	
8/88		70	0	2	5.2	8.5	0	3	5	15	6	
9/88		70	-7	0	4.8	9.5	0	3	5	15	3	
10/88	54	42	-18	-11	5	9	0	3	6	20	7	
11/88	45	32			5.2	9	0	3	5	15	6	
4/89	46	50	-5	10	6.2	8.5	0	4	5	20	6	
5/89	52	58	-10	0	5.2	9	0	4	6	20	6	
6/89	64	70	-14	8	5.6	9	0	5	5	15	6	
7/89	65	81	-10	5		9.5	0	5	5	35	5	
8/89	66	83	-6	8	5.2	9.5	0	4	5	10	6	
9/89	63	80	-6	-3	5.6	9	0	5	6	20	6	
10/89												
11/89												
12/89	43	31	-5	0	5	8.5	0	6	8	20	6	
1/90	37	34		-5	5.8	8.5	0	4	6	20	5	
3/90	40	52	-10	5	4.4	8.5	0	5	5	15	7	
4/90	48	45	-10	2	5	8.5	0	5	5	15	5	
6/90	59	69	-10	0	4.8	8.5	0	5	6	15	7	
8/90	74	85	-5	5	5	8.5	0	5	5	20	6	
10/90	54	45	-10	-2	5.2	8.5	0	6	6	20	8	
12/90	38	33	-8	-5	5.2	8.5	0	5	7	20	8	
4/91	44	49	-5	10	5	8.5	0	5	6	10	5	
7/91	67	72	-12	-5	5.6	8.5	0	5	5	15	7	
8/91	77	85	0	10	5.6	8.5	0	5	7	25	6	
11-91	40	36	-15	-7	7.6	9	0	4	6	25	6	
12/91	39	35	-5	-10	8.6	8.8	0	0	7	40	6	
1/92	38	40	-5	-10	10.4	8.8	0	2	6	10	6	
2/92		36	-6	-14	11.6	8.8	0	1	6	5	6	
3/92	49	44	7.5	10	4.8	8.8	0	1	6	5	6	
4/92	49	44	5	20	10.6	8.8	0	1	6	5	5	
5/92		68	-5	23	8.4	9	0	1	5	5	5	
6/92		65	8	25	9	8.6	0	1	5	5	5	
7/92	73	85	15	30	4.6	9	0	1	6	5	5	

Table 1c. Ione City Park water quality data collected by Pend Oreille PUD.

Date	Temperature		B.Can	Gas Pressure		DO	pH	Acidity		Methyl	CO2	Total
	Water (F)	Air (F)	Flow	Before	After			Free	Total	Alkaline		Hardness
10/92	54	32	-3	32	4.2	9	0	1	6	5	6	
11/92	46	41	8	4	4.6	8.5	0	1	6	5	5	
12/92	35	30	12	15	5.2	8.5	0	1	6	5	5	
1/93	32	35	4	-6	5.2	8	0	1	7	5	5	
2/93	33	38	0	-15	6	8.5	0	1	7	5	7	

Table 1d. Sullivan Lake water quality data collected by Pend Oreille PUD.

Date	Temperature Water (F)	Temperature Air (F)	B.Can Flow	Gas Pressure Before	Gas Pressure After	DO	pH	Acidity Free	Acidity Total	Methyl Alkaline	CO2	Total Hardness
4/88												
5/88												
6/88	57	50	-5	10	5.6	8.5	0	2	4	20	6	
7/88	71	70	-10	17	5.2	8.5	0	2	5	20	5	
8/88	70	60	5	8	5	8.5	0	3	4	20	5	
9/88	65	70	-10	15	5.4	9	0	2	5	20	5	
10/88		60			5.6	9	0	2	5	15	5	
6/89	62	70	-10	17	5	0	0	5	5	25	6	
7/89	69	79	2	25		8.5	0	3	5	25	5	
8/89	64	72	-7	22	4.4	9	0	2	5	15	6	
9/89	64	72	-5	7	4.8	8.5	0	3	5	20	4	
10/89	59	67	-7	5	6	8.5	0	4	5	20	6	
11/89												
12/89	39	31	-7	5	5.6	8.5	0	3	6	20	6	
1/90	38	30	-7	5	5.6	9	0	4	5	15	5	
3/90	40	46	-12	-5	5.6	8.5	0	5	5	20	5	
4/90	45	52	-5	8	4.4	8.5	0	3	5	15	4	
6/90	50	53	-20	-5	4.4	8.5	0	3	5	25	6	
8/90	73	78	-5	20	6	8.5	0	3	6	25	5	
10/90	54	46	-5	5	5.7	8.5	0	3	6	25	5	
12/90	38	31	-7	4	4.8	8.5	0	3	5	20	6	
4/91	41	45	-6	0	6	8.5	0	4	5	20	6	
7/91	67	75	-15	7	5.6	8.5	0	3	5	15	5	
8/91	72	80	-12	8	5.6	8.5	0	4	6	25	6	
11/91		34	-18	-11	8.4	8.5	0	2	4	25	8	
12/91	38	30	-15	5	7.4	7.5	0	0	5	25	6	
1/92	36	36	7	0	8	8.5	0	2	4	5	7	
2/92	41	34	-21	-30	11.6	8.5	0	1	4	5	5	
3/92	56	70	23	19	11	8.5	0	1	4	5	4	
4/92		74	27	20	10	8	0	1	4	5	4	
5/92	53		7.5	0	9.4	8.5	0	1	4	5	4	
6/92	68	76	31	25	8.4	9	0	1	4	5	4	
7/92	66	75	10	15	4.6	9	0	1	4	5	3	
8/92	66	58	6	15	4.8	9	0	1	4	5	3	
9/92	61	58	30	23	4.2	8.5	0	1	4	5	3	
10/92	52	38	5	6	4.2	8.5	0	1	4	5	3	

Table 1d. Sullivan Lake water quality data collected by Pend Oreille PUD.

	Temperature		B.Can	Gas Pressure				Acidity		Methyl		Total
Date	Water (F)	Air (F)	Flow	Before	After	DO	pH	Free	Total	Alkaline	CO2	Hardness
11/92	40	28	10	5	4.4	8.5	0	1	4	5	3	
12/92	38	30	14	5	4.2	8	0	1	4	5	3	
1/93	36	17	5	0	4.6	8	0	1	4	5	3	
2/93	34	41	7	-2	4.8	8	0	1	4	5	4	

U.S. FOREST SERVICE

WATER QUALITY DATA SHEETS

SULLIVAN CREEK DRAINAGE

21110216

COLVILLE NATIONAL FOREST
DATA SUMMARY SHEET

Name of Source: PASS CREEK
Station Number: ~~21110216~~ Minor Basin Code: 02
PWI Watershed Number: 16-02-00-00-09 ~~001~~
65321-009 17010216-11

District: SULLIVAN LAKE
Station Location:
T. 39 N R. 44 E Sec. 34 Sub. NW SE

Station Type Code: 2 1 1 2C
Latitude: 48 deg. 50 min. Longitude: 117 deg. 13 min

DATE/TIME OF SAMPLE COLLECTION	ACIDITY (MG/L)	ALKALINITY (MG/L)	BICARBONATE (MG/L)	CALCIUM (MG/L)	CARBON DIOXIDE (MG/L)	CARBONATE (MG/L)	CHLORIDE (MG/L)	COLIFORM, FECAL (COLONIES/100 ml.)	COLIFORM, TOTAL (COLONIES/100 ml.)	COLOR (COB UNITS)	CONDUCTIVITY (MICROMHOS)	COPPER (MG/L)	FLOW, STREAM (C.F.S.)	FLUORIDE (MG/L)	HARDNESS, CALCIUM (MG/L)	HARDNESS, MAGNESIUM (MG/L)	HARDNESS, NON-CARBONATE (MG/L)	HARDNESS, TOTAL (MG/L)	IRON (MG/L)	MAGNESIUM (MG/L)	MANGANESE (MG/L)	NITRATES (MG/L)	NITRITES (MG/L)	OXYGEN, DISSOLVED (MG/L)	pH (STANDARD UNITS)	PHOSPHATE, META (MG/L)	PHOSPHATE, ORTHO (MG/L)	SEDIMENT, SUSPENDED MG/L	SILICA (MG/L)	SODIUM (MG/L)	SOLIDS, TOTAL DISSOLVED (MG/L)	SULFATE (MG/L)	TEMPERATURE (F°)	TURBIDITY (JTU)			
4/7/70-1520																																		.5				
5/4/70-1440																																		1.8				
5/6/70-1440																																		1.4				
5/17/70-1345																																		2.5				
5/27/70-1150																																		4.2				
4/14/71-1415																																		.30				
4/21/71-1515																																		.43				
5/3/71-1445																																		3.2				
5/14/71-0930																																		5.1				
8/19/71-1215																																		.13				
4/27/72-1620																																		.3				
5/9/72-1620																																		1.8				
5/12/72-1615																																		7.2				
5/15/72-0900																																		53				
5/22/72-1620																																		21				
5/30/72/1515																																		28				
6/11/74 —																													109.2									

21110216

COLVILLE NATIONAL FOREST
DATA SUMMARY SHEET

Name of Source: PASS CREEK
Station Number: 21110216 Minor Basin Code: 02
PWI Watershed Number: 16-02-00-00-09 OOA
65321-009 17010216-11

District: SULLIVAN LAKE
Station Location: T. 39 N R. 44 E Sec. 34 Sub. NW SE

Station Type Code: 21 11 20
Latitude: 48 deg. 50 min. Longitude: 117 deg. 13 mi

DATE/TIME OF SAMPLE COLLECTION	ACIDITY (MG/L)	ALKALINITY (MG/L)	BICARBONATE (MG/L)	CALCIUM (MG/L)	CARBON DIOXIDE (MG/L)	CARBONATE (MG/L)	CHLORIDE (MG/L)	COLIFORM, FECAL (COLONIES/100 ml.)	COLIFORM, TOTAL (COLONIES/100 ml.)	COLOR (COB UNITS)	CONDUCTIVITY (MICROMHOS)	COPPER (MG/L)	FLOW, STREAM (C.F.S.)	FLUORIDE (MG/L)	HARDNESS, CALCIUM (MG/L)	HARDNESS, MAGNESIUM (MG/L)	HARDNESS, NON-CARBONATE (MG/L)	HARDNESS, TOTAL (MG/L)	IRON (MG/L)	MAGNESIUM (MG/L)	MANGANESE (MG/L)	NITRATES (MG/L)	NITRITES (MG/L)	OXYGEN, DISSOLVED (MG/L)	pH (STANDARD UNITS)	PHOSPHATE, META (MG/L)	PHOSPHATE, ORTHO (MG/L)	SEDIMENT, SUSPENDED MG/L)	SILICA (MG/L)	SODIUM (MG/L)	SOLIDS, TOTAL DISSOLVED (MG/L)	SULFATE (MG/L)	TEMPERATURE (F°) H_2O	TURBIDITY (JTU)	Temp. Air °C		
8/7/74-1435		125								0	235							125	.05						8.1		.1				125		48	0	20		
10/8/74-1600		145								11	265		2.79					140	.02						8.2						145			7			

48

Name of Source: THUNDER CREEK
Station Number: 21110227 Minor Basin Code: 02
FWI Watershed Number: 65321-009
17010216-11

21110227
COLVILLE NATIONAL FOREST
WATER QUALITY DATA
SUMMARY SHEET

District: SUL. LK.
Station Location:
T. 39 N R. 45 E Sec. 16 Sub. NE NE

Station Type Code: 2111204
Latitude: 48 deg. 53 min. Longitud 117 deg. 06 min

DATE/TIME OF SAMPLE COLLECTION \ WATER PARAMETERS	ACIDITY (MG/L)	ALKALINITY (MG/L)	BICARBONATE (MG/L)	CALCIUM (MG/L)	CARBON DIOXIDE (MG/L)	CARBONATE (MG/L)	CHLORIDE (MG/L)	COLIFORM, FECAL (COLONIES/100 ml.)	COLIFORM, TOTAL (COLONIES/100 ml.)	COLOR (COB UNITS)	CONDUCTIVITY (MICROMHOS)	COPPER (MG/L)	FLOW, STREAM (C.F.S.)	FLUORIDE (MG/L)	HARDNESS, CALCIUM (MG/L)	HARDNESS, MAGNESIUM (MG/L)	HARDNESS, NON-CARBONATE (MG/L)	HARDNESS, TOTAL (MG/L)	IRON (MG/L)	MAGNESIUM (MG/L)	MANGANESE (MG/L)	NITRATES (MG/L)	NITRITES (MG/L)	OXYGEN, DISSOLVED (MG/L)	pH (STANDARD UNITS)	PHOSPHATE, META (MG/L)	PHOSPHATE, ORTHO (MG/L)	SEDIMENT, SUSPENDED MG/L)	SILICA (MG/L)	SODIUM (MG/L)	SOLIDS, TOTAL DISSOLVED (MG/L)	SULFATE (MG/L)	AIR TEMPERATURE (C°)	WATER TEMPERATURE (C°)	TURBIDITY (JTU)		
7/2/71-0000																																			7			
7/28/71-0000																																			10			
8/19/71-1015																																				.13		

21-2500-3 (10/76)

21110228

COLVILLE NATIONAL FOREST
WATER QUALITY DATA
SUMMARY SHEET

Name of Source: Stony Creek
Station Number: 211102281 Minor Basin Code: 02
PWI Watershed Number: 76-02-00-00-09
65321-009 17010216-11

District: Sullivan
Station Location: T. 39 R. 44 Sec. 35 Sub. NE SE
Station Type Code: 2111204
Latitude: 48 deg. 51 min. Longitude: 117 deg. 10 min.

DATE/TIME OF SAMPLE COLLECTION	ACIDITY (MG/L)	ALKALINITY (MG/L)	BICARBONATE (MG/L)	CALCIUM (MG/L)	CARBON DIOXIDE (MG/L)	CARBONATE (MG/L)	CHLORIDE (MG/L)	COLIFORM, FECAL (COLONIES/100 ml.)	COLIFORM, TOTAL (COLONIES/100 ml.)	COLOR (COB UNITS)	CONDUCTIVITY (MICROMHOS)	COPPER (MG/L)	FLOW, STREAM (C.F.S.)	FLUORIDE (MG/L)	HARDNESS, CALCIUM (MG/L)	HARDNESS, MAGNESIUM (MG/L)	HARDNESS, NON-CARBONATE (MG/L)	HARDNESS, TOTAL (MG/L)	IRON (MG/L)	MAGNESIUM (MG/L)	MANGANESE (MG/L)	NITRATES (MG/L)	NITRITES (MG/L)	OXYGEN, DISSOLVED (MG/L)	pH (STANDARD UNITS)	PHOSPHATE, META (MG/L)	PHOSPHATE, ORTHO (MG/L)	SEDIMENT, SUSPENDED MG/L)	SILICA (MG/L)	SODIUM (MG/L)	SOLIDS, TOTAL DISSOLVED (MG/L)	SULFATE (MG/L)	AIR TEMPERATURE (C°)	WATER TEMPERATURE (C°)	TURBIDITY (JTU)		
8/23/62-1100													2.3																									
5/20/63-1000													20.4																									
5/4/64-10.30													11.6																									
4/29/65-1600													1.49																									
5/6/65-1645													21.2																									
5/20/65-1100													50.8																									
6/4/65-1515													11.7																									
6/30/65-1400													3.25																									
8/3/65-1330													18.5																									
9/2/65-1050													9.7																									
5/13/66-																																			1.0			
3/24/68																																			1.13			
6/10/68																																			2.1			
6/16/68																																			.85			
4/8/69-0900																																			1			
4/24/69																																			17			
5/13/69																																			43			

21-2500-3 (10/76)

21110228

COLVILLE NATIONAL FOREST
WATER QUALITY DATA
SUMMARY SHEET

Name of Source: STONY CREEK
Station Number: 21110228 Minor Basin Code: 02
PWI Watershed Number: 16-02-00-00-09
65321-009 17010216-11

District: SULLIVAN LAKE
Station Location:
T. 39 N. R. 44 E. Sec. 25 Sub. NE SE

Station Type Code:
Latitude: 48 deg. 51 min. Longitude: 117 deg. 10 min.

DATE/TIME OF SAMPLE COLLECTION	ACIDITY (MG/L)	ALKALINITY (MG/L)	BICARBONATE (MG/L)	CALCIUM (MG/L)	CARBON DIOXIDE (MG/L)	CARBONATE (MG/L)	CHLORIDE (MG/L)	COLIFORM, FECAL (COLONIES/100 ml.)	COLIFORM, TOTAL (COLONIES/100 ml.)	COLOR (COB UNITS)	CONDUCTIVITY (MICROMHOS)	COPPER (MG/L)	FLOW, STREAM (C.F.S.)	FLUORIDE (MG/L)	HARDNESS, CALCIUM (MG/L)	HARDNESS, MAGNESIUM (MG/L)	HARDNESS, NON-CARBONATE (MG/L)	HARDNESS, TOTAL (MG/L)	IRON (MG/L)	MAGNESIUM (MG/L)	MANGANESE (MG/L)	NITRATES (MG/L)	NITRITES (MG/L)	OXYGEN, DISSOLVED (MG/L)	pH (STANDARD UNITS)	PHOSPHATE, META (MG/L)	PHOSPHATE, ORTHO (MG/L)	SEDIMENT, SUSPENDED MG/L)	SILICA (MG/L)	SODIUM (MG/L)	SOLIDS, TOTAL DISSOLVED (MG/L)	SULFATE (MG/L)	AIR TEMPERATURE (C°)	WATER TEMPERATURE (C°)	TURBIDITY (JTU)		
9/23/69																																				1.1	
4/7/70-1550																																				19	
5/4/70-1450																																				23	
5/6/70-1450																																				4.5	
5/17/70-1400																																				3.7	
5/27/70-1210			7/2/71					Water temp				8°																								6.5	
4/12/71-1445			7/28/71					"		"		12°																								.18	
5/3/71-1500																																				32	
8/19/71-1045																																				.18	
4/27/72-1540																																				1.0	
5/12/72-1600																																				15	
5/14/72-1900																																				51	
5/15/72-1515																																				25	
5/22/72-0930																																				8	
5/30/72-1600																																				43	
10/8/74-1520													2.8																								
4/16/80-1300																																				33	

21-2500-3 (10/76)

21110211

COLVILLE NATIONAL FOREST
DATA SUMMARY SHEET

Name of Source MANKATO CREEK
Station Number 21110211 Minor Basin Code 02
PWI Watershed Number 16-02-00-00-09
65321-009 17010216-11

District SULLIVAN LAKE
Station Location:
T. 39 N R. 45 E Sec. 19 Sub. NE NE

Station Type Code 21112
Latitude: 48 deg. 52 min. Longi: 117 deg. 08

DATE/TIME OF SAMPLE COLLECTION	ACIDITY (MG/L)	ALKALINITY (MG/L)	BICARBONATE (MG/L)	CALCIUM (MG/L)	CARBON DIOXIDE (MG/L)	CARBONATE (MG/L)	CHLORIDE (MG/L)	COLIFORM, FECAL (COLONIES/100 ml.)	COLIFORM, TOTAL (COLONIES/100 ml.)	COLOR (COB UNITS)	CONDUCTIVITY (MICROMHOS)	COPPER (MG/L)	FLOW, STREAM (C.F.S.)	FLUORIDE (MG/L)	HARDNESS, CALCIUM (MG/L)	HARDNESS, MAGNESIUM (MG/L)	HARDNESS, NON-CARBONATE (MG/L)	HARDNESS, TOTAL (MG/L)	IRON (MG/L)	MAGNESIUM (MG/L)	MANGANESE (MG/L)	NITRATES (MG/L)	NITRITES (MG/L)	OXYGEN, DISSOLVED (MG/L)	pH (STANDARD UNITS)	PHOSPHATE, META (MG/L)	PHOSPHATE, ORTHO (MG/L)	SEDIMENT, SUSPENDED MG/L)	SILICA (MG/L)	SODIUM (MG/L)	SOLIDS, TOTAL DISSOLVED (MG/L)	SULFATE (MG/L)	TEMPERATURE (F°)	TURBIDITY (JTU)	Temp., Air F°	" " C°
8/07/70-1115		65								0	123							60	0						7.7						60		44	0		16
8/14/73		102.7									140							102.7						11	8								54	.16	76	
4/4/74-1330																																		.18		
6/10/74											102																	13.1					42			
6/12/74																												29.5								

52

53

Name of Source GYPSY CREEK
Station Number 21110217 Minor Basin Code 02
PWI Watershed Number 16-02-00-00-09
65321-009 17010216-11

21110217
COLVILLE NATIONAL FOREST
DATA SUMMARY SHEET

District SULLIVAN LAKE
Station Location:
T. 39 N R. 45 E Sec. 19 Sub. NE NE

Station Type Code 21 1 1 204
Latitude: 48 deg. 52 min. Longitude 117 deg. 08 min.

DATE/TIME OF SAMPLE COLLECTION	ACIDITY (MG/L)	ALKALINITY (MG/L)	BICARBONATE (MG/L)	CALCIUM (MG/L)	CARBON DIOXIDE (MG/L)	CARBONATE (MG/L)	CHLORIDE (MG/L)	COLIFORM, FECAL (COLONIES/100 ml.)	COLIFORM, TOTAL (COLONIES/100 ml.)	COLOR (COB UNITS)	CONDUCTIVITY (MICROMHOS)	COPPER (MG/L)	FLOW, STREAM (C.F.S.)	FLUORIDE (MG/L)	HARDNESS, CALCIUM (MG/L)	HARDNESS, MAGNESIUM (MG/L)	HARDNESS, NON-CARBONATE (MG/L)	HARDNESS, TOTAL (MG/L)	IRON (MG/L)	MAGNESIUM (MG/L)	MANGANESE (MG/L)	NITRATES (MG/L)	NITRITES (MG/L)	OXYGEN, DISSOLVED (MG/L)	pH (STANDARD UNITS)	PHOSPHATE, META (MG/L)	PHOSPHATE, ORTHO (MG/L)	SEDIMENT, SUSPENDED MG/L)	SILICA (MG/L)	SODIUM (MG/L)	SOLIDS, TOTAL DISSOLVED (MG/L)	SULFATE (MG/L)	TEMPERATURE (F°)	TURBIDITY (~~JTU~~ NTU)	Temp Air C°	Water Temp C°	RATING	
7/2/71																																	47			9		
7/28/71 —																																	54			12		
8/19/71-1030																																		.12				
6/10/74 —											70																	115.4					47			5		
6/11/74 —																												260.9										
8/7/74-1115		70								0								70	.04						7.5						75		47	0	16	8		
10/8/74-1500		100								10	182		2.58					90	.02						8.0		.09				97			5				
6/26/89-1420											130														8.21						75			.25				
4/19/90-0950											140														8.25						85			.65	12	7	GOOD	
5/9/90-1036											130														8.21						95			.23	14	3		
6/19/90-1358											85														8.05						65			.46	18	8.5		
7/24/90-0959											140														8.31						100			.37	17	10		
8/28/90-1307											170														8.25						100			.20	24	8		
9/24/90-1500											185														8.22						115			.16	22	10	GOOD	
10/31/90-1310											150														8.22						90			.30	20	4.5		
11/28/90-1150											120																				75			.32	2	0		

21110217

COLVILLE NATIONAL FOREST
WATER QUALITY DATA
SUMMARY SHEET

Name of Source: Gypsy
Station Number: Minor Basin Code: 02
PWI Watershed Number: 16-02-00-00-09
17010216-11

District: SULLIVAN LK
Station Location:
T. 39 R. 45 Sec. 19 Sub. NE NE

Station Type Code: 2111
Latitude: 48 deg. 52 min. Lon 117 deg 0

DATE/TIME OF SAMPLE COLLECTION \ WATER PARAMETERS	ACIDITY (MG/L)	ALKALINITY (MG/L)	BICARBONATE (MG/L)	CALCIUM (MG/L)	CARBON DIOXIDE (MG/L)	CARBONATE (MG/L)	CHLORIDE (MG/L)	COLIFORM, FECAL (COLONIES/100 ml.)	COLIFORM, TOTAL (COLONIES/100 ml.)	COLOR (COB UNITS)	CONDUCTIVITY (MICROMHOS)	COPPER (MG/L)	FLOW, STREAM (C.F.S.)	FLUORIDE (MG/L)	HARDNESS, CALCIUM (MG/L)	HARDNESS, MAGNESIUM (MG/L)	HARDNESS, NON-CARBONATE (MG/L)	HARDNESS, TOTAL (MG/L)	IRON (MG/L)	MAGNESIUM (MG/L)	MANGANESE (MG/L)	NITRATES (MG/L)	NITRITES (MG/L)	OXYGEN, DISSOLVED (MG/L)	pH (STANDARD UNITS)	PHOSPHATE, META (MG/L)	PHOSPHATE, ORTHO (MG/L)	SEDIMENT, SUSPENDED MG/L)	SILICA (MG/L)	SODIUM (MG/L)	SOLIDS, TOTAL DISSOLVED (MG/L)	SULFATE (MG/L)	AIR TEMPERATURE (C°)	WATER TEMPERATURE (C°)	TURBIDITY (JTU)	STABILITY RATING
5/30/91-1530								2			80														8.04						45		16	5.	1.7	
6/12/91-1317								0			70														8.08						45		8	4	1.3	
7/9/91-1500								0			125														8.20						80		19	10	.22	
8/27/91-1330								0			195		4.08												8.24						100		23	10	.24	Good
9/19/91-1130								0			175		—												8.22						100		14	9.	.10	Good
10/15/91-1200								0			175		1.85												8.16						100		10	4	.40	Good
11/7/91-1135								2			175		—												8.01						100		4	3	.15	—
4/22/92 1330								0			95		25.97												7.96						50		5	4	1.2	Good
5/27/92 1225											90														8.21						60		18	8	.21	
6/23/92-1450								0			130														8.13						80		27	16	.14	
7/21/92-1415								1			200														8.18						90		19	11	.35	
8/20/92-1605								2			180														8.26						100		23	11	.10	
10/28/92 1545								0			80														8.24						100		7	3	.10	

Name of Source Cascade Creek *
Station Number 21110223 Minor Basin Code
PWI Watershed Number

COLVILLE NATIONAL FOREST
WATER QUALITY DATA
SUMMARY SHEET

District Sullivan Lk.
Station Location:
T. 39 N R. 44 E Sec. 34 Sub. NE SE

Station Type Code
Latitude: 48 deg. 50 min. Longitude 117 deg. 13 min.

WATER PARAMETERS / DATE/TIME OF SAMPLE COLLECTION	ACIDITY (MG/L)	ALKALINITY (MG/L)	BICARBONATE (MG/L)	CALCIUM (MG/L)	CARBON DIOXIDE (MG/L)	CARBONATE (MG/L)	CHLORIDE (MG/L)	COLIFORM, FECAL (COLONIES/100 ml.)	COLIFORM, TOTAL (COLONIES/100 ml.)	COLOR (COB UNITS)	CONDUCTIVITY (MICROMHOS)	COPPER (MG/L)	FLOW, STREAM (C.F.S.)	FLUORIDE (MG/L)	HARDNESS, CALCIUM (MG/L)	HARDNESS, MAGNESIUM (MG/L)	HARDNESS, NON-CARBONATE (MG/L)	HARDNESS, TOTAL (MG/L)	IRON (MG/L)	MAGNESIUM (MG/L)	MANGANESE (MG/L)	NITRATES (MG/L)	NITRITES (MG/L)	OXYGEN, DISSOLVED (MG/L)	pH (STANDARD UNITS)	PHOSPHATE, META (MG/L)	PHOSPHATE, ORTHO (MG/L)	SEDIMENT, SUSPENDED MG/L)	SILICA (MG/L)	SODIUM (MG/L)	SOLIDS, TOTAL DISSOLVED (MG/L)	SULFATE (MG/L)	AIR TEMPERATURE (°C)	WATER TEMPERATURE (°C)	TURBIDITY (JTU)			
7/2/71																																			6				
7/28/71																																			7				
8/19/71-1145																																				.16			
7/30/76		30									43.5				12	8		20				.15	.005		6.9		.09				23	2			.12				
6/27/84-1140											35											.03			6.5						20				.22				

* Stream Channel Stability Evaluation 63 Low Good
(Some debris jam Potential)

21-2500-3 (10/76)

ıme of Source DEEMER CREEK
ation Number 21110231 Minor Basin Code 02
:I Watershed Number 65321-009

21110231
COLVILLE NATIONAL FOREST
WATER QUALITY DATA
SUMMARY SHEET

District SULLIVAN LAKE
Station Location:
T. 39 N R. 45 E Sec. 03 Sub. NE NW

Station Type Code 21 11204
Latitude: 48 deg. 54 min. Longitude 117 deg. 05 min.

17010216-11

WATER PARAMETERS / DATE/TIME SAMPLE COLLECTION	ACIDITY (MG/L)	ALKALINITY (MG/L)	BICARBONATE (MG/L)	CALCIUM (MG/L)	CARBON DIOXIDE (MG/L)	CARBONATE (MG/L)	CHLORIDE (MG/L)	COLIFORM, FECAL (COLONIES/100 ml.)	COLIFORM, TOTAL (COLONIES/100 ml.)	COLOR (COB UNITS)	CONDUCTIVITY (MICROMHOS)	COPPER (MG/L)	FLOW, STREAM (C.F.S.)	FLUORIDE (MG/L)	HARDNESS, CALCIUM (MG/L)	HARDNESS, MAGNESIUM (MG/L)	HARDNESS, NON-CARBONATE (MG/L)	HARDNESS, TOTAL (MG/L)	IRON (MG/L)	MAGNESIUM (MG/L)	MANGANESE (MG/L)	NITRATES (MG/L)	NITRITES (MG/L)	OXYGEN, DISSOLVED (MG/L)	pH (STANDARD UNITS)	PHOSPHATE, META (MG/L)	PHOSPHATE, ORTHO (MG/L)	SEDIMENT, SUSPENDED MG/L)	SILICA (MG/L)	SODIUM (MG/L)	SOLIDS, TOTAL DISSOLVED (MG/L)	SULFATE (MG/L)	AIR TEMPERATURE (C°)	WATER TEMPERATURE (C°)	TURBIDITY (JTU)	STABILITY RATING
1040 10/15/91								0			115		3.31												8.24						75		8	5	.46	GOOD
1100 11/7/91								0			195		—												7.96						75		3	2	.25	GOOD
1330 5/21/92								0			90		50.85												8.20			28			60		11	5	.22	
1405 6/23/92								7			115														8.16						70		25	13	.40	
1340 7/21/92								5			160														8.08						75		18	10	.28	
1540 8/20/92								0			110														8.31						75		24	10	.15	
1520 10/28/92								0			120														8.06						75		7	2	.20	

56

57

Name of Source DEEMER CREEK
Station Number 21110231 Minor Basin Code 02
PWI Watershed Number 65321 - 009
17010216 - 11

21110231
COLVILLE NATIONAL FOREST
DATA SUMMARY SHEET

District SULLIVAN LAKE
Station Location:
T. 39 N R. 45 E Sec. 03 Sub. NE NW

Station Type Code 2 1 1 1
Latitude: 48 deg. 54 min. Long 1 1 7 deg. 0

DATE/TIME OF SAMPLE COLLECTION	ACIDITY (MG/L)	ALKALINITY (MG/L)	BICARBONATE (MG/L)	CALCIUM (MG/L)	CARBON DIOXIDE (MG/L)	CARBONATE (MG/L)	CHLORIDE (MG/L)	COLIFORM, FECAL (COLONIES/100 ml.)	COLIFORM, TOTAL (COLONIES/100 ml.)	COLOR (COB UNITS)	CONDUCTIVITY (MICROMHOS)	COPPER (MG/L)	FLOW, STREAM (C.F.S.)	FLUORIDE (MG/L)	HARDNESS, CALCIUM (MG/L)	HARDNESS, MAGNESIUM (MG/L)	HARDNESS, NON-CARBONATE (MG/L)	HARDNESS, TOTAL (MG/L)	IRON (MG/L)	MAGNESIUM (MG/L)	MANGANESE (MG/L)	NITRATES (MG/L)	NITRITES (MG/L)	OXYGEN, DISSOLVED (MG/L)	pH (STANDARD UNITS)	PHOSPHATE, META (MG/L)	PHOSPHATE, ORTHO (MG/L)	SEDIMENT, SUSPENDED MG/L)	SILICA (MG/L)	SODIUM (MG/L)	SOLIDS, TOTAL DISSOLVED (MG/L)	SULFATE (MG/L)	TEMPERATURE (F°)	~~TURBIDITY~~ TURBIDITY (JTU)	TEMP. AIR °C	TEMP. H2O °C	D
✓ 8/19/71-0945																																		.15			
✓ 8/19/71- —																																		.13			
✓ 8/19/71-0950																																		2.8	READ BE GRADED		NU
✓ 6/13/74-1145																												94.3									
✓ 8/7/74-1145		70								0	119							65	.04						7.8		.1				60		46	0	16	8	
✓ 10/8/74-1245		70								18	135		2.1					65	.03						7.9						70			6			
5/1/90- 1107											120														7.92						70			.24	14	3	
7/24/90- 1025											110														8.44						75			.24	17	9	
8/28/90- 1345											125														7.94						75			.14	19	9	60°
9/24/90- 1420											140														8.21						80			.27	21	10	60°
10/31/90- 1345											130														8.32						70			.53	5	3	
11/28/90- 1120											130																				80			.45	-2	0	
6/12/91- 1250								0			70		72.												8.01						45			1.1	9	3	
7/9/91- 1430								2			100														8.03						63			.20	20	9	
8/27/91-1145								0			120		0.34												8.28						75			.35	22	10	60°
9/19/91-1045								0			115		—												8.22						75			.20	13	8	60°

Name of Source LEOLA CREEK (upper)
Station Number 21110313 Minor Basin Code 02
PWI Watershed Number 16-02-00-00-09
17010216-11 65321-009

COLVILLE NATIONAL FOREST
WATER QUALITY DATA
SUMMARY SHEET
21110313

District SULLIVAN LK.
Station Location:
T. 39 N R. 45 E Sec. 4 Sub. NW NW

Station Type Code 211120
Latitude: 48 deg. 55 min. Longit 117 deg. 07 m

WATER PARAMETERS / DATE/TIME OF SAMPLE COLLECTION	ACIDITY (MG/L)	ALKALINITY (MG/L)	BICARBONATE (MG/L)	CALCIUM (MG/L)	CARBON DIOXIDE (MG/L)	CARBONATE (MG/L)	CHLORIDE (MG/L)	COLIFORM, FECAL (COLONIES/100 ml.)	COLIFORM, TOTAL (COLONIES/100 ml.)	COLOR (COB UNITS)	CONDUCTIVITY (MICROMHOS)	COPPER (MG/L)	FLOW, STREAM (C.F.S.)	FLUORIDE (MG/L)	HARDNESS, CALCIUM (MG/L)	HARDNESS, MAGNESIUM (MG/L)	HARDNESS, NON-CARBONATE (MG/L)	HARDNESS, TOTAL (MG/L)	IRON (MG/L)	MAGNESIUM (MG/L)	MANGANESE (MG/L)	NITRATES (MG/L)	NITRITES (MG/L)	OXYGEN, DISSOLVED (MG/L)	pH (STANDARD UNITS)	PHOSPHATE, META (MG/L)	PHOSPHATE, ORTHO (MG/L)	SEDIMENT, SUSPENDED MG/L)	SILICA (MG/L)	SODIUM (MG/L)	SOLIDS, TOTAL DISSOLVED (MG/L)	SULFATE (MG/L)	AIR TEMPERATURE (C°)	WATER TEMPERATURE (C°)	TURBIDITY (JTU)		
8/7/74 -1150		50								0	87							40	.1						7.5						46		18	9	0		
10/8/74 - 1208													.75																									
10/18/76 - 1315		60									100							47				.25	.001		7.6		.24				55		5	1	.32		
5/20/77 - 1030									5		80											.42			7.6						40		17	4	.12		
7/5/77 - 1130									26		77											.25			8.0						49		13	8	.11		
8/10/77 - 1630									0		118											.20			8.25						60		22	10	.09		
9/6/77 - 1000									41		115											.19			7.3						53		17	6	.10		
10/5/77 - 1030									0		100		12									.21			7.65						50		11	3	.08		

21-2500-3 (10/76)

Name of Source LEOLA CREEK (lower)
Station Number 21110314 Minor Basin Code 02
PWI Watershed Number 16-02-00-00-09
17010216-11 65321-009

21110314
COLVILLE NATIONAL FOREST
WATER QUALITY DATA
SUMMARY SHEET

District SULLIVAN LK. R.D. Station Type Code 21110314
Station Location:
T. 39 N R. 45 E Sec. 3 Sub. NE SW
Latitude: 48 deg. 55 min. Longitude: 117 deg. 05 min.

DATE/TIME OF SAMPLE COLLECTION	ACIDITY (MG/L)	ALKALINITY (MG/L)	BICARBONATE (MG/L)	CALCIUM (MG/L)	CARBON DIOXIDE (MG/L)	CARBONATE (MG/L)	CHLORIDE (MG/L)	COLIFORM, FECAL (COLONIES/100 ml.)	COLIFORM, TOTAL (COLONIES/100 ml.)	COLOR (COB UNITS)	CONDUCTIVITY (MICROMHOS)	COPPER (MG/L)	FLOW, STREAM (C.F.S.)	FLUORIDE (MG/L)	HARDNESS, CALCIUM (MG/L)	HARDNESS, MAGNESIUM (MG/L)	HARDNESS, NON-CARBONATE (MG/L)	HARDNESS, TOTAL (MG/L)	IRON (MG/L)	MAGNESIUM (MG/L)	MANGANESE (MG/L)	NITRATES (MG/L)	NITRITES (MG/L)	OXYGEN, DISSOLVED (MG/L)	pH (STANDARD UNITS)	PHOSPHATE, META (MG/L)	PHOSPHATE, ORTHO (MG/L)	SEDIMENT, SUSPENDED MG/L)	SILICA (MG/L)	SODIUM (MG/L)	SOLIDS, TOTAL DISSOLVED (MG/L)	SULFATE (MG/L)	AIR TEMPERATURE (C°)	WATER TEMPERATURE (C°)	TURBIDITY (JTU)		
5/20/77-1030									3		80											.25			7.6						43		12	4	.13		
7/5/77-1130									30		105											.20			8.1						50		13	8	.11		
8/10/77-1145									0		145											.18			8.3						75		20	10	.08		
9/6/77-1030									22		122											.16			7.45						57		14	6	.10		
10/5/77-1015									0		112		12									.23			7.75						65		8	2.5	.075		

21-2500-3 (10/76)

21110210

COLVILLE NATIONAL FOREST
DATA SUMMARY SHEET

Name of Source KINYON CREEK
Station Number 21110210 Minor Basin Code 02
PWI Watershed Number 16-02-00-00-09
65321-009 17 0102/6

District SULLIVAN LAKE
Station Location:
T. 39 N R. 45 E Sec. 19 Sub. NE SW

Station Type Code 21 1 2
Latitude: 48 deg. 51 min. 1 1 7 deg. 0 2
Longi

DATE/TIME OF SAMPLE COLLECTION	ACIDITY (MG/L)	ALKALINITY (MG/L)	BICARBONATE (MG/L)	CALCIUM (MG/L)	CARBON DIOXIDE (MG/L)	CARBONATE (MG/L)	CHLORIDE (MG/L)	COLIFORM, FECAL (COLONIES/100 ml.)	COLIFORM, TOTAL (COLONIES/100 ml.)	COLOR (COB UNITS)	CONDUCTIVITY (MICROMHOS)	COPPER (MG/L)	FLOW, STREAM (C.F.S.)	FLUORIDE (MG/L)	HARDNESS, CALCIUM (MG/L)	HARDNESS, MAGNESIUM (MG/L)	HARDNESS, NON-CARBONATE (MG/L)	HARDNESS, TOTAL (MG/L)	IRON (MG/L)	MAGNESIUM (MG/L)	MANGANESE (MG/L)	NITRATES (MG/L)	NITRITES (MG/L)	OXYGEN, DISSOLVED (MG/L)	pH (STANDARD UNITS)	PHOSPHATE, META (MG/L)	PHOSPHATE, ORTHO (MG/L)	SEDIMENT, SUSPENDED MG/L)	SILICA (MG/L)	SODIUM (MG/L)	SOLIDS, TOTAL DISSOLVED (MG/L)	SULFATE (MG/L)	TEMPERATURE (F°)	TURBIDITY (JTU)	Temp. Air °F	" " °C
✓ 9/3/73		102.7									160							102.7						11.5	8								47	.1	58	
✓ 4/4/74-1420																																		.12		
✓ 6/11/74																												42								
8/07/74-1100		75								0	14.2							65	0						7.8						75		49	0		16

21110218

COLVILLE NATIONAL FOREST
DATA SUMMARY SHEET

Name of Source UPPER SULLIVAN CREEK
Station Number 21110218 Minor Basin Code 02
PWI Watershed Number 16-02-00-00-09
65321-009 17010216-11

District SULLIVAN LAKE
Station Location:
T. 39 N R. 45 E Sec. 03 Sub. NE SE

Station Type Code 21112
Latitude: 48deg.54min. Longi 117deg.04

DATE/TIME OF SAMPLE COLLECTION	ACIDITY (MG/L)	ALKALINITY (MG/L)	BICARBONATE (MG/L)	CALCIUM (MG/L)	CARBON DIOXIDE (MG/L)	CARBONATE (MG/L)	CHLORIDE (MG/L)	COLIFORM, FECAL (COLONIES/100 ml.)	COLIFORM, TOTAL (COLONIES/100 ml.)	COLOR (COB UNITS)	CONDUCTIVITY (MICROMHOS)	COPPER (MG/L)	FLOW, STREAM (C.F.S.)	FLUORIDE (MG/L)	HARDNESS, CALCIUM (MG/L)	HARDNESS, MAGNESIUM (MG/L)	HARDNESS, NON-CARBONATE (MG/L)	HARDNESS, TOTAL (MG/L)	IRON (MG/L)	MAGNESIUM (MG/L)	MANGANESE (MG/L)	NITRATES (MG/L)	NITRITES (MG/L)	OXYGEN, DISSOLVED (MG/L)	pH (STANDARD UNITS)	PHOSPHATE, META (MG/L)	PHOSPHATE, ORTHO (MG/L)	SEDIMENT, SUSPENDED MG/L)	SILICA (MG/L)	SODIUM (MG/L)	SOLIDS, TOTAL DISSOLVED (MG/L)	SULFATE (MG/L)	TEMPERATURE (F°) AIR	TURBIDITY (JTU) NTU	WATER TEMP C°	RATING
9/23/69																																			.185	
7/2/71																																	~~47~~		9	
7/28/71																																	~~54~~		12	
8/19/71-1000																																			.18	
5/16/72-1500																																			3.1	
6/13/74																												106.6								
10/8/74-1400													3.39																							
6/19/90-1419											80														8.16						50		15 C°	.30	8	GOOD
7/24/90-1015											95														8.44						40		15	.24	10	
8/28/90-1320											110														8.27						75		23	.24	8	
9/24/90-1435											130														8.34						75		19	.17	9	GOOD
10/31/90-1325											120														8.29						65		9	.32	3	
11/28/90-1135											100														[illegible]						70		0	.35	0	
6/12/91-1300								0			70		63.												8.06						45		10	1.0	3	
7/9/91-1441								1			85														8.12						55		20	.21	9	
8/27/91-1240								1			120		1.50												8.25						75		22	.22	10	GOOD

21110218

COLVILLE NATIONAL FOREST
WATER QUALITY DATA
SUMMARY SHEET

ame of Source UPPER SULLIVAN CREEK
ation Number 21110218 Minor Basin Code 02
I Watershed Number 16-02-00-00-09
65321-009 17010216-11

District SULLIVAN
Station Location:
T. 39 N R. 45 E Sec. 05 Sub. NE SE

Station Type Code 2 1 1 1 2 0
Latitude: 48deg.54min. Longitu 117deg.04mi

WATER PARAMETERS / DATE/TIME SAMPLE COLLECTION	ACIDITY (MG/L)	ALKALINITY (MG/L)	BICARBONATE (MG/L)	CALCIUM (MG/L)	CARBON DIOXIDE (MG/L)	CARBONATE (MG/L)	CHLORIDE (MG/L)	COLIFORM, FECAL (COLONIES/100 ml.)	COLIFORM, TOTAL (COLONIES/100 ml.)	COLOR (COB UNITS)	CONDUCTIVITY (MICROMHOS)	COPPER (MG/L)	FLOW, STREAM (C.F.S.)	FLUORIDE (MG/L)	HARDNESS, CALCIUM (MG/L)	HARDNESS, MAGNESIUM (MG/L)	HARDNESS, NON-CARBONATE (MG/L)	HARDNESS, TOTAL (MG/L)	IRON (MG/L)	MAGNESIUM (MG/L)	MANGANESE (MG/L)	NITRATES (MG/L)	NITRITES (MG/L)	OXYGEN, DISSOLVED (MG/L)	pH (STANDARD UNITS)	PHOSPHATE, META (MG/L)	PHOSPHATE, ORTHO (MG/L)	SEDIMENT, SUSPENDED MG/L)	SILICA (MG/L)	SODIUM (MG/L)	SOLIDS, TOTAL DISSOLVED (MG/L)	SULFATE (MG/L)	AIR TEMPERATURE (C°)	WATER TEMPERATURE (C°)	TURBIDITY (~~JTU~~) NTU	STABILITY RATING	
1112 9/19/91								0			115		—												8.25						75		9	8	.20	GOOD	
1130 10/15/91								1			105		1.78												8.25						75		5	5	.50	GOOD	
1115 11/7/91								0			110		—												8.05						75		4	1	.25	—	
1402 5/21/92								0			90														7.54						55		9	5	.19		
1425 6/23/92								0			105														8.22						70		25	13	.17		
1355 7/21/92								2			150														8.19						75		19	10	.25		
1550 8/20/92								0			140														8.19						100		18	10	.15		
1535 10/28/92								0			25														8.11						75		7	1	.10		

21110233

COLVILLE NATIONAL FOREST
WATER QUALITY DATA
SUMMARY SHEET

Name of Source SULLIVAN CR GYPSY
Station Number 21110233 Minor Basin Code
PWI Watershed Number

District SULLIVAN LK
Station Location:
T. 39 R. 45 Sec. 19 Sub. SW-NE

Station Type Code
Latitude: deg. min. Longit deg. m

DATE/TIME OF SAMPLE COLLECTION \ WATER PARAMETERS	ACIDITY (MG/L)	ALKALINITY (MG/L)	BICARBONATE (MG/L)	CALCIUM (MG/L)	CARBON DIOXIDE (MG/L)	CARBONATE (MG/L)	CHLORIDE (MG/L)	COLIFORM, FECAL (COLONIES/100 ml.)	COLIFORM, TOTAL (COLONIES/100 ml.)	COLOR (COB UNITS)	CONDUCTIVITY (MICROMHOS)	COPPER (MG/L)	FLOW, STREAM (C.F.S.)	FLUORIDE (MG/L)	HARDNESS, CALCIUM (MG/L)	HARDNESS, MAGNESIUM (MG/L)	HARDNESS, NON-CARBONATE (MG/L)	HARDNESS, TOTAL (MG/L)	IRON (MG/L)	MAGNESIUM (MG/L)	MANGANESE (MG/L)	NITRATES (MG/L)	NITRITES (MG/L)	OXYGEN, DISSOLVED (MG/L)	pH (STANDARD UNITS)	PHOSPHATE, META (MG/L)	PHOSPHATE, ORTHO (MG/L)	SEDIMENT, SUSPENDED MG/L)	SILICA (MG/L)	SODIUM (MG/L)	SOLIDS, TOTAL DISSOLVED (MG/L)	SULFATE (MG/L)	AIR TEMPERATURE (C°)	WATER TEMPERATURE (C°)	TURBIDITY (JTU)		
08/31/89 - 1135											155																											
09/27/89 - 0925											170																					75				>1.0		
																																80				.16		

21110212

COLVILLE NATIONAL FOREST
DATA SUMMARY SHEET

Name of Source: SULLIVAN CREEK II
Station Number: 21110212 Minor Basin Code: 02
PWI Watershed Number: 16-02-00-00-09
65321-009 17/10/0216-11

District: SULLIVAN LAKE
Station Location: T. 39 N R. 45 E Sec. 10 Sub. SW NE

Station Type Code: 21 1 1 20
Latitude: 48 deg. 53 min. Longitude: 117 deg. 04 min

DATE/TIME OF SAMPLE COLLECTION	ACIDITY (MG/L)	ALKALINITY (MG/L)	BICARBONATE (MG/L)	CALCIUM (MG/L)	CARBON DIOXIDE (MG/L)	CARBONATE (MG/L)	CHLORIDE (MG/L)	COLIFORM, FECAL (COLONIES/100 mL.)	COLIFORM, TOTAL (COLONIES/100 mL.)	COLOR (COB UNITS)	CONDUCTIVITY (MICROMHOS)	COPPER (MG/L)	FLOW, STREAM (C.F.S.)	FLUORIDE (MG/L)	HARDNESS, CALCIUM (MG/L)	HARDNESS, MAGNESIUM (MG/L)	HARDNESS, NON-CARBONATE (MG/L)	HARDNESS, TOTAL (MG/L)	IRON (MG/L)	MAGNESIUM (MG/L)	MANGANESE (MG/L)	NITRATES (MG/L)	NITRITES (MG/L)	OXYGEN, DISSOLVED (MG/L)	pH (STANDARD UNITS)	PHOSPHATE, META (MG/L)	PHOSPHATE, ORTHO (MG/L)	SEDIMENT, SUSPENDED MG/L)	SILICA (MG/L)	SODIUM (MG/L)	SOLIDS, TOTAL DISSOLVED (MG/L)	SULFATE (MG/L)	TEMPERATURE (F°) Water	TURBIDITY (JTU) NTU	Temp. Air °F	" °C		
8/17/71 —	9	85.6			10													68.4						9	7.5													
8/19/71 —																																		.18				
3/30/72-1615																																		.3				
5/4/72-1715																																		1.2				
5/5/72-1600																																		.5				
8/14/73 —		94.4									120							85.6						10.5	8								55	.29	78			
4/4/74-1215																																		.15				
6/10/74 —											90																	11.7					39					
6/11/74 —																												152.7										
6/13/74 —																												132.6										
8/7/74-1400		60								0	116							55	.05						7.6						54		49	0		18		
10/8/74-1340		95								230	130		3.39					65	.75						7.2		.26				70			90	Bridge			
06/26/89-1410											100																				60			.6				
08/31/89-1200											120																				60			>1.0				
09/27/89-0955											130																				75			.75				

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Name of Source SULLIVAN CREEK AT BRIDGE
Station Number 21110207 Minor Basin Code 02
PWI Watershed Number 16-02-00-00-09
65321-009 17010216-11

21110207
COLVILLE NATIONAL FOREST
DATA SUMMARY SHEET

District SULLIVAN LAKE
Station Location:
T. 39 N R. 44 E Sec. 30 Sub. SW SE

Station Type Code 21 1 1 2 0 4
Latitude: 48 deg. 49 min. Longitude 117 deg. 17 min.

WATER PARAMETERS / DATE/TIME OF SAMPLE COLLECTION	ACIDITY (MG/L)	ALKALINITY (MG/L)	BICARBONATE (MG/L)	CALCIUM (MG/L)	CARBON DIOXIDE (MG/L)	CARBONATE (MG/L)	CHLORIDE (MG/L)	COLIFORM, FECAL (COLONIES/100 ml.)	COLIFORM, TOTAL (COLONIES/100 ml.)	COLOR (COB UNITS)	CONDUCTIVITY (MICROMHOS)	COPPER (MG/L)	FLOW, STREAM (C.F.S.)	FLUORIDE (MG/L)	HARDNESS, CALCIUM (MG/L)	HARDNESS, MAGNESIUM (MG/L)	HARDNESS, NON-CARBONATE (MG/L)	HARDNESS, TOTAL (MG/L)	IRON (MG/L)	MAGNESIUM (MG/L)	MANGANESE (MG/L)	NITRATES (MG/L)	NITRITES (MG/L)	OXYGEN, DISSOLVED (MG/L)	pH (STANDARD UNITS)	PHOSPHATE, META (MG/L)	PHOSPHATE, ORTHO (MG/L)	SEDIMENT, SUSPENDED MG/L)	SILICA (MG/L)	SODIUM (MG/L)	SOLIDS; TOTAL DISSOLVED (MG/L)	SULFATE (MG/L)	TEMPERATURE (F°)	TURBIDITY (~~JTU~~) NTU				
6/4/60													866																										
9/27-31/60													29																										
5/26-27/61													1190																										
1/3 & 12/5-8/61													20																										
2/23-24/62													10																										
5/28/62													670																										
1/11-12/63													12																										
5/24/63													718																										
2/7/64													19																										
6/3/64													886																										
5/29/65													850																										
12/17/65													12																										
1/20/66													13																										
5/10/66													745																										
5/8/67													110																										
11/11/67													17																										
6/2/68													910																										

6/4/60 - 5/25/70 flow data taken from U.S.G.S. records

21110207

COLVILLE NATIONAL FOREST
DATA SUMMARY SHEET

Name of Source: SULLIVAN CREEK
Station Number: 21110207 Minor Basin Code: 02
PWI Watershed Number: 65321-009
17010216-11

District: SULLIVAN LAKE
Station Location:
T. 39 N R. 44 E Sec. 30 Sub. SW SE

Station Type Code: 21 1 1 204
Latitude: 48 deg. 49 min. Longitude 117 deg. 17 min.

DATE/TIME OF SAMPLE COLLECTION	ACIDITY (MG/L)	ALKALINITY (MG/L)	BICARBONATE (MG/L)	CALCIUM (MG/L)	CARBON DIOXIDE (MG/L)	CARBONATE (MG/L)	CHLORIDE (MG/L)	COLIFORM, FECAL (COLONIES/100 ml.)	COLIFORM, TOTAL (COLONIES/100 ml.)	COLOR (COB UNITS)	CONDUCTIVITY (MICROMHOS)	COPPER (MG/L)	FLOW, STREAM (C.F.S.)	FLUORIDE (MG/L)	HARDNESS, CALCIUM (MG/L)	HARDNESS, MAGNESIUM (MG/L)	HARDNESS, NON-CARBONATE (MG/L)	HARDNESS, TOTAL (MG/L)	IRON (MG/L)	MAGNESIUM (MG/L)	MANGANESE (MG/L)	NITRATES (MG/L)	NITRITES (MG/L)	OXYGEN, DISSOLVED (MG/L)	pH (STANDARD UNITS)	PHOSPHATE, META (MG/L)	PHOSPHATE, ORTHO (MG/L)	SEDIMENT, SUSPENDED MG/L)	SILICA (MG/L)	SODIUM (MG/L)	SOLIDS, TOTAL DISSOLVED (MG/L)	SULFATE (MG/L)	TEMPERATURE (F°)	TURBIDITY (JTU NTU)	TEMP. °F AIR			
12/13/68													15																										
3/9/69													20																										
5/10/69													1080																										
5/13/69																																			32				
2/2/70													25																										
3/16/70-1710																																			.2				
4/3/70-1700																																			.3				
4/6/70-1645																																			1.5				
5/4/70-2145																																			38				
5/17/70-1440																																			13				
5/17/70-1800																																			23				
5/17/70-1945																																			37				
5/22/70-1945																																			23				
5/24/70-1930																																			22				
5/25/70													850		U.S.G.S. Records																								
9/4/70-1355																																			1.7	after 1" rainfall			
4/9/71-1545																																			.44				

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Name of Source SULLIVAN CREEK
Station Number 21110207 Minor Basin Code 02
PWI Watershed Number 65321 — 009
17010216-11

21110207
COLVILLE NATIONAL FOREST
DATA SUMMARY SHEET

District SULLIVAN LK.
Station Location:
T. 39 N R. 44 E Sec. 30 Sub. SW SE

Station Type Code 2 1 1 2 0 4
Latitude: 48 deg. 49 min. Longitude 1 1 7 deg. 17 min.

WATER PARAMETERS / DATE/TIME OF SAMPLE COLLECTION	ACIDITY (MG/L)	ALKALINITY (MG/L)	BICARBONATE (MG/L)	CALCIUM (MG/L)	CARBON DIOXIDE (MG/L)	CARBONATE (MG/L)	CHLORIDE (MG/L)	COLIFORM, FECAL (COLONIES/100 ml.)	COLIFORM, TOTAL (COLONIES/100 ml.)	COLOR (COB UNITS)	CONDUCTIVITY (MICROMHOS)	COPPER (MG/L)	FLOW, STREAM (C.F.S.)	FLUORIDE (MG/L)	HARDNESS, CALCIUM (MG/L)	HARDNESS, MAGNESIUM (MG/L)	HARDNESS, NON-CARBONATE (MG/L)	HARDNESS, TOTAL (MG/L)	IRON (MG/L)	MAGNESIUM (MG/L)	MANGANESE (MG/L)	NITRATES (MG/L)	NITRITES (MG/L)	OXYGEN, DISSOLVED (MG/L)	pH (STANDARD UNITS)	PHOSPHATE, META (MG/L)	PHOSPHATE, ORTHO (MG/L)	SEDIMENT, SUSPENDED MG/L)	SILICA (MG/L)	SODIUM (MG/L)	SOLIDS, TOTAL DISSOLVED (MG/L)	SULFATE (MG/L)	TEMPERATURE (F°)	TURBIDITY (~~JTU~~) NTU	Acidity. Free	Phenolphthalein Acidity		
✓ 4/21/71 - 1500																																			.43				
✓ 5/3/71 - 1345																																			6.8				
✓ 5/4/71 - 1645																																			23				
✓ 7/2/71 p.m																																		50					
• 7/28/71 p.m.																																		58					
✓ 8/12/71	5.1	136.8																102.6						8	8											0			
✓ 8/19/71 - 1240																																			.11				
✓ 3/30/72 - 1615																																			.3				
✓ 5/4/72 - 1715																																			1.2				
• 5/5/72 - 1600																																			.5				
• 5/9/72 - 1730																																			.7				
✓ 5/9/72 - 1745																																			1.8				
• 5/10/72 - 1600																																			1.6				
• 5/12/72 - 1545																																			6.5				
• 5/14/72 - 1930																																			28				
• 5/14/72 - 2130																																			83				
• 5/15/72 - 1600																																			28				

21110207

COLVILLE NATIONAL FOREST
DATA SUMMARY SHEET

Name of Source: SULLIVAN CREEK
Station Number: 21110207 Minor Basin Code: 02
PWI Watershed Number: 16-02-00-00-09
65321-009 170102 16-11

District: SULLIVAN LK
Station Location: T. 39 N R. 44 E Sec. 30 Sub. SW SE
Station Type Code: 21 1 1 2 0 4
Latitude: 48 deg. 49 min. Longitude: 117 deg. 17 min.

DATE/TIME OF SAMPLE COLLECTION	ACIDITY (MG/L)	ALKALINITY (MG/L)	BICARBONATE (MG/L)	CALCIUM (MG/L)	CARBON DIOXIDE (MG/L)	CARBONATE (MG/L)	CHLORIDE (MG/L)	COLIFORM, FECAL (COLONIES/100 ml.)	COLIFORM, TOTAL (COLONIES/100 ml.)	COLOR (COB UNITS)	CONDUCTIVITY (MICROMHOS)	COPPER (MG/L)	FLOW, STREAM (C.F.S.)	FLUORIDE (MG/L)	HARDNESS, CALCIUM (MG/L)	HARDNESS, MAGNESIUM (MG/L)	HARDNESS, NON-CARBONATE (MG/L)	HARDNESS, TOTAL (MG/L)	IRON (MG/L)	MAGNESIUM (MG/L)	MANGANESE (MG/L)	NITRATES (MG/L)	NITRITES (MG/L)	OXYGEN, DISSOLVED (MG/L)	pH (STANDARD UNITS)	PHOSPHATE, META (MG/L)	PHOSPHATE, ORTHO (MG/L)	SEDIMENT, SUSPENDED MG/L)	SILICA (MG/L)	SODIUM (MG/L)	SOLIDS, TOTAL DISSOLVED (MG/L)	SULFATE (MG/L)	TEMPERATURE (F°) H_2O	TURBIDITY ~~(JTU)~~ NTU	AIR TEMP °F	AIR TEMP °C	WATER TEMP °C
5/22/72-0845																																			32			
5/30/72-1630																								Near peak of 10 year return period											54	runoff		
9/12/73 —		119.83							149*1		180							119.83						10	8.5								54	.16	72		
6/10/74																												40.2									
6/11/74-9998																												36.9									
6/11/74-1000																												70.3									
8/1/74-1400		90								0	155	.04						75	.05		0		0		7.5		.1				78	0	14	0			
10/8/74-1630													29.88																								
10/8/74-1700		95								15	195							95	.05						8.1		.05				100			6			
5/17/76-1030									7		95		water too high to measure flow									.2		11	7.8		.08						6	5.7	54		
9/1/76-0950									9		150		98.7*2									.23		14	7.7		.09							.15		22	11
4/20/77-0930									0		158		55.6									.36		13	7.9		.12							.2		8	4
10/3/77-0845									2		170		44									.21		10	8.1		.03							.10		2	4
5/15/78-0900									10		120		504									.03		11	7.6		.06							[illegible]		9	3
5/17/78-1440											142																	17.17						2.9			
10/2/78-1535									2		170		95.2									.01		12	8.3		.05							.21		14	6
4/29/80-1030											135													12	7.5						55			235	9	2		

*1 TOTAL COLIFORM 149 - average of two samples

*2 98.1 - current meter reading 90.1 was reading w/ velocity Head Rod.

Name of Source SULLIVAN CREEK
Station Number 21110207 Minor Basin Code 02
PWI Watershed Number 17010216-11

COLVILLE NATIONAL FOREST
WATER QUALITY DATA
SUMMARY SHEET

District SULLIVAN LAKE Station Type Code 2 1 1 1 2
Station Location:
T. 39 N R. 44 E Sec. 30 Sub SW SE
Latitude: 48 deg. 49 min. Longit 117 deg. 12

69 WATER PARAMETERS / DATE/TIME OF SAMPLE COLLECTION	ACIDITY (MG/L)	ALKALINITY (MG/L)	BICARBONATE (MG/L)	CALCIUM (MG/L)	CARBON DIOXIDE (MG/L)	CARBONATE (MG/L)	CHLORIDE (MG/L)	COLIFORM, FECAL (COLONIES/100 mL.)	COLIFORM, TOTAL (COLONIES/100 mL.)	COLOR (COB UNITS)	CONDUCTIVITY (MICROMHOS)	COPPER (MG/L)	FLOW, STREAM (C.F.S.)	FLUORIDE (MG/L)	HARDNESS, CALCIUM (MG/L)	HARDNESS, MAGNESIUM (MG/L)	HARDNESS, NON-CARBONATE (MG/L)	HARDNESS, TOTAL (MG/L)	IRON (MG/L)	MAGNESIUM (MG/L)	MANGANESE (MG/L)	NITRATES (MG/L)	NITRITES (MG/L)	OXYGEN, DISSOLVED (MG/L)	pH (STANDARD UNITS)	PHOSPHATE, META (MG/L)	PHOSPHATE, ORTHO (MG/L)	SEDIMENT, SUSPENDED MG/L)	SILICA (MG/L)	SODIUM (MG/L)	SOLIDS, TOTAL DISSOLVED (MG/L)	SULFATE (MG/L)	AIR TEMPERATURE (C°)	WATER TEMPERATURE (C°)	TURBIDITY (JTU) NTU	RATING	
5/9/83-1100								0	14		148											.065			7.8		1.4				77				1.3		
06/01/89-1200											100																					60				.70		
06/15/89-1500											130																					70				.35		
06/26/89-1330											155																					80				.32		
08/31/89-1050											270																					85				.37		
09/27/89-1105											185																					95				.2		
3/23/90-1427											160														8.30						100		3	2	.42		
4/18/90-1408											120														8.25						75		18	4	.61	GOOD	
5/9/90-1200											100														8.25						70		17	4	.34		
6/19/90-1300											95														8.20						72		25	9	.76		
7/24/90-0937											140														8.27						100		18	11	.39		
8/28/90-1245											175														8.27						105		21	10	.16		
9/24/90-1530											190														8.23						110		21	12	.29	GOOD	
10/18/90 1209											150														8.10						105		7	5	.36		
11/28/90 1240											140														[illegible]						90		2	0	.29		

21-2500-3 (10/76)

21110207

COLVILLE NATIONAL FOREST
WATER QUALITY DATA
SUMMARY SHEET

Name of Source: SULLIVAN @ BRIDGE
Station Number: Minor Basin Code: 02
PWI Watershed Number: 17010216-11

District: SULLIVAN LK.
Station Location: T. 39 N R. 44 E Sec. 30 Sub. SW SE

Station Type Code: 211204
Latitude: 48 deg. 49 min. Longitude: 117 deg. 12 min.

WATER PARAMETERS / DATE/TIME OF SAMPLE COLLECTION	ACIDITY (MG/L)	ALKALINITY (MG/L)	BICARBONATE (MG/L)	CALCIUM (MG/L)	CARBON DIOXIDE (MG/L)	CARBONATE (MG/L)	CHLORIDE (MG/L)	COLIFORM, FECAL (COLONIES/100 ml.)	COLIFORM, TOTAL (COLONIES/100 ml.)	COLOR (COB UNITS)	CONDUCTIVITY (MICROMHOS)	COPPER (MG/L)	FLOW, STREAM (C.F.S.)	FLUORIDE (MG/L)	HARDNESS, CALCIUM (MG/L)	HARDNESS, MAGNESIUM (MG/L)	HARDNESS, NON-CARBONATE (MG/L)	HARDNESS, TOTAL (MG/L)	IRON (MG/L)	MAGNESIUM (MG/L)	MANGANESE (MG/L)	NITRATES (MG/L)	NITRITES (MG/L)	OXYGEN, DISSOLVED (MG/L)	pH (STANDARD UNITS)	PHOSPHATE, META (MG/L)	PHOSPHATE, ORTHO (MG/L)	SEDIMENT, SUSPENDED MG/L)	SILICA (MG/L)	SODIUM (MG/L)	SOLIDS, TOTAL DISSOLVED (MG/L)	SULFATE (MG/L)	AIR TEMPERATURE (C°)	WATER TEMPERATURE (C°)	TURBIDITY (JTU)	STABILITY RATING
4/30/91 - 1614								0			150														8.13						80		12	4	.39	GOOD
5/30/91 - 1450								1			100														8.09						60		19	5	2.8	
6/12/91 - 1340								0			85														7.97						55		12	4	3.6	
7/9/91 - 1355								0			105														8.11						80		19	12	.34	
8/26/91 - 1400								4			170		53.31												8.13						100		24	13	.30	—
9/19/91 - 1200								0			180		1												8.32						100		22	11	.16	GOOD
10/24/91 - 1045								0			200		350												8.08						100		6	5	.25	GOOD
11/7/91 - 1205								1			200		—												8.02						100		4	3	.25	—
4/22/92 - 1425								0			110														7.84			117			75		15	6	.98	GOOD
5/27/92 - 1520											100														7.78						70		22	10	.22	
6/24/92 - 1220								1			120														8.34						125		32	15	.15	
7/14/92 - 0945								3			160														8.12						100		19	11	.65	
8/20/92 - 1100								2			180														8.12						100		25	13	.15	

N FK SULLIVAN SULLIVAN LAKE RD T39 R43 S23 SESE #21110220 WRC 17010216-11

DATE	TIME	F COL #/100ml	SP COND uMHO	FLOW cfs	D.O. mg/l	pH units	S SED mg/l	TDS mg/l	A TEMP DEG C	W TEMP DEG C	TURB NTU	STABILITY RATING
09/06/62	1530			6.96								
05/20/63	1500			45.45								
04/21/65	1400			59.24								
05/06/65	1600			70.49								
05/20/65	1420			103.50								
06/01/65	1625			93.99								
07/06/65	1000			59.73								
08/03/65	1600			32.86								
09/02/65	1145			20.90								
05/13/66											1.60	
03/25/68											1.70	
05/26/68											1.75	
06/03/68											13.00	
05/20/68											1.80	
06/10/68											1.35	
04/08/69	1105										1.90	
04/21/69	1620										1.20	
04/24/69											11.00	
05/13/69											5.40	
03/31/70	1500										0.20	
04/07/71	1525										0.43	
04/21/71	1415										0.40	
05/03/71	1400										2.50	
03/30/72	1600										0.50	
05/12/72	1530										1.10	
09/05/73											0.15	
06/06/74	1430	2										
06/12/74	830						32.100					
07/27/74			50			7.10		25			0.00	
07/31/74	1100		104			7.75		61			0.40	
08/07/74				20.50								
09/27/74	1015	0										
10/09/74	830		130	1.91		7.80		70			7.00	
05/06/75	1130		150			7.50				3	1.00	
5/17/76	1100		50	24.70	11	7.60			12	5	1.40	
09/01/76	1050		85	17.00	14	7.40			13	10	0.14	
04/20/77	1000		180	2.50	11	7.80			5	2	0.10	
10/03/77	1015		85	5.20	9	7.85			1	4	0.10	
5/15/78	950		60	234.00	11	7.55			9	4	2.60	
10/03/78	900		160	100.50	11	7.95			5	9	0.36	

05/14/79	920	0	99	33.20	11	6.95			9	3	0.71	
09/17/79	940	0	180	4.00	11	7.75			8	8	0.18	
04/29/80	1115		81		11	7.35	388.000		5	1	74.00	
05/21/80	1000	0	92	62.70	13	7.10		30	10	6	0.98	
10/08/80	1100	0	165	7.20	11	7.45		85	9	7	0.22	
05/06/81	1000	0	71	39.60	11	7.50		30	5	4	1.10	
10/20/81	1035	0	155	7.15	11	7.80		74	2	5	0.19	
05/26/82	1030	0	46		11	7.20		25	9	4	5.60	
09/21/82	1012	1	138	2.70	11	7.60		70	11	9	0.20	
05/09/83	1121	1	100	55.00	14	7.75		55	6	4	1.10	
05/16/84	1015	1	112	45.00	13	6.95		55	7	5	1.10	
10/10/84	936	0	200	1.14	13	6.90		90	11	7	0.39	
05/17/85	1135	2	92		13	6.50		30	17	5	3.00	
05/09/90	1400		60			8.19		38	14	4	0.38	
06/18/90	1428		82			7.96		50	23	7	1.00	GOOD
07/24/90	923		110			8.14		75	17	10	0.23	
08/28/90	1234		140			8.13		80	20	8	0.22	
09/24/90	1545		165			8.08		100			0.25	GOOD
10/18/90	1158		155			8.00		90	6	3	0.23	
11/28/90	1510		105					70	4	0	0.29	
04/30/91	1558	0	120			8.06		70	16	5	0.73	GOOD
05/30/91	1430	2	55			7.98		30	18	5	1.50	
06/12/91	1350	0	41			7.93		30	8	5	1.60	
07/09/91	1342	0	80			8.11		55	26	10	0.42	
08/26/91	1340	0	140	7.50		8.03		75	25	10	0.29	
09/19/91	1211	0	150			8.29		80	17	9	0.15	GOOD
10/24/91	1005	0	175	7.69		8.18		100	10	5	0.25	GOOD
11/07/91	1220	0	175			8.00		100	4	4	0.20	
04/28/92	1115	0	75			7.69		50	16	7	1.10	GOOD
05/27/92	1535		60			7.75		40	23	8	0.57	
06/24/92	1120	0	100			8.24		60	20	10	0.15	
07/14/92	1000	8	120			8.11		60	12	9	0.17	
08/20/92	1115	0	100			8.13		75	20	9	0.65	
09/17/92	1340	0	160			8.03		100	12	5	0.13	GOOD
10/21/92	1245	0	200			7.76		100	15	5	0.40	
11/18/92	1443	0	120			7.86		75	9	3	0.13	

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NFSUL.WK3

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Name of Source Noisy Creek
Station Number 21110215 Minor Basin Code 02
PWI Watershed Number 16-02-00-00-09
65371-009 17010216-11

21110215
COLVILLE NATIONAL FOREST
DATA SUMMARY SHEET

District Sullivan Lake
Station Location:
T. 39 N R. 44 E Sec. 18 Sub. NE SE

Station Type Code 2111200
Latitude: 48 deg. 47 min. Longitude 117 deg. 16 min.

DATE/TIME OF SAMPLE COLLECTION	ACIDITY (MG/L)	ALKALINITY (MG/L)	BICARBONATE (MG/L)	CALCIUM (MG/L)	CARBON DIOXIDE (MG/L)	CARBONATE (MG/L)	CHLORIDE (MG/L)	COLIFORM, FECAL (COLONIES/100 ml.)	COLIFORM, TOTAL (COLONIES/100 ml.)	COLOR (COB UNITS)	CONDUCTIVITY (MICROMHOS)	COPPER (MG/L)	FLOW, STREAM (C.F.S.)	FLUORIDE (MG/L)	HARDNESS, CALCIUM (MG/L)	HARDNESS, MAGNESIUM (MG/L)	HARDNESS, NON-CARBONATE (MG/L)	HARDNESS, TOTAL (MG/L)	IRON (MG/L)	MAGNESIUM (MG/L)	MANGANESE (MG/L)	NITRATES (MG/L)	NITRITES (MG/L)	OXYGEN, DISSOLVED (MG/L)	pH (STANDARD UNITS)	PHOSPHATE, META (MG/L)	PHOSPHATE, ORTHO (MG/L)	SEDIMENT, SUSPENDED MG/L)	SILICA (MG/L)	SODIUM (MG/L)	SOLIDS, TOTAL DISSOLVED (MG/L)	SULFATE (MG/L)	TEMPERATURE (F°)	TURBIDITY (JTU)	Total Coliform MPN	TEMPERATURE (C°) AIR	TEMPERATURE (C°) H_2O	PATTING
5/4/59 —																																			0			
8/1/74-1445		100								0	200							100	.04						7.7						110		57.5	0				
9/28/77-1025									2		220		4									.24		10	8.0		.04							.11		13.5	8.5	
9/24/90-1335											270														8.37						165			.33		23	11	Good
10/18/90-1249											245														8.18						150			.32		7	4	
11/28/90-1550											180																				100			.46		-1	0	
4/30/91-1438								0			145														8.04						85			.73		12	3	Good
5/30/91-1606								1			105														8.06						60			1.1		19	4	
6/25/91-1423								0			140		9.55												8.25						75			.47		17	8	Good
7/17/91-0945								3			175														8.31						100			.41		20	10	
8/19/91-1535								—			250		—												8.60						140			.55		22	16	—
9/18/91-1550								0			250		.49												8.62						150			1.2		14	11	Good
10/15/91-1300								0			250		.06												8.20						150			1.0		21	5	Good
11/7/91-1000								0			250		—												7.94						150			.21		6	2	—
4/22/92 1200								0			105		4.55												7.98			111			75			.95		10	5	Good
5/27/92 1135											160														8.12						95			.25		18	9	

Name of Source NOISY CREEK
Station Number 21110215 Minor Basin Code 02
PWI Watershed Number 16-02-00-00-09
65321-009

21140215

COLVILLE NATIONAL FOREST
WATER QUALITY DATA
SUMMARY SHEET

District SULLIVAN LAKE
Station Location:
T. 38 N R. 44 E Sec. 18 Sub. NE SE

2111204
Station Type Code
Latitude: 48 deg. 47 min. Lon 117 deg. 16

WATER PARAMETERS / DATE/TIME OF SAMPLE COLLECTION	ACIDITY (MG/L)	ALKALINITY (MG/L)	BICARBONATE (MG/L)	CALCIUM (MG/L)	CARBON DIOXIDE (MG/L)	CARBONATE (MG/L)	CHLORIDE (MG/L)	COLIFORM, FECAL (COLONIES/100 ml.)	COLIFORM, TOTAL (COLONIES/100 ml.)	COLOR (COB UNITS)	CONDUCTIVITY (MICROMHOS)	COPPER (MG/L)	FLOW, STREAM (C.F.S.)	FLUORIDE (MG/L)	HARDNESS, CALCIUM (MG/L)	HARDNESS, MAGNESIUM (MG/L)	HARDNESS, NON-CARBONATE (MG/L)	HARDNESS, TOTAL (MG/L)	IRON (MG/L)	MAGNESIUM (MG/L)	MANGANESE (MG/L)	NITRATES (MG/L)	NITRITES (MG/L)	OXYGEN, DISSOLVED (MG/L)	PH (STANDARD UNITS)	PHOSPHATE, META (MG/L)	PHOSPHATE, ORTHO (MG/L)	SEDIMENT, SUSPENDED MG/L)	SILICA (MG/L)	SODIUM (MG/L)	SOLIDS, TOTAL DISSOLVED (MG/L)	SULFATE (MG/L)	AIR TEMPERATURE (C°)	WATER TEMPERATURE (C°)	TURBIDITY (JTU)	STABILITY RATING
6/22/92 1300									2		180														8.16						115		32	15	.20	
7/14/92 0912									2		165														8.29						100		13	10	.20	
8/20/92 1045									15		55														8.34						30		22	13	.12	

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Name of Source MIDDLE HARVEY FK.
Station Number _____ Minor Basin Code _____
PWI Watershed Number _____

COLVILLE NATIONAL FOREST
WATER QUALITY DATA
SUMMARY SHEET

District SULLIVAN LK
Station Location:
T. 38 R. 44 Sec. 35 Sub. NW SE

Station Type Code _____
Latitude: ___deg. ___min. Long ___deg. ___

WATER PARAMETERS / DATE/TIME OF SAMPLE COLLECTION	ACIDITY (MG/L)	ALKALINITY (MG/L)	BICARBONATE (MG/L)	CALCIUM (MG/L)	CARBON DIOXIDE (MG/L)	CARBONATE (MG/L)	CHLORIDE (MG/L)	COLIFORM, FECAL (COLONIES/100 ml.)	COLIFORM, TOTAL (COLONIES/100 ml.)	COLOR (COB UNITS)	CONDUCTIVITY (MICROMHOS)	COPPER (MG/L)	FLOW, STREAM (C.F.S.)	FLUORIDE (MG/L)	HARDNESS, CALCIUM (MG/L)	HARDNESS, MAGNESIUM (MG/L)	HARDNESS, NON-CARBONATE (MG/L)	HARDNESS, TOTAL (MG/L)	IRON (MG/L)	MAGNESIUM (MG/L)	MANGANESE (MG/L)	NITRATES (MG/L)	NITRITES (MG/L)	OXYGEN, DISSOLVED (MG/L)	pH (STANDARD UNITS)	PHOSPHATE, META (MG/L)	PHOSPHATE, ORTHO (MG/L)	SEDIMENT, SUSPENDED MG/L)	SILICA (MG/L)	SODIUM (MG/L)	SOLIDS, TOTAL DISSOLVED (MG/L)	SULFATE (MG/L)	AIR TEMPERATURE (C°)	WATER TEMPERATURE (C°)	TURBIDITY (JTU)	STABILITY RATING
7/17/91 - 1045								1			150		10.47												8.08						80		15	7	25		

Name of Source N. + M FK HARVEY CR
Station Number _____ Minor Basin Code _____
PWI Watershed Number 21 11 0235

COLVILLE NATIONAL FOREST
WATER QUALITY DATA
SUMMARY SHEET

District SULLIVAN
Station Location:
T. 38 R. 44 Sec. 35 Sub. SWNW

Station Type Code _____
Latitude: ___deg. ___min.
Longitude ___deg. ___min.

DATE/TIME OF SAMPLE COLLECTION \ WATER PARAMETERS	ACIDITY (MG/L)	ALKALINITY (MG/L)	BICARBONATE (MG/L)	CALCIUM (MG/L)	CARBON DIOXIDE (MG/L)	CARBONATE (MG/L)	CHLORIDE (MG/L)	COLIFORM, FECAL (COLONIES/100 ml.)	COLIFORM, TOTAL (COLONIES/100 ml.)	COLOR (COB UNITS)	CONDUCTIVITY (MICROMHOS)	COPPER (MG/L)	FLOW, STREAM (C.F.S.)	FLUORIDE (MG/L)	HARDNESS, CALCIUM (MG/L)	HARDNESS, MAGNESIUM (MG/L)	HARDNESS, NON-CARBONATE (MG/L)	HARDNESS, TOTAL (MG/L)	IRON (MG/L)	MAGNESIUM (MG/L)	MANGANESE (MG/L)	NITRATES (MG/L)	NITRITES (MG/L)	OXYGEN, DISSOLVED (MG/L)	pH (STANDARD UNITS)	PHOSPHATE, META (MG/L)	PHOSPHATE, ORTHO (MG/L)	SEDIMENT, SUSPENDED MG/L)	SILICA (MG/L)	SODIUM (MG/L)	SOLIDS, TOTAL DISSOLVED (MG/L)	SULFATE (MG/L)	AIR TEMPERATURE (C°)	WATER TEMPERATURE (C°)	TURBIDITY (JTU)	RATING		
9/20/90-1425											162														8.45						100		15	7	.26	GOOD		
10/31/90-1230											145														8.18						85		10	4	.52			
6/19/91-1455								0			115														8.20						75		9	7	.58	GOOD		
8/19/91-1445								0			150														8.01						100		29	14	.25			
9/18/91-1435								1			175														8.64						100		13	9	.25	GOOD		
10/15/91-1450								2			145		1.69												8.11						100		11	2	.90	GOOD		
11/7/91-0920								0			150		—												7.86						80		2	1	.98	—		
5/21/92 1050								0			22		25.16												7.93						15		10	5	.25			
6/22/92 1115								2			95														8.11						55		24	12	.15			
7/21/92 1220								3			210														8.04						100		18	10	.22			
8/20/92 1345								0			140														8.19						75		25	13	.17			

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21110213

COLVILLE NATIONAL FOREST
DATA SUMMARY SHEET

Name of Source: JUNGLE CREEK
Station Number: 21110213 Minor Basin Code: 02
PWI Watershed Number: 16-02-00-00-09
65321-009 17010216-11

District: SULLIVAN LAKE
Station Location:
T. 37 N R. 44 E Sec. 11 Sub. NE NE

Station Type Code: 21 1 1 20
Latitude: 48 deg. 43 min. Longitude: 117 deg. 11 min.

WATER PARAMETERS / DATE/TIME OF SAMPLE COLLECTION	ACIDITY (MG/L)	ALKALINITY (MG/L)	BICARBONATE (MG/L)	CALCIUM (MG/L)	CARBON DIOXIDE (MG/L)	CARBONATE (MG/L)	CHLORIDE (MG/L)	COLIFORM, FECAL (COLONIES/100 mL.)	COLIFORM, TOTAL (COLONIES/100 mL.)	COLOR (COB UNITS)	CONDUCTIVITY (MICROMHOS)	COPPER (MG/L)	FLOW, STREAM (C.F.S.)	FLUORIDE (MG/L)	HARDNESS, CALCIUM (MG/L)	HARDNESS, MAGNESIUM (MG/L)	HARDNESS, NON-CARBONATE (MG/L)	HARDNESS, TOTAL (MG/L)	IRON (MG/L)	MAGNESIUM (MG/L)	MANGANESE (MG/L)	NITRATES (MG/L)	NITRITES (MG/L)	OXYGEN, DISSOLVED (MG/L)	PH (STANDARD UNITS)	PHOSPHATE, META (MG/L)	PHOSPHATE, ORTHO (MG/L)	SEDIMENT, SUSPENDED MG/L)	SILICA (MG/L)	SODIUM (MG/L)	SOLIDS, TOTAL DISSOLVED (MG/L)	SULFATE (MG/L)	TEMPERATURE (F°)	TURBIDITY (JTU)	TEMP. Air °F		
9/3/73 —		34.2								<50								17.12						10	7								50	.16	70		

21110214

COLVILLE NATIONAL FOREST
DATA SUMMARY SHEET

Name of Source ROCKY FORK CREEK
Station Number 21110214 Minor Basin Code 02
PWI Watershed Number 16-02-00-00-09
65321-009 17010216-11

District SULLIVAN LAKE
Station Location:
T. 38 N R. 44 E Sec. 30 Sub. SW NE

Station Type Code 21112
Latitude: 48 deg. 46 min. Longit 117 deg. 17 m

WATER PARAMETERS / DATE/TIME OF SAMPLE COLLECTION	ACIDITY (MG/L)	ALKALINITY (MG/L)	BICARBONATE (MG/L)	CALCIUM (MG/L)	CARBON DIOXIDE (MG/L)	CARBONATE (MG/L)	CHLORIDE (MG/L)	COLIFORM, FECAL (COLONIES/100 ml.)	COLIFORM, TOTAL (COLONIES/100 ml.)	COLOR (COB UNITS)	CONDUCTIVITY (MICROMHOS)	COPPER (MG/L)	FLOW, STREAM (C.F.S.)	FLUORIDE (MG/L)	HARDNESS, CALCIUM (MG/L)	HARDNESS, MAGNESIUM (MG/L)	HARDNESS, NON-CARBONATE (MG/L)	HARDNESS, TOTAL (MG/L)	IRON (MG/L)	MAGNESIUM (MG/L)	MANGANESE (MG/L)	NITRATES (MG/L)	NITRITES (MG/L)	OXYGEN, DISSOLVED (MG/L)	pH (STANDARD UNITS)	PHOSPHATE, META (MG/L)	PHOSPHATE, ORTHO (MG/L)	SEDIMENT, SUSPENDED MG/L)	SILICA (MG/L)	SODIUM (MG/L)	SOLIDS, TOTAL DISSOLVED (MG/L)	SULFATE (MG/L)	TEMPERATURE (F°)	TURBIDITY (JTU)			
✓ 8/1/74-1500		25								0	38.5							20	.05						7.4						20		55	0			

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Name of Source UPPER HARVEY (below Onota creek.
Station Number
Minor Basin Code
PWI Watershed Number 21 11 0234

COLVILLE NATIONAL FOREST
WATER QUALITY DATA
SUMMARY SHEET

District SULLIVAN
Station Location:
T. 37 R. 44 Sec. 02 Sub NENW

Station Type Code
Latitude: deg. min.
Longitude deg. min.

WATER PARAMETERS / DATE/TIME OF SAMPLE COLLECTION	ACIDITY (MG/L)	ALKALINITY (MG/L)	BICARBONATE (MG/L)	CALCIUM (MG/L)	CARBON DIOXIDE (MG/L)	CARBONATE (MG/L)	CHLORIDE (MG/L)	COLIFORM, FECAL (COLONIES/100 ml.)	COLIFORM, TOTAL (COLONIES/100 ml.)	COLOR (COB UNITS)	CONDUCTIVITY (MICROMHOS)	COPPER (MG/L)	FLOW, STREAM (C.F.S.)	FLUORIDE (MG/L)	HARDNESS, CALCIUM (MG/L)	HARDNESS, MAGNESIUM (MG/L)	HARDNESS, NON-CARBONATE (MG/L)	HARDNESS, TOTAL (MG/L)	IRON (MG/L)	MAGNESIUM (MG/L)	MANGANESE (MG/L)	NITRATES (MG/L)	NITRITES (MG/L)	OXYGEN, DISSOLVED (MG/L)	pH (STANDARD UNITS)	PHOSPHATE, META (MG/L)	PHOSPHATE, ORTHO (MG/L)	SEDIMENT, SUSPENDED MG/L)	SILICA (MG/L)	SODIUM (MG/L)	SOLIDS, TOTAL DISSOLVED (MG/L)	SULFATE (MG/L)	AIR TEMPERATURE (C°)	WATER TEMPERATURE (C°)	TURBIDITY (JTU)	RATINGS		
8/28/90-1455											42														7.74						25		24	10	.32	Good		
9/24/90-1300											55														8.19						35		25	9	.37	Good		
10/31/90-1200											28														8.19						15		10	4	.69			
6/19/91-1430								0			19														8.24						10		13	9	.51	Good		
7/17/91-1100								88			29														7.80						10		18	10	1.0			
8/19/91-1420								3			45		.501												8.29						25		26	14	.21	—		
9/18/91-1400								2			2		—												8.34						35		17	10	.35	Good		
10/15/91-1425								4			55		2.08												8.27						40		14	3	.40	Good		
11/7/91-0903								0			55		?												7.92						25		2	1	.30			
5/21/92 1050								0			18		79.55												7.63						15		10	5	.18			
6/23/92 1040								3			43														8.05						20		27	15	.15			
7/21/92 1211								1			40														8.14						25		18	12	.37			
8/20/92 1250								0			30														8.47						30		25	13	.14			
10/29/92 1235								1			30														8.27						25		9	3	.15			

Name of Source HARVEY CR (below ONOTA)
Station Number 21110234 Minor Basin Code
PWI Watershed Number

21110234
COLVILLE NATIONAL FOREST
WATER QUALITY DATA
SUMMARY SHEET

District SULLIVAN LK
Station Location:
T. 38 R. 44 Sec. 35 Sub. NE SW

Station Type Code
Latitude: deg. min. Longitude deg. min.

DATE/TIME OF SAMPLE COLLECTION	ACIDITY (MG/L)	ALKALINITY (MG/L)	BICARBONATE (MG/L)	CALCIUM (MG/L)	CARBON DIOXIDE (MG/L)	CARBONATE (MG/L)	CHLORIDE (MG/L)	COLIFORM, FECAL (COLONIES/100 ml.)	COLIFORM, TOTAL (COLONIES/100 ml.)	COLOR (COB UNITS)	CONDUCTIVITY (MICROMHOS)	COPPER (MG/L)	FLOW, STREAM (C.F.S.)	FLUORIDE (MG/L)	HARDNESS, CALCIUM (MG/L)	HARDNESS, MAGNESIUM (MG/L)	HARDNESS, NON-CARBONATE (MG/L)	HARDNESS, TOTAL (MG/L)	IRON (MG/L)	MAGNESIUM (MG/L)	MANGANESE (MG/L)	NITRATES (MG/L)	NITRITES (MG/L)	OXYGEN, DISSOLVED (MG/L)	pH (STANDARD UNITS)	PHOSPHATE, META (MG/L)	PHOSPHATE, ORTHO (MG/L)	SEDIMENT, SUSPENDED MG/L)	SILICA (MG/L)	SODIUM (MG/L)	SOLIDS, TOTAL DISSOLVED (MG/L)	SULFATE (MG/L)	AIR TEMPERATURE (C°)	WATER TEMPERATURE (C°)	TURBIDITY (JTU)			
09/26/89-1600											41																					25				.35			

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HARVEY @ BRIDGE SULLIVAN LAKE RD T38 R44 S30 NWNW #21110222 WRC 17010216-11

DATE	TIME	F COL #/100ml	SP COND uMHO	FLOW cfs	D.O. mg/l	pH units	S SED mg/l	TDS mg/l	A TEMP DEG C	W TEMP DEG C	TURB NTU	STABILITY RATING
03/26/68											2.05	
05/20/68											3.90	
06/10/68											1.75	
04/01/70	1445										3.20	
04/06/70	1545										3.00	
05/05/70	1145										4.20	
05/17/70	1900										22.00	
02/17/71	1545										0.18	
04/07/71	1600										0.62	
04/21/71	1350										0.43	
05/03/71	1440										2.10	
05/12/71	1815										33.00	
08/20/71	915										0.15	
10/24/71					14	7.00						
03/30/72	1715										0.40	
04/06/72	1700										0.70	
05/04/72	1720										5.50	
05/12/72	830										2.20	
05/16/72	1510										3.80	
05/31/72	1300										3.00	
08/01/74	1515		80			7.80		52		15	0.00	
09/04/74			75			7.90		45			0.20	
05/18/76	1100		54	292.00	12	7.40			10	4	0.85	
09/07/76	1115		100	15.00	14	7.60			11	8	0.24	
04/20/77	1300		115	14.20	12	7.80			14	4	0.34	
10/03/77	1355		120	14.20	12	7.85			7	4	0.22	
05/15/78	1250		55	560.00	11	7.30			10	3	4.10	
05/19/78	1208		70				11.200				1.50	
10/03/78	1255		110	20.40	12	7.90			10	6	0.25	
04/29/80	930		70		14	7.20		25	7	1	51.00	
05/09/83	1050	0	84			7.25		45			1.10	
08/31/89	1320		100					55		11	1.00	
09/26/89	1705		145					75		10	0.24	
11/20/89	1200		82					49		4	0.07	
03/23/90	1447		105			8.16		70	1	2	0.35	
04/18/90	1437		70			8.08		40	18	3	1.10	GOOD
05/09/90	939		59			8.07		40	15	3	0.28	
06/19/90	1517		75			8.23		49	24	10	0.41	
07/24/90	1104		115			8.36		78	19	12	0.24	
08/28/90	1421		135			8.19		85	21	10	0.29	

		coli.f	EC	cfs	DO	pH	susp sed	TDS	air temp	W. temp	NTU	
09/24/90	1330		162			8.26		100	22	9	0.37	GOOD
10/18/90	1257		135			8.06		80	7	3	1.20	
11/28/90	1540		55					45	2	0	0.46	
04/30/91	1650	0	80			8.00		45	12	4	0.58	GOOD
05/30/91	1615	0	45			7.84		25	17	5	1.50	
06/19/91	1516	2	60			7.90		40	16	9	0.40	
07/17/91	1000	7	100			8.36		50	17	10	0.46	
08/19/91	1515	0	145	26.68		8.40		90	24	15	0.25	
09/18/91	1525	1	195			8.71		90	19	10	0.23	GOOD
10/15/91	1335	1	175	31.18		8.31		100	21	3	0.65	GOOD
11/07/91	950	0	150			7.75		100	5	2	0.98	
02/03/92	1210		105			8.02		70	7	2	0.60	
04/22/92	1530	0	60			7.93	101.000	40	16	5	0.98	GOOD
05/21/92	1230	0	50			8.11		35	14	7	0.15	
06/23/92	1150	0	90	22.49		8.29		55	25	16	0.17	
07/14/92	855	18	115			7.68		55	15	9	0.26	
08/20/92	1035	5	150			8.20		90	25	12	0.10	
09/17/92	1450	10	140	10.56		8.28		100	14	6	0.18	
10/21/92	1225	7	145			7.87		80	15	6	0.22	
11/18/92	1500	0	120			7.87		60	10	3	0.15	

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

APPENDIX E.3-2
SULLIVAN LAKE PRODUCTIVITY STUDY

DRAFT

SULLIVAN CREEK HYDROELECTRIC PROJECT
FERC No. 2225

Report on Productivity Sampling in Sullivan Lake and Outlet Creek

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

Prepared by
EES Consulting, Inc.

December 28, 2009

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REPORT ON PRODUCTIVITY SAMPLING IN SULLIVAN LAKE AND OUTLET CREEK

1.0 INTRODUCTION AND BACKGROUND

This study was conducted by EES Consulting (EESC) for the Pend Oreille Public Utility District (District) in connection with decommissioning the Sullivan Creek Hydroelectric Project (FERC No. 2225).

Sullivan Lake is located approximately seven miles east of Metaline Falls, WA. Sullivan Lake is of glacial origin, with a surface area of roughly 1,300 acres, at a surface elevation of approximately 2,580 ft above mean sea level (AMSL). The lake is fed by three tributaries - Harvey, Noisy, and Hall creeks, with Harvey Creek being the only perennial tributary. The lake drains into Outlet Creek, which then merges with Sullivan Creek, eventually draining into the Pend Oreille River near Metaline Falls.

Sullivan Lake supports a population of kokanee (*Oncorhynchus nerka*), which originally stemmed from several different stocking efforts, but now reproduces naturally. 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 are low in Sullivan Lake (WDOE 1997).

The dam at the outlet of Sullivan Lake is owned and operated by the District under FERC license for the benefit of downstream power producers. Under current operations, Sullivan Lake is drawn down approximately 20 ft each fall from its full pool elevation of 2588 ft AMSL, beginning October 1. During settlement negotiation meetings regarding operations of Sullivan Lake dam, there was concern expressed that this drawdown might further deplete nutrients and/or productivity in Sullivan Lake.

Preliminary investigations suggest that productivity in oligotrophic lakes increases in spring, starting in April or May, and that productivity drops off considerably by early October (EESC 2009). These investigations also suggest that productivity is concentrated in the upper layers of such lakes.

2.0 OBJECTIVE

The objective of this study was to assess primary and secondary productivity as a function of time of the year and depth in the lake. Primary productivity is the production of organic compounds from atmospheric or aquatic carbon dioxide through the process of photosynthesis. Secondary productivity is the biomass formation or energy fixation by heterotrophic organisms, such as grazers and decomposers, deriving their energy from photosynthetic plants or other autotrophs.

3.0 METHODS

The methods employed in this study closely follow those used by Nine and Scholz (2005) in their limnological studies of Sullivan Lake, with the intent of allowing comparison between data gathered in this study with that obtained by Nine and Scholz from 2003.

Field measurements included monthly samples of:

- Water column profiles for temperature, dissolved oxygen (DO), conductivity, and pH at 5m intervals at the deepest point in the lake.
- Secchi disk transparency at the deepest point in the lake.
- Water samples taken at 5m intervals at the deepest points in the northern, middle, and southern portions of the lake for water quality and productivity analyses.
- Primary production assessed by measuring chlorophyll *a*, with water samples collected at the deepest points in the northern, middle, and southern portions of the lake.
- Secondary production assessed by monitoring zooplankton, with zooplankton samples collected at the deepest points in the northern, middle, and southern portions of the lake.
- Temperature, DO, conductivity, and pH in Outlet Creek below the dam.
- Water samples collected from Outlet Creek below the dam.
- Primary and secondary productivity assessed in Outlet Creek.

3.1 Water Quality

Water quality assessments followed the guidelines recommended by the American Public Health Administration (APHA 1985). One water quality station was established at the deepest point (northern end) in Sullivan Lake (Figure 1). Water quality data were collected once per month from July through November. A Hydrolab Sonde® was used to measure profiles of temperature, dissolved oxygen, conductivity, and pH. Profiles were measured from the surface to 50m at 5m intervals. A 20cm limnological Secchi disk was used to measure water transparency. The Secchi disk was slowly lowered in the water column until it was no longer visible to the biologist.

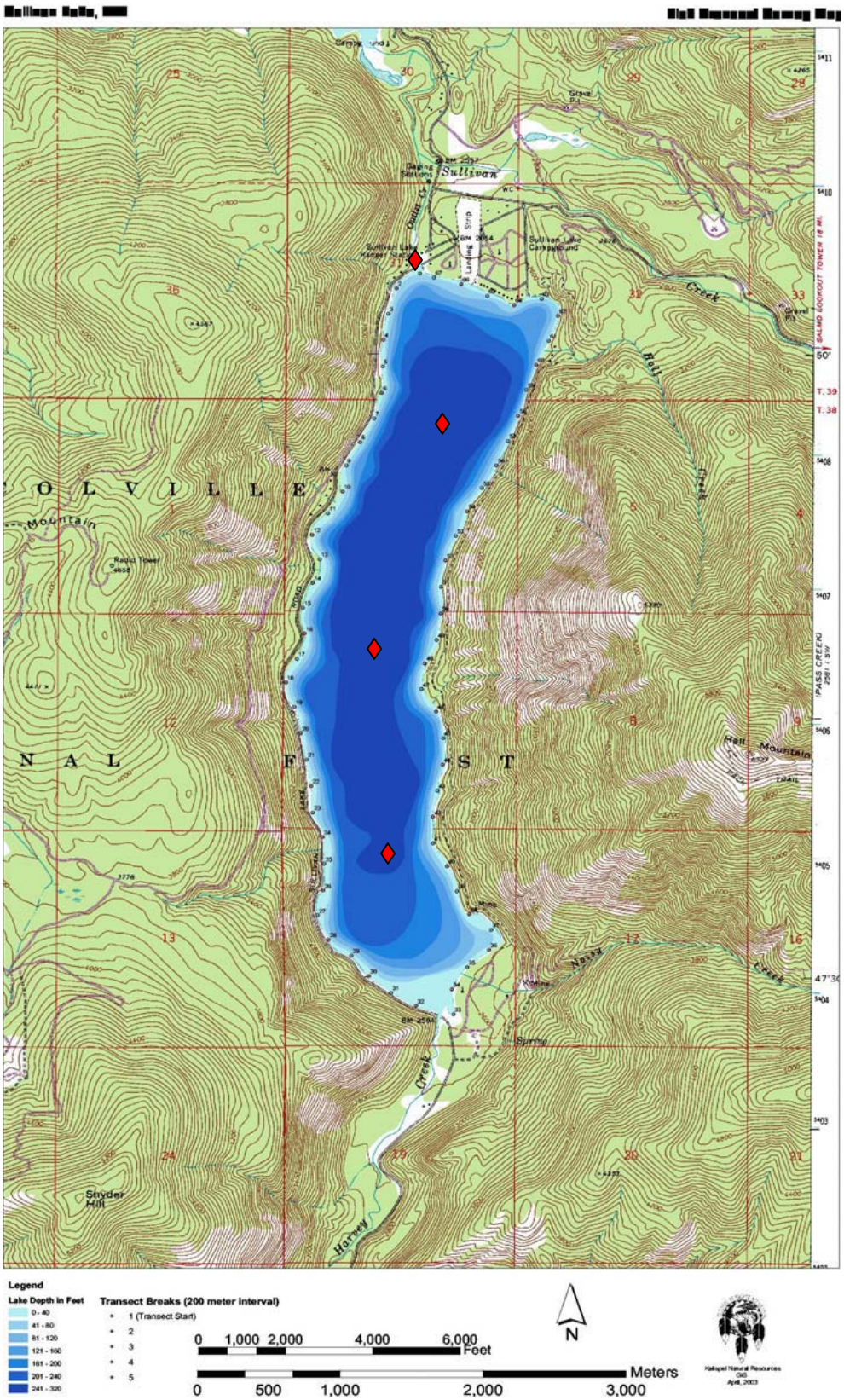

Figure 1. Approximate locations of limnological sampling sites in Sullivan Lake and Outlet Creek.

3.2 Nutrients

Water samples were taken from the surface to the bottom at 5m intervals in the epilimnion and metalimnion and 10m intervals in the hypolimnion using a Van Dorn sampling bottle.[1] Composite samples were made for each stratum by taking an equal amount of water from each depth sampled in the stratum. Water samples were stored on ice until analyzed. Each composite sample was analyzed for:

- Ammonia nitrogen (EPA 350.1)
- Nitrate nitrogen (EPA 300.0)
- Total nitrogen (EPA 351.2)
- Orthophosphate (EPA 365.1)
- Total phosphorus (EPA 365.4)
- Sulfate (EPA 300.0)
- Total dissolved solids (TDS) (SM2540C)
- Turbidity (portable turbidimeter used on site)

All water quality tests (except turbidity) were performed by the Spokane Tribal Laboratory, which is accredited by The Washington Department of Ecology.

A water quality sampling station was established in Outlet Creek immediately downstream of the dam. Water quality data were collected once per month from July through November, on the same date that data were collected in the lake. A Hydrolab Sonde® was used to measure temperature, dissolved oxygen, conductivity, and pH.

3.3 Primary Productivity

Phytoplankton production was assessed by measuring chlorophyll *a*. Chlorophyll *a* composite samples were taken from the epilimnion, metalimnion, and hypolimnion at three established water quality sites. One site was the water quality sampling location established at the deepest point (northern end) in the lake. Two additional sites were established at the deepest points in the middle and southern parts of the lake.

For the middle and southern chlorophyll sampling sites, the Hydrolab was used to measure water temperatures every 5m of depth to establish the epilimnion, metalimnion, and hypolimnion. Water samples were again taken from the surface to the bottom at 5m intervals in the epilimnion and metalimnion and 10m intervals in the hypolimnion using a Van Dorn sampling bottle. Composite samples were made for each stratum by taking an equal amount of water from each depth sampled in the stratum. Water samples were stored on ice until analyzed.

[1] Epilimnion, metalimnion, and hypolimnion refer to the layers of a thermally stratified lake. The epilimnion is the uppermost layer, which is well mixed by winds and currents. The hypolimnion is the deepest and coldest layer. The metalimnion is the transition zone between the two.

A chlorophyll sample was also taken in Outlet Creek from the same location as the water quality sample.

3.4 Secondary Productivity

Zooplankton samples were collected each month from July through November, taken from the northern, middle, and southern portions of the lake. A vertical tow plankton net with 80µ mesh and a silk bucket was used to collect zooplankton. Vertical tows were made from the bottom to the surface and from 5m to the surface to allow density comparisons between the entire water column and the epilimnion.

A zooplankton sample was also taken in Outlet Creek from the same location as the water quality and chlorophyll samples.

4.0 RESULTS

4.1 Water Quality

Sullivan Lake water temperature, DO, pH, conductivity, and turbidity are illustrated in Figures 2-7. For comparison purposes, the same parameters for Outlet Creek are shown in Table 1. Over the summer and fall, temperatures in the lake ranged from 3.3-21.5°C over all depths (Figure 2). The five-month lake average was 14.8°C in the epilimnion, 7.3°C in the metalimnion and 3.7°C in the hypolimnion. Outlet Creek temperature averaged 15.7°C.

The five-month lake average for dissolved oxygen was 9.0 mg/l in the epilimnion, 10.5 mg/l in the metalimnion, and 9.6 mg/l in the hypolimnion (Figure 3). Dissolved oxygen remained close to saturation levels through the epilimnion and metalimnion for the duration of the study period, but dropped to near 70% at 50m depth (Figure 4). It is unclear why DO appears to have increased during the September sampling period; it is possible this is due to an equipment malfunction, although the instrument was calibrated prior to each sampling date. Outlet Creek DO averaged 5.2 mg/l and 55% saturation.

Sullivan Lake remained alkaline throughout the five-month study period (Figure 5). The five-month lake average pH was 8.3 in the epilimnion, 8.0 in the metalimnion, and 7.7 in the hypolimnion. The pH showed a consistent increasing trend through the summer and into fall. Outlet Creek pH averaged 7.9.

The five-month lake average conductivity was 0.092 mS/cm in the epilimnion, 0.093 mS/cm in the metalimnion, and 0.097 mS/cm in the hypolimnion (Figure 6). The lowest conductivity value was 0.086 mS/cm in the metalimnion in July; the highest was 0.098 mS/cm in the hypolimnion in November. Outlet Creek conductivity averaged 0.114 mS/cm.

The five-month lake average turbidity was 0.79 NTU in the epilimnion, 0.91 NTU in the metalimnion, and 0.81 in the hypolimnion (Figure 7). Lake turbidity remained below 1.0 NTU, except in November; it is uncertain whether turbidity actually rose in November, or if this is due to the fact that the November sampling employed a different sampling team with a different

turbidimeter, which was necessitated due to scheduling conflicts. Outlet Creek turbidity averaged 0.77 NTU.

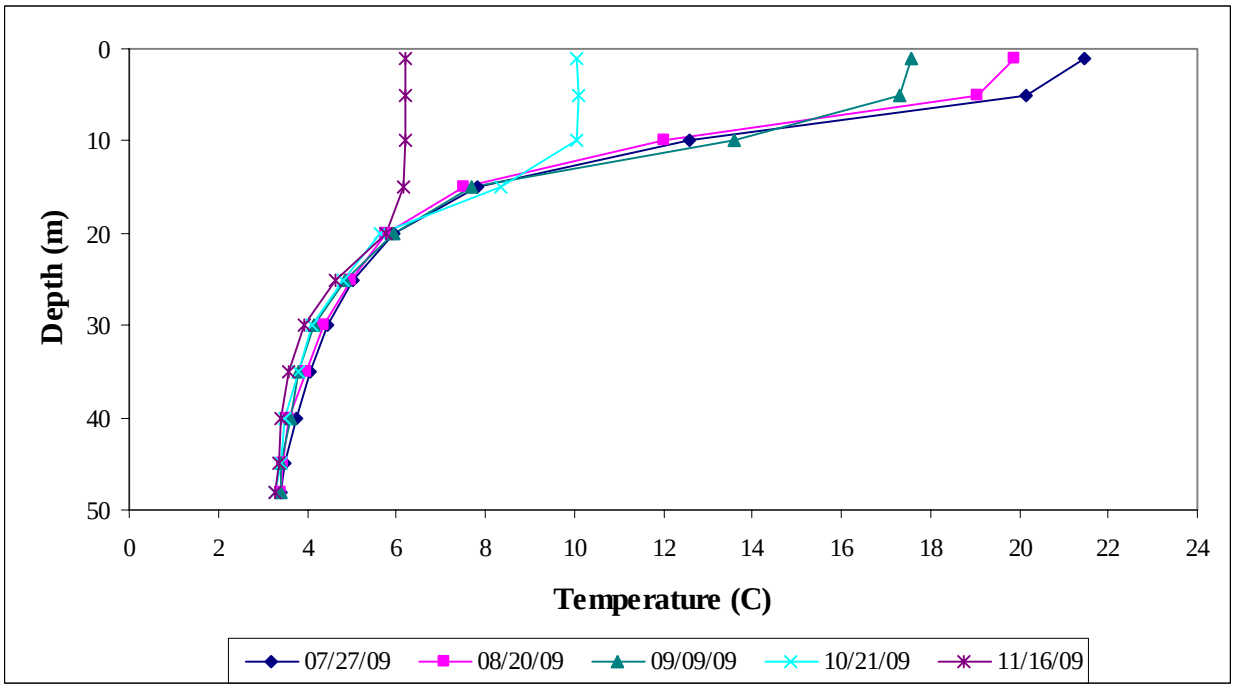

Figure 2. Sullivan Lake temperature profiles.
Averages between northern, middle, and southern lake locations.

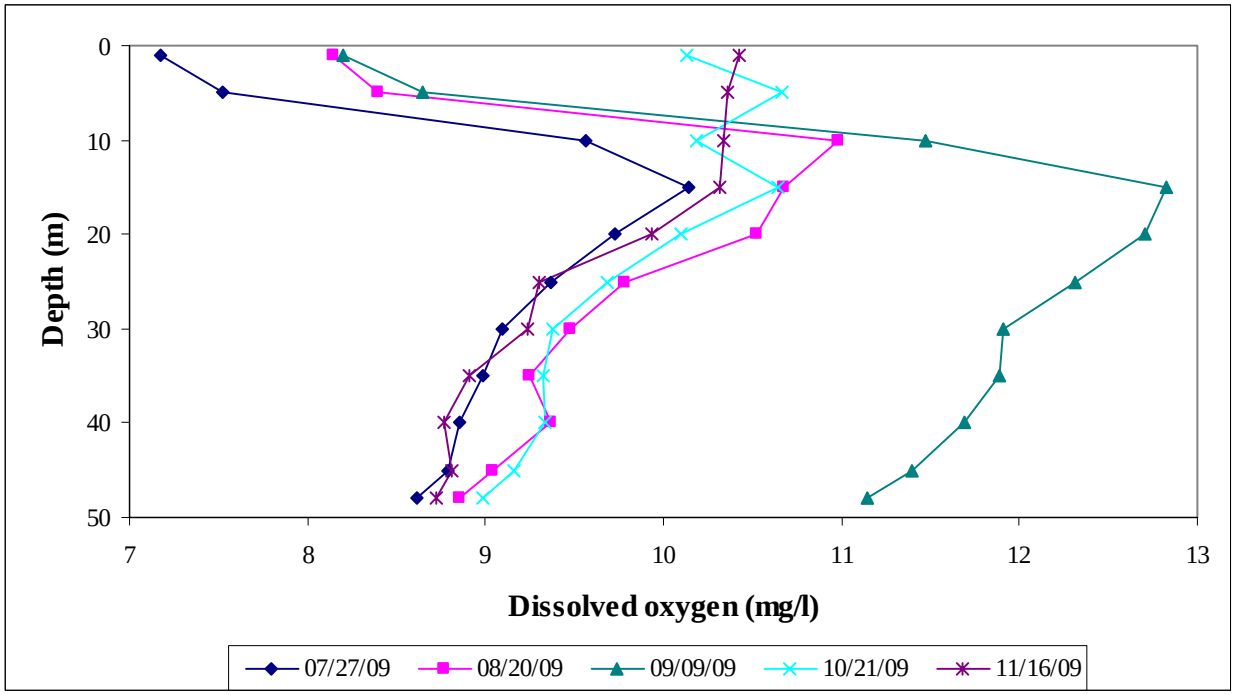

Figure 3. North Sullivan Lake dissolved oxygen profiles.

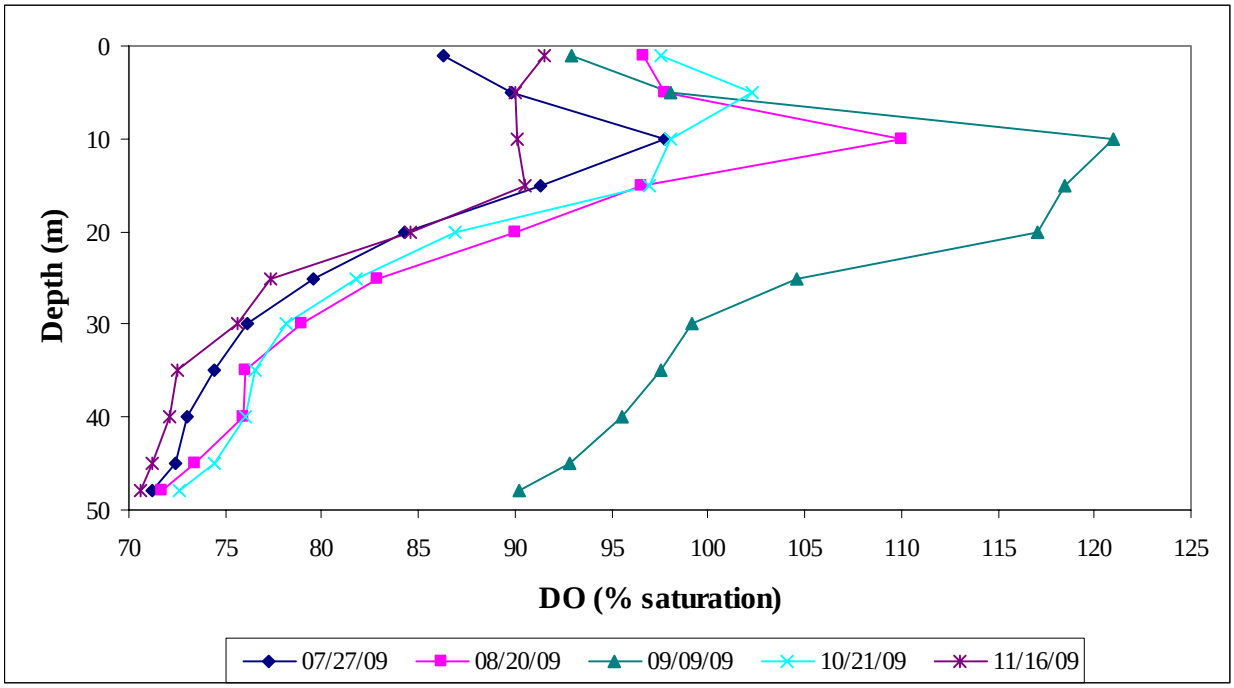

Figure 4. North Sullivan Lake DO saturation profiles.

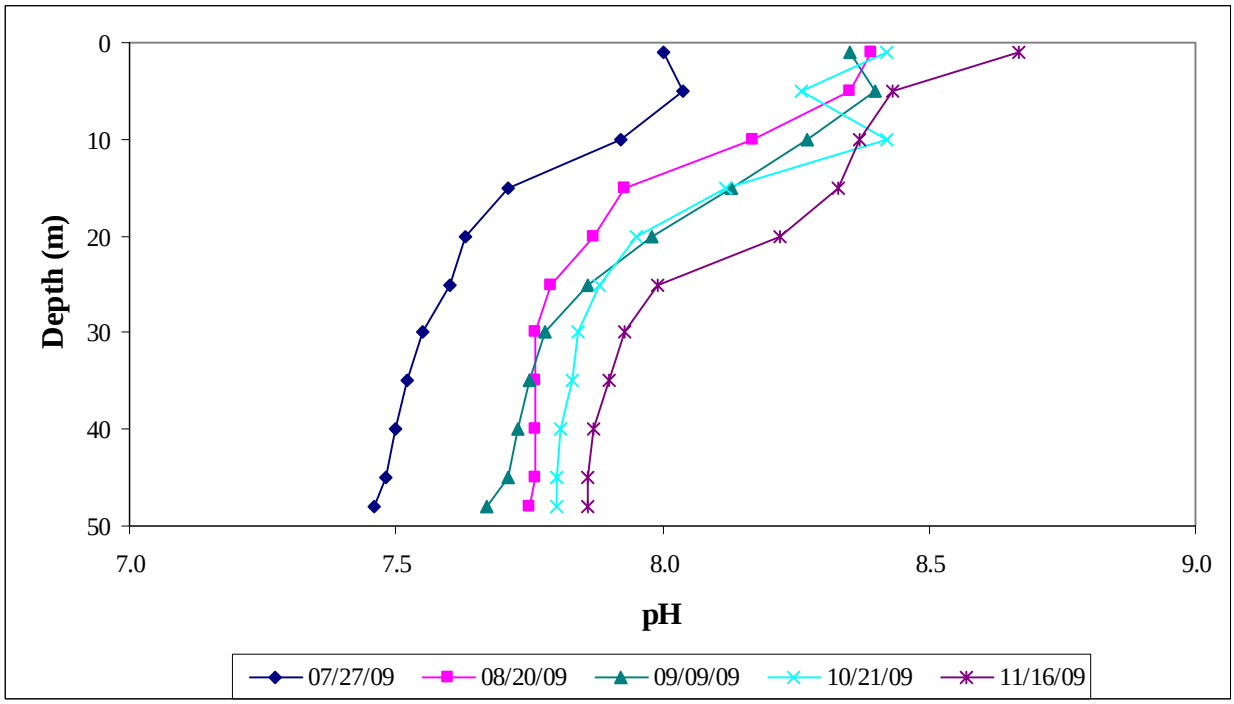

Figure 5. North Sullivan Lake pH profiles.

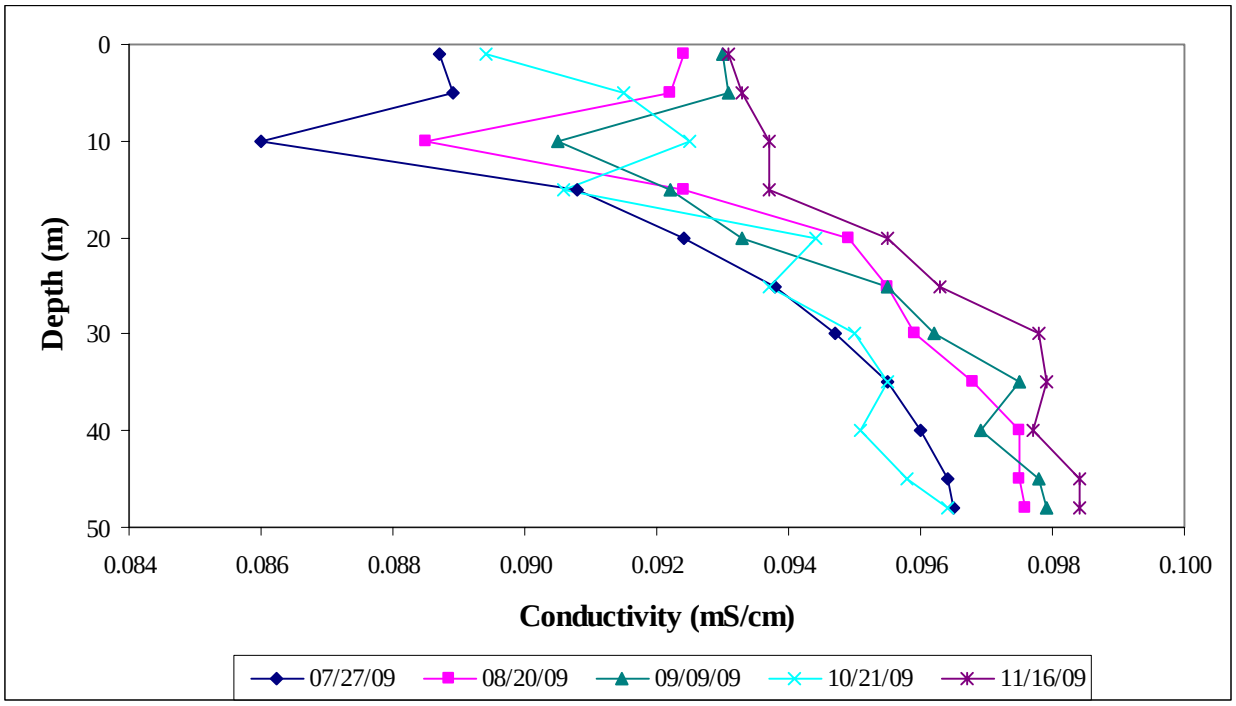

Figure 6. North Sullivan Lake conductivity profiles.

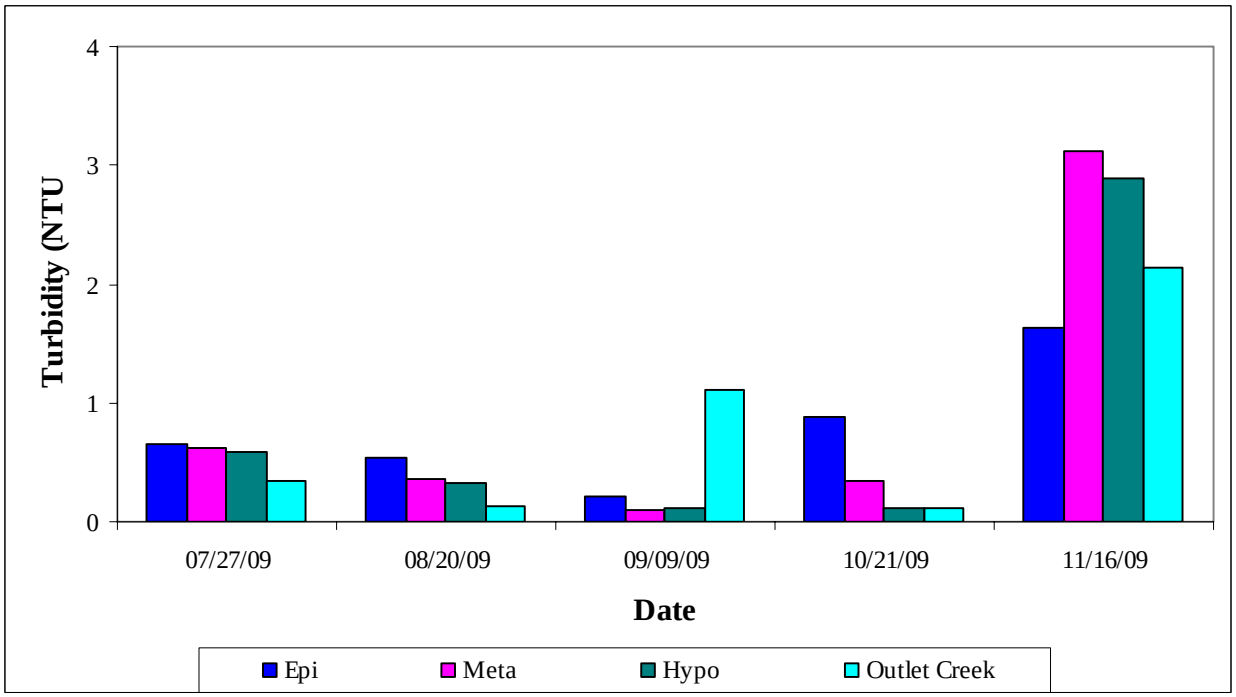

Figure 7. Turbidity in Sullivan Lake and Outlet Creek.
Lake values represent averages between northern, middle, and southern lake locations.

Table 1. Water Quality Parameters for Outlet Creek.

	07/27/09	08/20/09	09/09/09	10/21/09 *	11/16/09	Average
Temperature (°C)	17.7	18.9	17.9		8.1	15.7
DO (mg/l)	4.44	3.97	3.97		8.28	5.17
DO saturation	50.2%	46.3%	45.6%		79.2%	55.3%
pH	7.73	7.78	7.83		8.35	7.92
Conductivity (mS/cm)	0.113	0.116	0.119		0.107	.114
Turbidity (NTU)	0.35	0.13	1.11	0.12	2.14	0.77
* Outlet Creek water quality parameters could not be sampled in October due to a bad battery in the Hydrolab display unit.						

4.2 Nutrients

Nutrients (nitrogen and phosphorus) were low in Sullivan Lake. Monthly values of nitrites, nitrates, ammonia, and Total Kjeldahl Nitrogen (TKN) are summarized in Table 2. All values of nitrite nitrogen in all strata of the water column were at or below the detection limits (≤ 0.01 mg/l). The five-month average values for the epilimnion, metalimnion, hypolimnion, and Outlet Creek are shown at the bottom of the table.

Monthly values of total phosphorus, ortho-phosphate, sulfate, and total dissolved solids (TDS) are summarized in Table 3. The five-month average values for the epilimnion, metalimnion, hypolimnion, and Outlet Creek are shown at the bottom of the table.

Table 2. Nitrogen Concentrations in Sullivan Lake and Outlet Creek.
All concentrations are in mg/l.

Date	Stratum	Nitrite (NO_2^-)	Nitrate (NO_3^-)	Ammonia (NH_4^+)	TKN
7/27/09	Epilimnion	<0.01	0.03	0.018	0.19
	Metalimnion	<0.01	<0.01	0.016	0.16
	Hypolimnion	<0.01	0.02	0.022	0.17
	Outlet Cr.	<0.01	0.06	0.010	0.15
8/20/09	Epilimnion	<0.01	0.03	0.017	0.12
	Metalimnion	<0.01	<0.01	0.019	0.14
	Hypolimnion	<0.01	0.02	0.018	0.26
	Outlet Cr.	<0.01	0.06	0.017	0.18
9/9/09	Epilimnion	<0.01	<0.01	0.013	0.16
	Metalimnion	<0.01	<0.01	<0.010	0.14
	Hypolimnion	<0.01	0.02	0.012	0.13
	Outlet Cr.	<0.01	0.05	<0.010	0.08
10/21/09	Epilimnion	<0.01	<0.01	<0.010	0.14
	Metalimnion	<0.01	0.01	<0.010	0.12
	Hypolimnion	<0.01	0.02	<0.010	0.11
	Outlet Cr.	<0.01	<0.01	<0.010	0.12
11/16/09	Epilimnion	<0.01	<0.01	<0.010	0.16
	Metalimnion	<0.01	<0.01	<0.010	0.17
	Hypolimnion	<0.01	0.02	<0.010	0.12
	Outlet Cr.	<0.01	0.02	<0.010	0.11
Average	Epilimnion	<0.01	<0.01	<0.010	0.16
	Metalimnion	<0.01	<0.01	<0.010	0.15
	Hypolimnion	<0.01	0.02	<0.010	0.16
	Outlet Cr.	<0.01	0.04	<0.010	0.13

Table 3. Phosphorus, Sulfate, and TDS Concentrations in Sullivan Lake and Outlet Creek.
All concentrations are in mg/l.

Date	Stratum	Total Phosphorus	Ortho-phosphate (PO_4^-)	Sulfate (SO_4^-)	TDS
7/27/09	Epilimnion	0.008	0.004	3.20	73
	Metalimnion	0.018	0.011	3.67	67
	Hypolimnion	0.011	0.008	3.92	70
	Outlet Cr.	0.015	0.008	3.54	60
8/20/09	Epilimnion	0.009	0.007	3.49	82
	Metalimnion	0.009	0.008	3.74	95
	Hypolimnion	0.008	0.007	4.05	98
	Outlet Cr.	0.012	0.013	3.61	90
9/9/09	Epilimnion	0.012	0.009	3.36	42
	Metalimnion	0.010	0.009	3.59	68
	Hypolimnion	0.010	0.009	3.90	63
	Outlet Cr.	0.014	0.012	3.38	90
10/21/09	Epilimnion	0.007	0.003	4.08	53
	Metalimnion	0.006	0.003	4.29	53
	Hypolimnion	<0.005	0.004	4.58	57
	Outlet Cr.	<0.005	<0.002	4.05	50
11/16/09	Epilimnion	<0.005	0.003	3.63	83
	Metalimnion	<0.005	0.004	3.71	87
	Hypolimnion	<0.005	0.003	3.88	88
	Outlet Cr.	0.005	0.005	3.66	80
Average	Epilimnion	0.006	0.005	3.55	67
	Metalimnion	0.009	0.007	3.80	74
	Hypolimnion	0.006	0.006	4.07	75
	Outlet Cr.	0.009	0.008	3.65	74

4.3 Primary Productivity

Monthly values for chlorophyll *a* are summarized in Table 4. Average values by strata and by date are also shown in the table. The average water column chlorophyll *a* concentration in the lake throughout the study period was 0.60 μg/l. The five-month average chlorophyll *a* concentration in Outlet Creek was 0.35 μg/l. Data from Table 4 are also plotted in Figure 8.

Secchi disk depths measured in Sullivan Lake are shown in Table 5. The five-month average Secchi disk depth in the lake was 12.9m.

Table 4. Chlorophyll *a* Concentrations in Sullivan Lake and Outlet Creek.
All concentrations are in µg/l.

	07/27/09	08/20/09	09/09/09	10/21/09	11/16/09	Average
Epilimnion	0.40	0.63	0.48	0.73	0.97	0.64
Metalimnion	0.49	1.09	0.50	0.75	1.26	0.82
Hypolimnion	0.36	0.25	0.11	0.35	0.70	0.35
Lake average	0.42	0.66	0.36	0.61	0.98	0.60
Outlet Cr.	<0.01	<0.01	<0.01	1.41	0.35	0.35

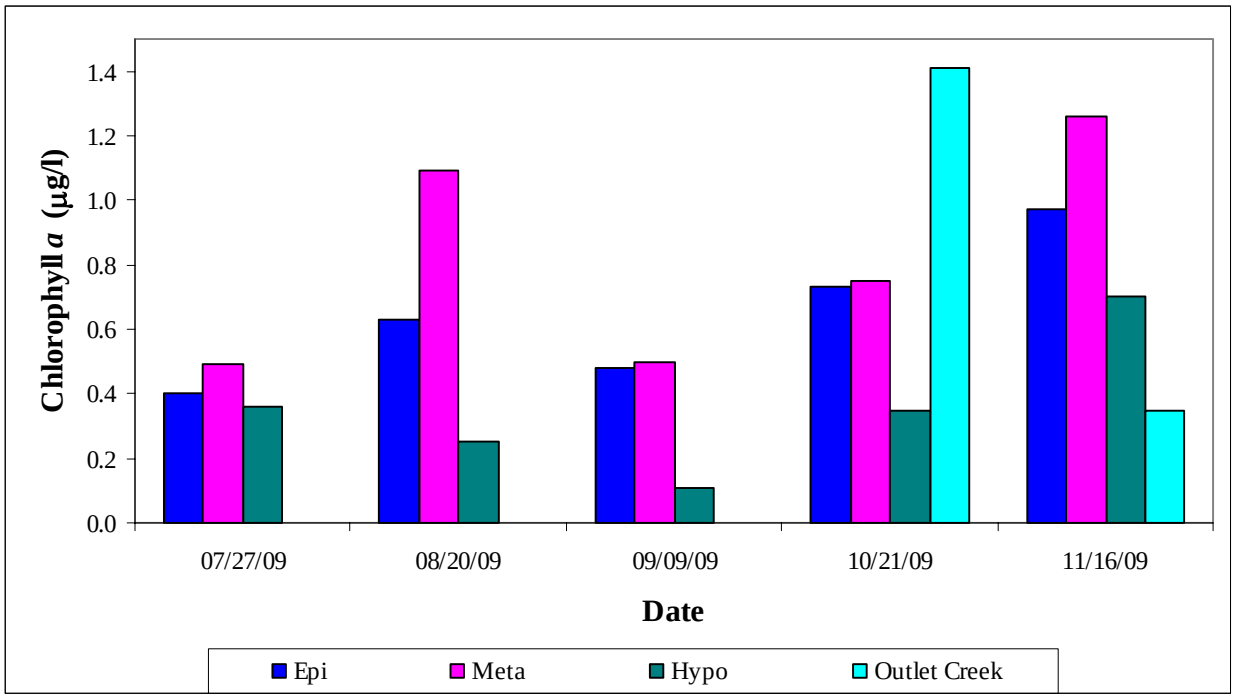

Figure 8. Chlorophyll *a* in Sullivan Lake and Outlet Creek.
Lake values represent averages between northern, middle, and southern lake locations.

Table 5. Sullivan Lake Secchi disk depths.

	07/27/09	08/20/09	09/09/09	10/21/09	11/16/09	Average
Depth (m)	11.7	12.5	10.5	13.0	17.0	12.9

4.4 Secondary Productivity

For the most part, zooplankton from Sullivan Lake and Outlet Creek were identified by species, with the exception of cyclopoids and calanoids (both subclass Copepoda, order Eucopepoda). For the purposes of reporting here, results were tallied by four categories into totals for *Daphnia spp.*, *Bosmina spp.* (both subclass Branchiopoda, order Cladocera), copepods, and rotifers (class Monogononta, order Ploima). The majority of zooplankton identified were either *Daphnia spp.*

or cyclopoids (28% *Daphnia spp.*, 2% *Bosmina spp.*, 44% cyclopoid, 10% calanoid, 16% rotifer). Tables 6-10 summarize the zooplankton results (Table 10 is the sum of Tables 6-9).

Table 6. *Daphnia spp.* Concentrations in Sullivan Lake and Outlet Creek.
All concentrations in #/l.

Location	Tow depth (m)	07/27/09	08/20/09	09/09/09	10/21/09	11/16/09	Average
North	5	26.63	0.99	0.66	1.92	1.97	6.43
	90	4.05	1.28	0.88	0.89	0.38	1.50
Middle	5	9.53	1.32	3.95	3.95	1.81	4.11
	90	4.05	1.25	0.60	0.41	0.35	1.33
South	5	3.95	0.66	3.95	5.92	0.49	2.99
	60	3.56	0.49	0.63	0.78	0.38	1.17
Average	5	13.37	0.99	2.85	3.93	1.42	4.51
	90	3.89	1.01	0.70	0.69	0.37	1.33
Outlet Cr.		3.29	0.55	0.00	1.64	0.55	1.21

Table 7. *Bosmina spp.* Concentrations in Sullivan Lake and Outlet Creek.
All concentrations in #/l.

Location	Tow depth (m)	07/27/09	08/20/09	09/09/09	10/21/09	11/16/09	Average
North	5	0.99	0.00	0.00	1.92	0.11	0.60
	90	0.09	0.00	0.00	0.34	0.24	0.13
Middle	5	0.33	0.00	0.66	0.16	0.16	0.26
	90	0.03	0.00	0.05	0.10	0.02	0.04
South	5	0.00	0.66	0.00	0.33	0.25	0.25
	60	0.05	0.08	0.11	0.05	0.11	0.08
Average	5	0.44	0.22	0.22	0.80	0.17	0.37
	90	0.06	0.03	0.05	0.16	0.12	0.08
Outlet Cr.		0.00	0.00	0.00	0.55	1.64	0.44

Table 8. Copepod Concentrations in Sullivan Lake and Outlet Creek.
All concentrations in #/l.

Location	Tow depth (m)	07/27/09	08/20/09	09/09/09	10/21/09	11/16/09	Average
North	5	16.77	3.62	13.15	19.45	9.53	12.50
	90	2.40	2.01	1.31	3.87	2.57	2.43
Middle	5	10.19	2.30	9.86	12.00	9.70	8.81
	90	2.50	1.22	0.89	2.26	1.42	1.66
South	5	6.25	3.29	18.41	12.49	4.27	8.94
	60	2.33	1.01	1.95	3.24	1.95	2.10
Average	5	11.07	3.07	13.81	14.65	7.83	10.09
	90	2.41	1.41	1.38	3.12	1.98	2.06
Outlet Cr.		7.67	1.10	0.00	10.96	14.25	6.80

Table 9. Rotifer Concentrations in Sullivan Lake and Outlet Creek.
All concentrations in #/l.

Location	Tow depth (m)	07/27/09	08/20/09	09/09/09	10/21/09	11/16/09	Average
North	5	1.97	0.66	0.00	2.47	1.42	1.30
	90	1.58	0.67	1.13	0.79	0.27	0.89
Middle	5	1.64	0.00	4.27	1.32	1.97	1.84
	90	1.00	1.25	0.68	0.55	0.27	0.75
South	5	0.66	0.00	3.62	0.00	0.74	1.00
	60	1.96	0.60	0.85	0.82	0.19	0.88
Average	5	1.42	0.22	2.63	1.26	1.38	1.38
	90	1.51	0.84	0.89	0.72	0.24	0.84
Outlet Cr.		2.19	0.55	0.00	2.19	0.55	1.10

Table 10. Total Zooplankton Concentrations in Sullivan Lake and Outlet Creek.
All concentrations in #/l.

Location	Tow depth (m)	07/27/09	08/20/09	09/09/09	10/21/09	11/16/09	Average
North	5	46.36	5.27	13.81	25.76	13.03	20.85
	90	8.12	3.96	3.32	5.89	3.46	4.95
Middle	5	21.69	3.62	18.74	17.43	13.64	15.02
	90	7.58	3.72	2.22	3.32	2.06	3.78
South	5	10.86	4.61	25.98	18.74	5.75	13.19
	60	7.90	2.18	3.54	4.89	2.63	4.23
Average	5	26.30	4.50	19.51	20.64	10.81	16.35
	90	7.87	3.29	3.03	4.70	2.72	4.32
Outlet Cr.		13.15	2.20	0.00	15.34	16.99	9.54

Selected results tabulated in Tables 6-9 are illustrated in Figures 9-13. Figure 9 shows densities by zooplankton category for the entire water column (vertical tows of 60-90m depending on location) averaged across all three sites (northern, middle, and southern). Figure 10 shows the corresponding data for Outlet Creek (3m horizontal tow). Figure 11 shows a comparison between the two most prevalent zooplankton categories for vertical tows of 5m and 90m at the North Sullivan Lake location. Figures 12 and 13 show the corresponding comparisons for the Middle and South Sullivan Lake locations, respectively.

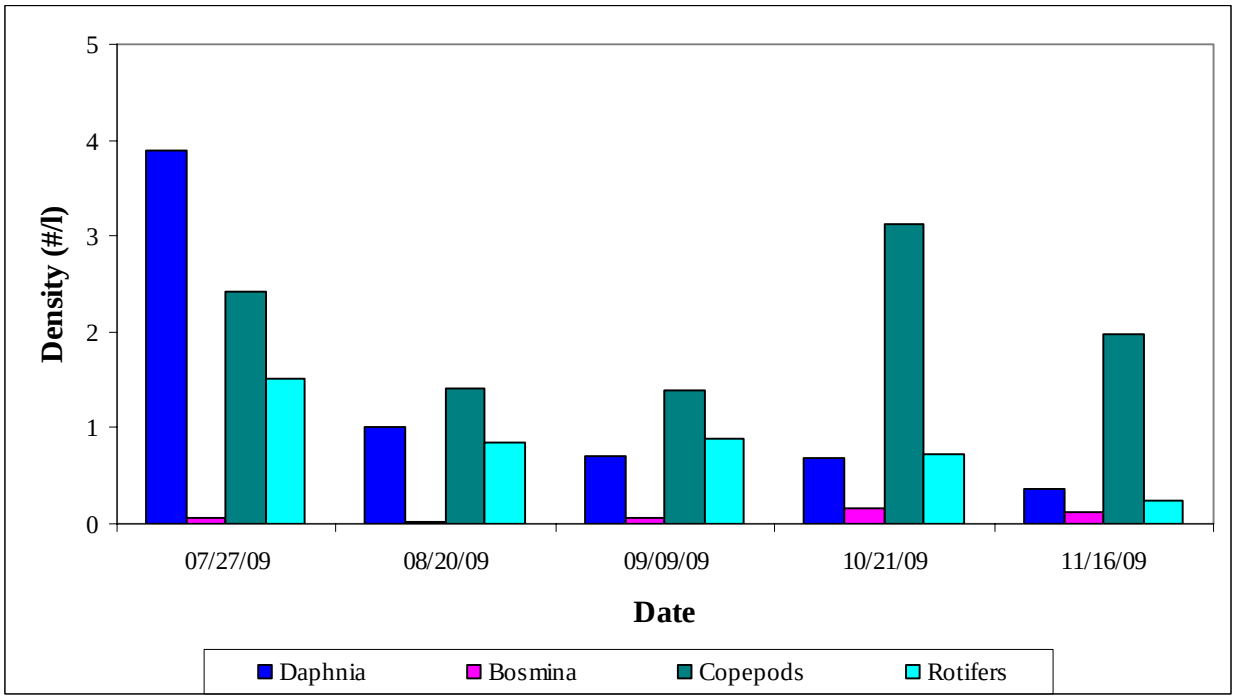

Figure 9. Zooplankton density in Sullivan Lake in total water column.
Averages between northern, middle, and southern lake locations.

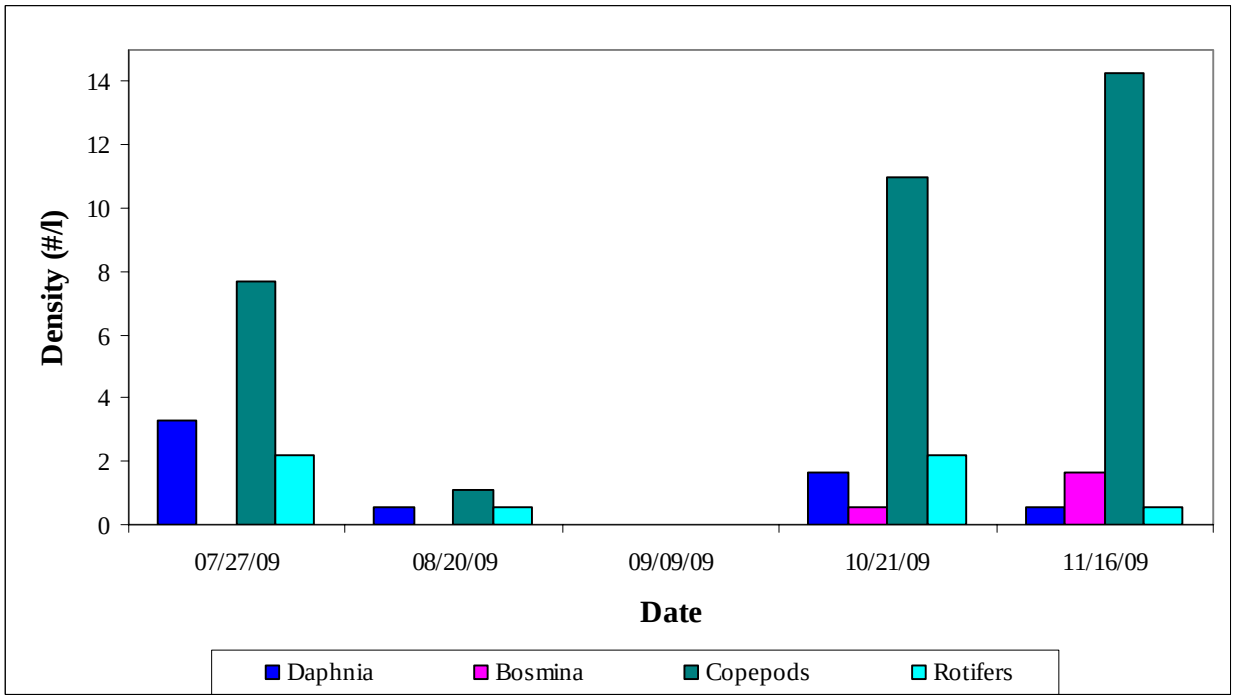

Figure 10. Zooplankton density in Outlet Creek.
No zooplankton was found in the September samples.

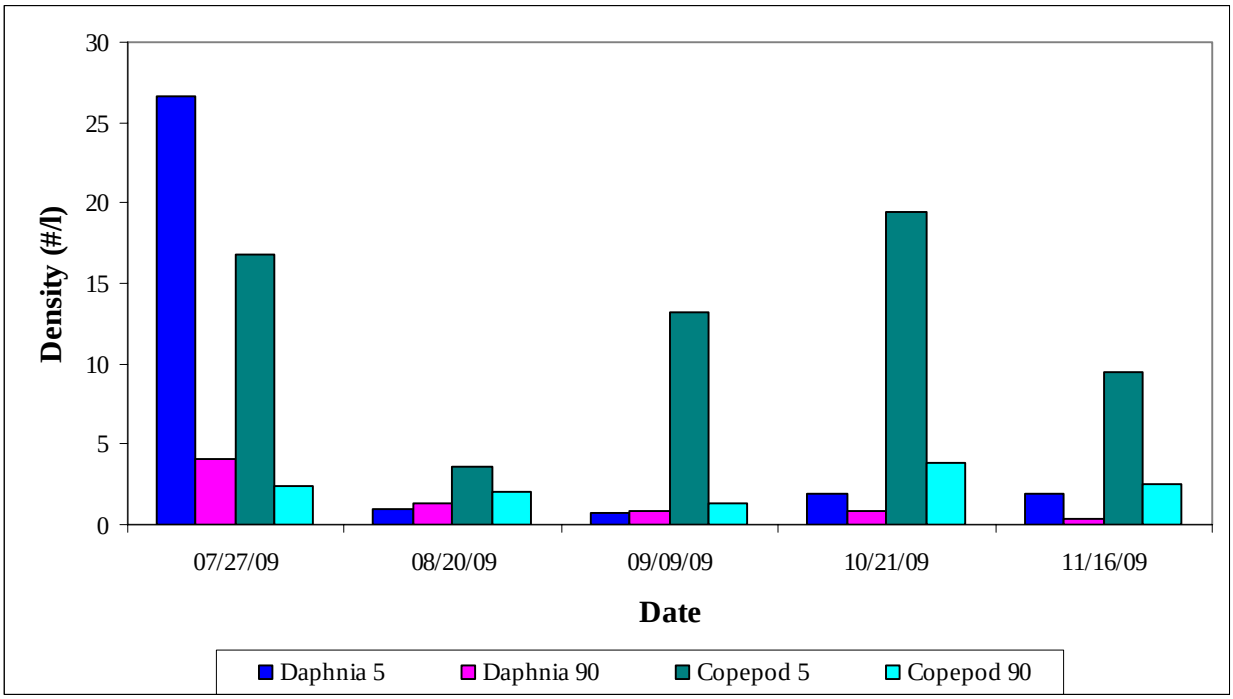

Figure 11. Zooplankton density comparison at North Sullivan Lake location for vertical tows of 5m and 90m.

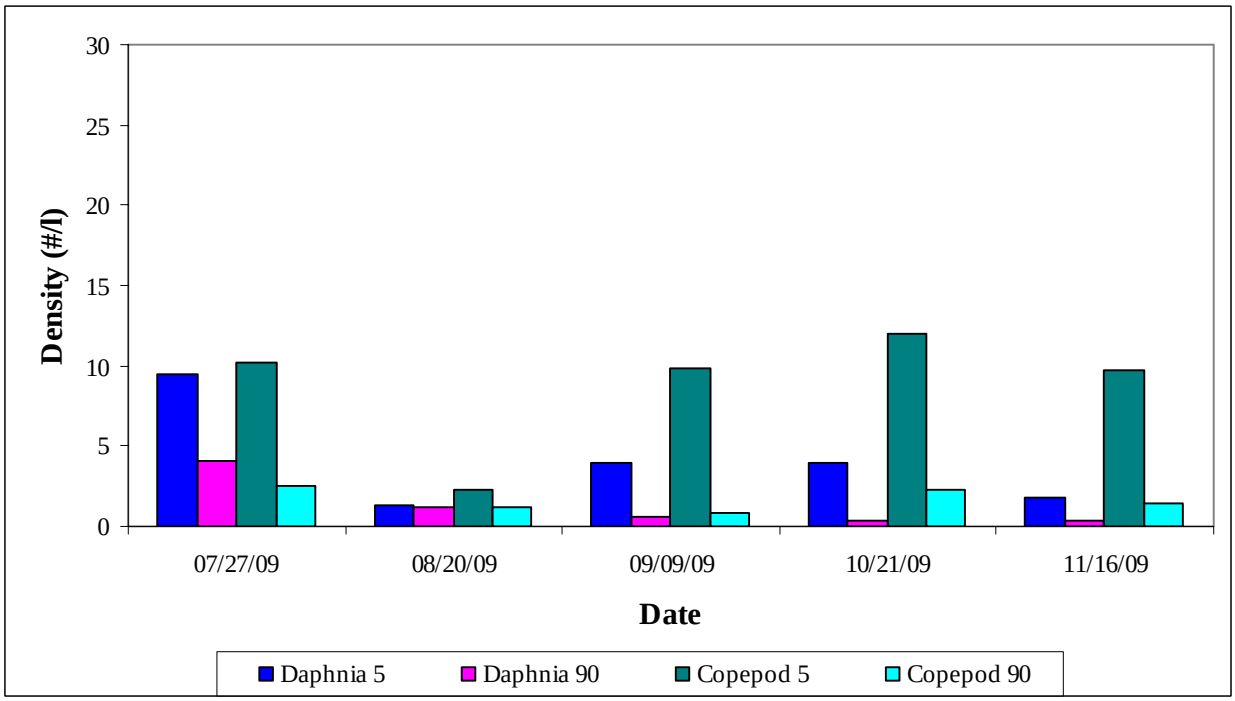

Figure 12. Zooplankton density comparison at Middle Sullivan Lake location for vertical tows of 5m and 90m.

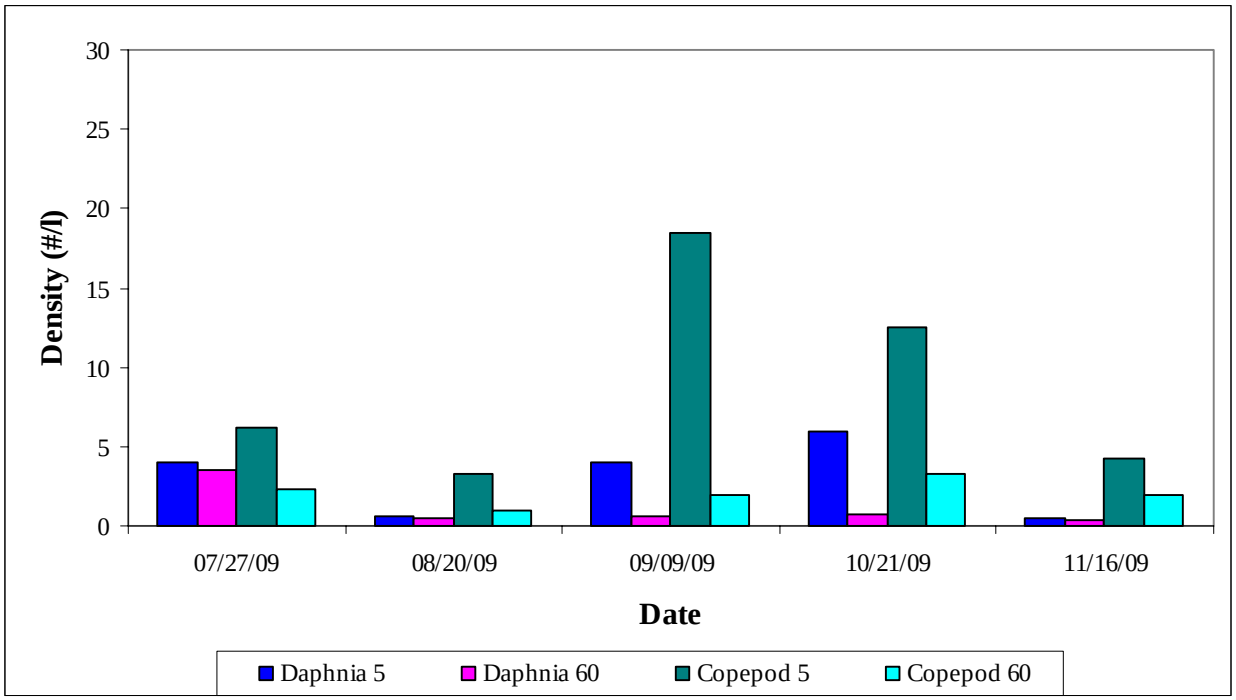

Figure 13. Zooplankton density comparison at South Sullivan Lake location for vertical tows of 5m and 60m.

5.0 DISCUSSION AND CONCLUSIONS[2]

5.1 Water Quality

Sullivan Lake was stratified for the entire study period, but was approaching isothermal conditions by the last sampling period in mid-November (Figure 2). This is consistent with continuous monitoring data collected independently by the District in 2009 (Figure 14). The spatial and temporal patterns of temperature distribution in the lake found in this study were consistent with that found by Nine and Scholz (2005). The highest water temperature recorded in this study was 21.5°C in the epilimnion in July. Water quality standards for surface waters of Washington State suggest an upper limit of 17.5°C for rearing and migration of salmonids (WAC 1999). Temperature does not appear to limit fish production in Sullivan Lake, because average temperatures fall between the preferred temperatures for salmonids (10°C to 20°C). In some cases, water temperatures at the surface may exceed optimum temperatures for salmonids, but temperatures in the metalimnion and hypolimnion provide refuge from higher temperatures at the surface, since there is abundant oxygen in all strata. Water temperatures in Outlet Creek were similar to those at approximately 5m depth in the lake.

[2] Much of the background information in this discussion is drawn from Nine and Scholz (2005).

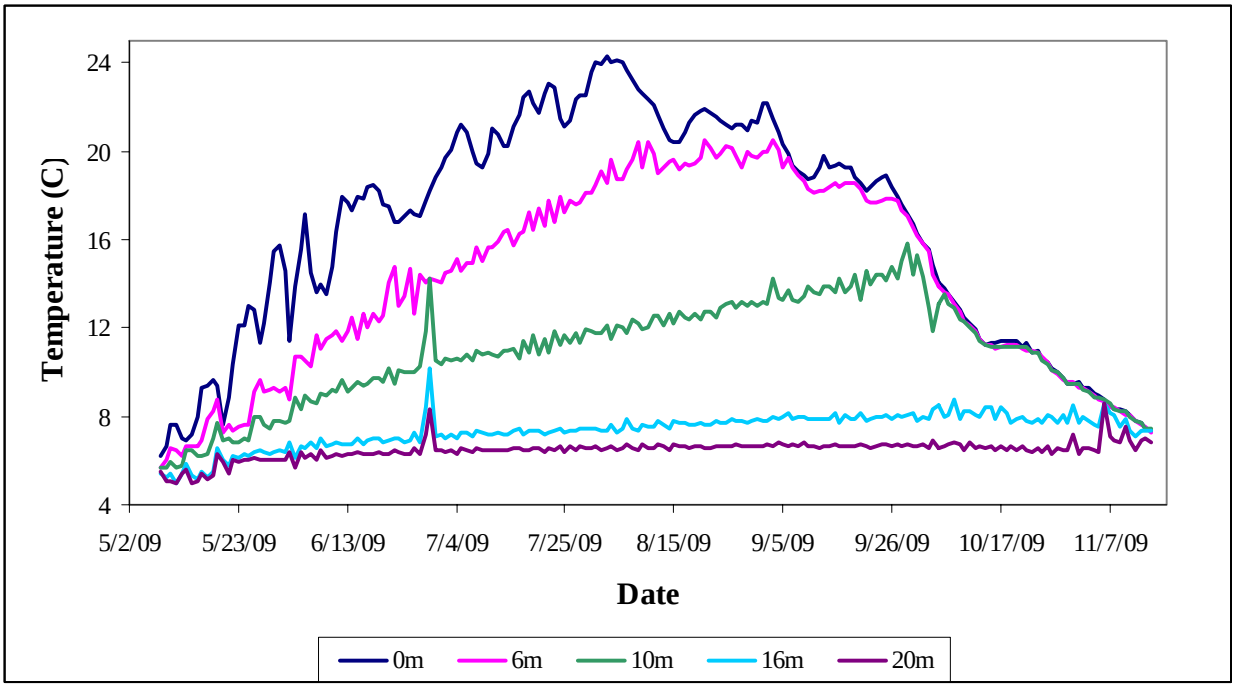

Figure 14. Continuous temperature monitoring data in Sullivan Lake at selected depths.

Dissolved oxygen concentrations averaged 9.0 mg/l in the epilimnion, which is within the optimum range for normal physiological functions in salmonids (Bjorn and Reiser 1991). Concentrations never declined below 7.2 mg/l anywhere in the lake, which is more than the 6.5 mg/l DO concentration required by salmonids (WAC 1999). The spatial and temporal patterns of DO distribution in the lake were consistent with that found by Nine and Scholz (2005). DO does not appear to limit fish production in Sullivan Lake. The lake also has sufficient oxygen content throughout the water column. DO in Outlet Creek was considerably lower, averaging 5.2 mg/l.

The optimum pH for fish is between 5 and 10, with the upper and lower ends of the range having negative impacts on fish (Bennett 1971). Washington State criteria recommend a range between 6.5 and 8.5 for salmonids (WAC 1999). The pH of Sullivan Lake averaged 8.3 in the epilimnion, 8.0 in the metalimnion and 7.7 in the hypolimnion. The pH measured in this study was in the same range as that found by Nine and Scholz (2005). However, there did appear to be an increasing trend in pH through the summer and into the fall, which was not apparent in observations made by Nine and Scholz (2005). Sullivan Lake falls within the recommended range, and therefore pH does not appear to limit fish distribution. Outlet Creek pH was in the same range as the lake.

Turbidity is a measure of the amount of suspended particulate in the water. The greater the amount of total suspended particulate in the water, the murkier it appears, and the higher the measured turbidity. For disturbance-related effects on turbidity, the recommended standard is 5 NTU over background when the background is less than 50 NTU (WAC 1999). The maximum turbidity recorded was 1.6 NTU in the epilimnion, 3.1 NTU in the metalimnion, and 2.9 NTU in the hypolimnion. Turbidities measured in this study were in the same range as those found by

Nine and Scholz (2005). The increased turbidity during the November sampling period may be due to a different sampling crew and equipment, or may be due to increased precipitation in the fall. Turbidity does not appear to be a limiting factor in Sullivan Lake. Turbidity in Outlet Creek was similar to that in the lake.

Conductivity is a measure of total dissolved ions in the water, such as ionized nutrients (NH_4^+, NO_2^-, NO_3^-, PO_4^-). Conductivity is therefore a useful indicator of a lake's productivity. The typical range of conductivity values for surface waters is 0.030-0.400 mS/cm (EPA 2001). Studies of inland fresh waters indicate that streams supporting good fisheries have a range between 0.15 and 0.50 mS/cm (EPA 2001). Conductivity in Sullivan Lake averaged 0.092 mS/cm in the epilimnion, 0.093 mS/cm in the metalimnion, and 0.097 in the hypolimnion. Conductivity measured in this study was similar to that found by Nine and Scholz (2005). This suggests that limited amounts of ionized nutrients may limit production in the lake. Conductivity in Outlet Creek was somewhat higher than in the lake, averaging 0.114 mS/cm.

5.2 Nutrients

Nitrogen and phosphorus are nutrients required to form proteins and other necessary biological compounds. Nitrogen availability in lakes is usually greater than phosphorus, with normal ratios in the range of 7:1 to 10:1. Higher ratios indicate a deficiency in phosphorus (Horne and Goldman 1994), and lakes with these higher ratios tend to be phosphorus limited. Phosphorus limitation is typically associated with oligotrophy (Horne and Goldman 1994). Lakes with lower ratios of nitrogen to phosphorus tend to be nitrogen limited. Nitrogen limitation is typically associated with eutrophy (Horne and Goldman 1994).

Phosphorus is a common growth limiting nutrient for phytoplankton in freshwater lakes, because it is present in very low concentrations (Horne and Goldman 1994). Oligotrophic lakes average less than 0.01 mg/l, compared to mesotrophic and eutrophic lakes that average 0.01-0.25 mg/l and >0.25 mg/l, respectively (EPA 1986). Sullivan Lake falls within the federal criteria for classification as oligotrophic, averaging 0.007 mg/l. Total phosphorus limits phytoplankton production in Sullivan Lake. Total phosphorus levels in Outlet Creek were similar to those in the lake. However, total phosphorus did appear to trend downward in the fall in both the lake and Outlet Creek (Figure 15), which is consistent with results found by Nine and Scholz (2005).

Total reactive phosphorus (ortho-phosphate) is a measure of the inorganic oxidized form of soluble phosphorus. It is a better measure of phosphorus in less productive lakes, because it determines what is biologically available to phytoplankton for photosynthesis (Horne and Goldman 1994). Sullivan Lake averaged 0.006 mg/l ortho-phosphate. Ortho-phosphate levels in Outlet Creek were similar to those in the lake. Ortho-phosphate levels also appear to have trended down in the fall (Figure 16), which is also consistent with results found by Nine and Scholz (2005).

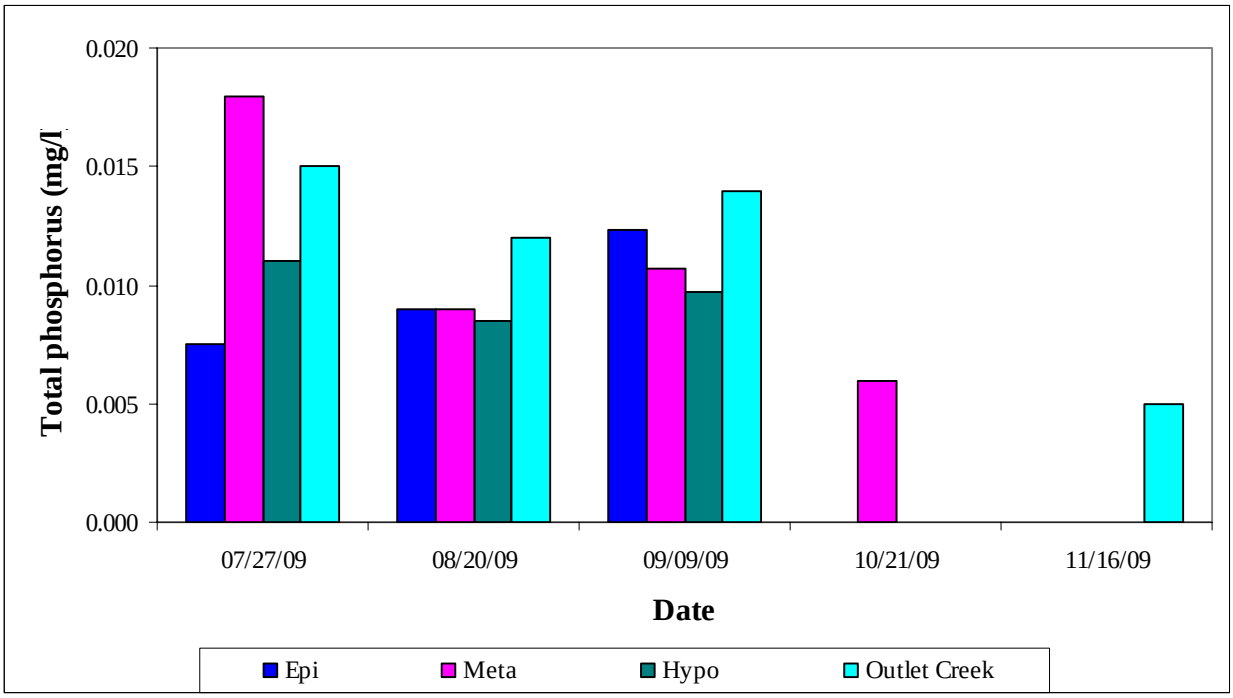

Figure 15. Total phosphorus in Sullivan Lake and Outlet Creek.

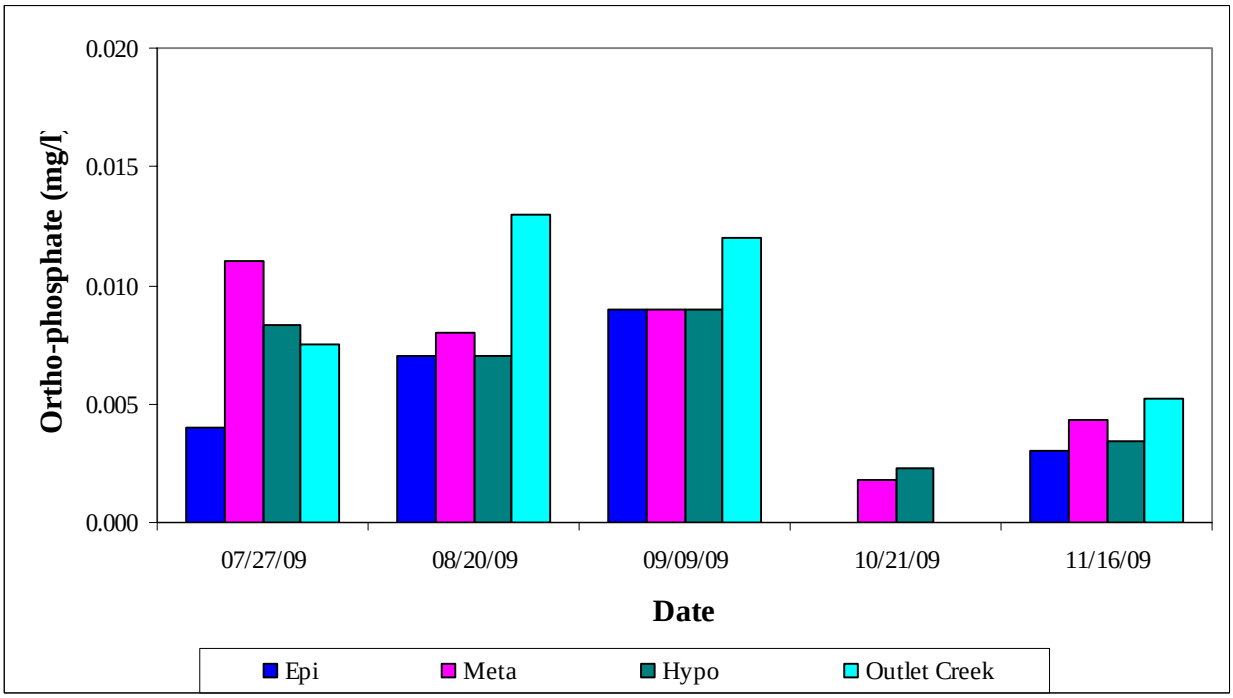

Figure 16. Ortho-phosphate in Sullivan Lake and Outlet Creek.

Published data on average total nitrogen and total phosphorus in the epilimnion have shown that nitrogen:phosphorus ratios are very high in oligotrophic lakes, because the majority of nitrogen

and phosphorus come from undisturbed watersheds, which export much less phosphorus than nitrogen (Downing and McCauley 1992). Lakes that receive the majority of their runoff from forests should have higher ratios compared to those that receive primarily groundwater or river water inputs (Downing and McCauley 1992). Sullivan Lake had a high ratio of 27:1 in the epilimnion (average of 0.16 mg/l of TKN and 0.006 mg/l of total phosphorus), indicating a system limited by phosphorus. This is higher than the ratio of 13:1 found by Nine and Scholz (2005). Nitrogen does not currently limit fish production, because the lake is phosphorus limited. However, if phosphorus levels increased, the lake would rapidly become nitrogen limited, because nitrogen levels are low. Total nitrogen and total phosphorus levels in Outlet Creek were generally in the same range as in the lake, but with a ratio of nitrogen:phosphorus of 14:1.

Nitrite is an unstable form of nitrogen that is rapidly oxidized to nitrate or reduced to nitrogen gas, and is usually found in small amounts, such as those found in Sullivan Lake (<0.01mg/l). Although a certain amount of nitrogen in this form is necessary to sustain life, nitrites can be toxic to aquatic life at relatively low concentrations. The nitrite nitrogen level in Sullivan Lake never increased above detection limits (0.01 mg/l). This is consistent with results found by Nine and Scholz (2005). Therefore, nitrite toxicity does not present a problem for fish in Sullivan Lake. Extremely low levels of nitrite may contribute to limiting phytoplankton production in Sullivan Lake, although the lake is currently limited by phosphorus, as described above. Nitrite nitrogen in Outlet Creek was also consistently below the detection limits of 0.01 mg/l.

Nitrate nitrogen in the lake was often less than 0.01 mg/l, but at times rose as high as 0.03 mg/l. Nitrate nitrogen is not toxic to fish until it increases above 10 mg/l (Horne and Goldman 1994). Piper et al. (1982) suggest nitrate nitrogen levels ranging from 0.0-0.3 mg/l for rearing trout. Nitrate levels in Sullivan Lake were within the recommended range, and therefore do not present a nitrate toxicity problem to fish. Nitrate levels measured in this study were in the same range as those found by Nine and Scholz (2005). Low levels of nitrate may contribute to limiting phytoplankton production in Sullivan Lake, although the lake is currently limited by phosphorus, as described above. Nitrate nitrogen in Outlet Creek was somewhat higher than in the lake, averaging 0.04 mg/l. Nitrate nitrogen levels were relatively consistent over the study period in both the lake and Outlet Creek.

Ammonia levels in most lakes are below 0.1 mg/l (Horne and Goldman 1994). Ammonia is a nutrient utilized by phytoplankton in combination with carbon. It is toxic to aquatic animals at concentrations between 10 and 30 mg/l and aquatic plant life at concentrations above 500 mg/l (Horne and Goldman 1994). Sullivan Lake had low levels of ammonia, often below detection limits of 0.01 mg/l, and always less than 0.1 mg/l. Ammonia levels measured in this study were in the same range as those found by Nine and Scholz (2005). Ammonia levels in Outlet Creek were similar to those in the lake. Ammonia levels in both the lake and Outlet Creek had diminished to below detectable limits by September and remained there into the fall (Table 2).

Hydrogen sulfide (H_2S) released at the mud-water interface oxidizes and forms sulfate (Horne and Goldman 1994). Sulfate in Sullivan Lake increased from an average of 3.55 mg/l in the epilimnion to 4.07 mg/l in the hypolimnion. This indicates an oxygenated micro-zone at the bottom of the lake, which is characteristic of oligotrophic lakes. Eutrophic lakes typically are

unable to oxidize H_2S into sulfate, because oxygen content is too low in the deepest waters. These results are consistent with those found by Nine and Scholz (2005). Sulfate levels in Outlet Creek were in the same range as those in the lake. Sulfate levels were relatively steady over the study period in both the lake and Outlet Creek.

Total dissolved solids (TDS) include inorganic salts and organic matter dissolved in the water. TDS concentration varies with different mineral solubilities. TDS is typically 30 mg/l-65 mg/l in water in contact with igneous and metamorphic rock, siliceous sand, well-leached soil, or other relatively insoluble material (Rainwater 1960; Garrison Investigative Board 1977). In areas where carbonates, chlorides, calcium, magnesium, and/or sulfates are present, TDS levels range between 195 mg/l-1100 mg/l (Garrison Investigative Board 1977). In a survey of the Great Lakes, TDS levels ranged from 61 mg/l-227 mg/l (Upper Lakes Reference Group 1977). In Sullivan Lake, TDS concentrations averaged 67 mg/l in the epilimnion, 74 mg/l in the metalimnion, and 75 mg/l in the hypolimnion. Since these concentrations are less than 195 mg/l, this indicates a system that is relatively clear of inorganic salts. TDS levels measured in this study were in the same range as those found by Nine and Scholz (2005). TDS levels in Outlet Creek were similar to those in the lake, averaging 74 mg/l. TDS levels were relatively consistent over the study period in both the lake and Outlet Creek.

5.3 Primary Productivity

Chlorophyll *a* is often used as a trophic state indicator for primary production (Carlson 1977). Chlorophyll *a* in Sullivan Lake was low, averaging 0.60 μg/l, compared to 1.5 μg/l - 20 μg/l in more productive lakes. In addition, Secchi disk transparency was deep (average 13m), allowing for a large euphotic zone, indicating a system with dispersed phytoplankton production throughout the large euphotic zone. It also indicates a lake with very low primary productivity. Chlorophyll *a* was relatively steady in the lake over the study period, which is consistent with results found by Nine and Scholz (2005). Chlorophyll *a* in Outlet Creek was even lower than in the lake, averaging 0.35 μg/l. However, chlorophyll *a* in Outlet Creek was undetectable in the summer, increased dramatically in October, then declined somewhat in November (Figure 8). This increase in chlorophyll *a* in Outlet Creek appears to have coincided with the drawdown of Sullivan Lake, which began approximately October 1.

5.4 Secondary Productivity

Zooplankton were limited with respect to both density and species diversity. Only two species of cladocerans were found, including one species each of *Daphnia spp.* and *Bosmina spp.* Zooplankton in Sullivan Lake are likely limited by low phytoplankton production. They may also be limited due to an abundant kokanee population, which crops off the larger sized zooplankton.

The collection of zooplankton samples from the epilimnion and from the bottom to the surface indicated that zooplankton are utilizing areas below the epilimnion, although they tend to be more concentrated nearer the surface. Zooplankton likely spend the day-light hours in the upper part of the hypolimnion or lower part of the metalimnion, and by dusk move up into the metalimnion and epilimnion. This is a typical diurnal vertical migration behavior displayed by

many zooplankton, especially larger-sized cladocerans, to avoid size-selective predation by visual predators (Zaret and Suffern 1976). Samples for this study were collected near the middle of the day, generally between 10:00 a.m. and 3:00 p.m., and may therefore reflect zooplankton migration toward the hypolimnion. The spatial pattern of zooplankton densities in this study is consistent with that found by Nine and Scholz (2005).

Species population data are inherently highly variable, which is also true in this instance, as illustrated by the data displayed in Figures 11-13. Therefore, trends in zooplankton density with time or location are difficult to discern. Nonetheless, *Daphnia spp.* appear to have declined in the lake over the study period, while copepods remained relatively steady or slightly increased (Figure 9). The temporal pattern of zooplankton densities is consistent with that found by Nine and Scholz (2005): *Daphnia spp.* peaked in July, copepods peaked in October, and *Bosmina spp.* remained relatively low but increased slightly in the fall. Zooplankton densities in Outlet Creek were similar to average densities found in the lake through the entire water column (compare Figures 9 and 10). However, copepods increased substantially in Outlet Creek in the fall (after initiation of lake drawdown in October) (Figure 10).

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

APPENDIX E.3-3
WDFW TEMPERATURE DATA AND TEMPERATURE MODELING STUDY

Sullivan Creek Mixed Water Temperature Modeling

(Including Cold Water Release Pipe Modeling)

Based on

2009 Washington Department of Fish and Wildlife Water Temperature Measurements in Sullivan Creek and Lake

Prepared for
PUD No. 1 of Pend Oreille County
Newport, WA

Prepared By

EES Consulting, Inc.
Kirkland, WA
February 10, 2010

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Sullivan Creek Mixed Water Temperature Modeling
Based on 2009 Washington Department of Fish and Wildlife Water Temperature Measurements in Sullivan Creek and Lake

1.0 Introduction

The Sullivan Creek Project consists of the following features:

- Sullivan Lake - approximately 1260 acres at elevation 2588.66
- Sullivan Dam - controls Lake level and discharges into Outlet Creek
- Outlet Creek - small creek extending ½ mile downstream from Sullivan Dam, to its confluence with Sullivan Creek. Outlet Creek has a USGS flow gauging station installed about 0.4 miles downstream of Sullivan Dam. Outlet Creek drainage area upstream of the gauge is about 50 sq mi.
- Upper Sullivan Creek - an unregulated creek with a drainage area of about 70 sq mi at its confluence with Outlet Creek
- Lower Sullivan Creek - After its confluence with Outlet Creek, Sullivan Creek nearly doubles in size, and flows about 1 mile into Mill Pond. At the outlet of Mill Pond, it flows over the uncontrolled spillway of Mill Pond Dam and continues about 4 miles to its confluence with the Pend Oreille River

As part of the Sullivan Creek Project FERC License (#2225) Surrender Process, all Parties indicated interest in the water temperatures in Sullivan Lake, Sullivan Creek and Outlet Creek during various parts of the year. Also of interest was the effect on downstream water temperatures of draining Sullivan Lake in the Fall. Washington Department of Fish and Wildlife (WDFW) installed temperature recording devices in several locations, as described below, and collected simultaneous water temperature data in the lake (at various levels), in Outlet Creek, Sullivan Creek above the confluence with Outlet Creek, Sullivan Creek below Outlet, Mill Pond, and downstream of Mill Pond.

After this simultaneous data was collected, the Public Utility District No. 1 of Pend Oreille County (POPUD) retained EES Consulting to analyze the data and to prepare a computer model to be used to predict mixed water temperatures in Sullivan Creek downstream of its confluence with Outlet Creek. This report summarizes the data and the modeling efforts.

2.0 WDFW Water Temperature Data Collection

WDFW installed 12 water temperature recording instruments in various locations. The station in Sullivan Lake had sensors deployed at various depths, from 20 m deep to the surface, in 2 m increments. Several other stations (but not all) had duplicate instruments at the same site to insure accurate and complete records would be recorded. The recording instruments were located as follows:

Table 1 WDFW Water Temperature Monitoring Stations			
Recorder #	**Location**	**Date Installed**	**Date Removed**
1	Sullivan Lake- with sensors at depths from 20m to the surface in 2m increments	5/8/09	11/16/09
2	Sullivan Creek- 50m Upstream of Confluence with Outlet Creek- Unit 1	7/1/09	11/16/09
3	Sullivan Creek- 50m Upstream of Confluence with Outlet Creek- Unit 2	7/1/09	11/16/09
4	Sullivan Creek- 75m downstream of confluence with Outlet Creek- Unit 4	7/1/09	11/16/09
5	Sullivan Creek- 1.5 km downstream of Mill Pond Dam- Unit 5	7/1/09	11/16/09
6	Sullivan Creek- 1.5 km downstream of Mill Pond Dam- Unit 6	7/1/09	11/16/09
7	Outlet Creek- 75m downstream of Dam outlet- Unit 1	7/1/09	11/16/09
8	Outlet Creek- 75m downstream of Dam outlet- Unit 2	7/1/09	11/16/09
9	Mill Pond 15m upstream of Mill Pond Dam- Unit 1	7/1/09	11/16/09
10	Mill Pond 15m upstream of Mill Pond Dam- Unit 1	7/1/09	11/16/09
11	Harvey Creek- Unit 1	7/1/09	11/16/09
12	Harvey Creek Unit 2	7/1/09	11/16/09

The data was collected and provided to EES Consulting in raw form on November 17, 2009. The data consisted of 24 daily readings, taken once per hour, for the period the recorders were deployed. EESC converted the data to daily average readings for the period of record. This re-formatted data is shown in Appendix A.

Once formatted, the data was graphed in various ways in order to visually evaluate what the data indicated. Note that lake temperature data was available from May 8, but all other temperature data began with temperatures first measured on July 1, 2009.

The lake water temperatures versus depth were graphed as appeared as shown in Figure 1 below.

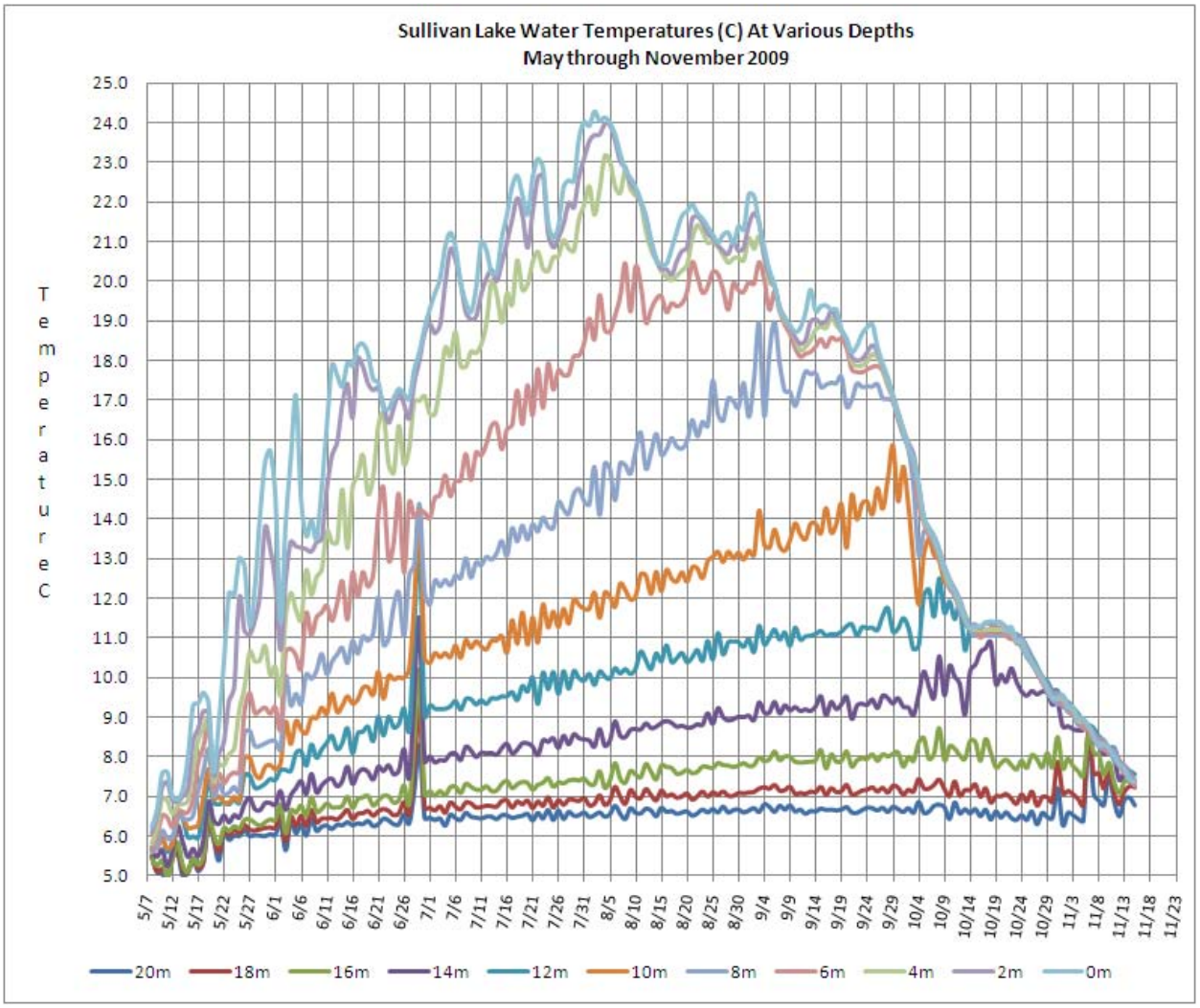


Figure 1
Sullivan Lake Water Temperatures (C) at Various Depths May through November 2009

The data show that the maximum lake surface water temperature in 2009 occurred around August 2, and reached about 24.3 C. Strong stratification of water temperatures with depth became evident beginning in the latter half of May and was fully developed by June 15. About October 1, surface water temperatures began to drop very quickly and the stratification began to "turn over" about October 1. By November 1, almost no difference in temperature remained between the surface water and water at depth.

The other data streams from Harvey, Sullivan and Outlet Creeks were also graphed. The results are shown in Figure 2, below.

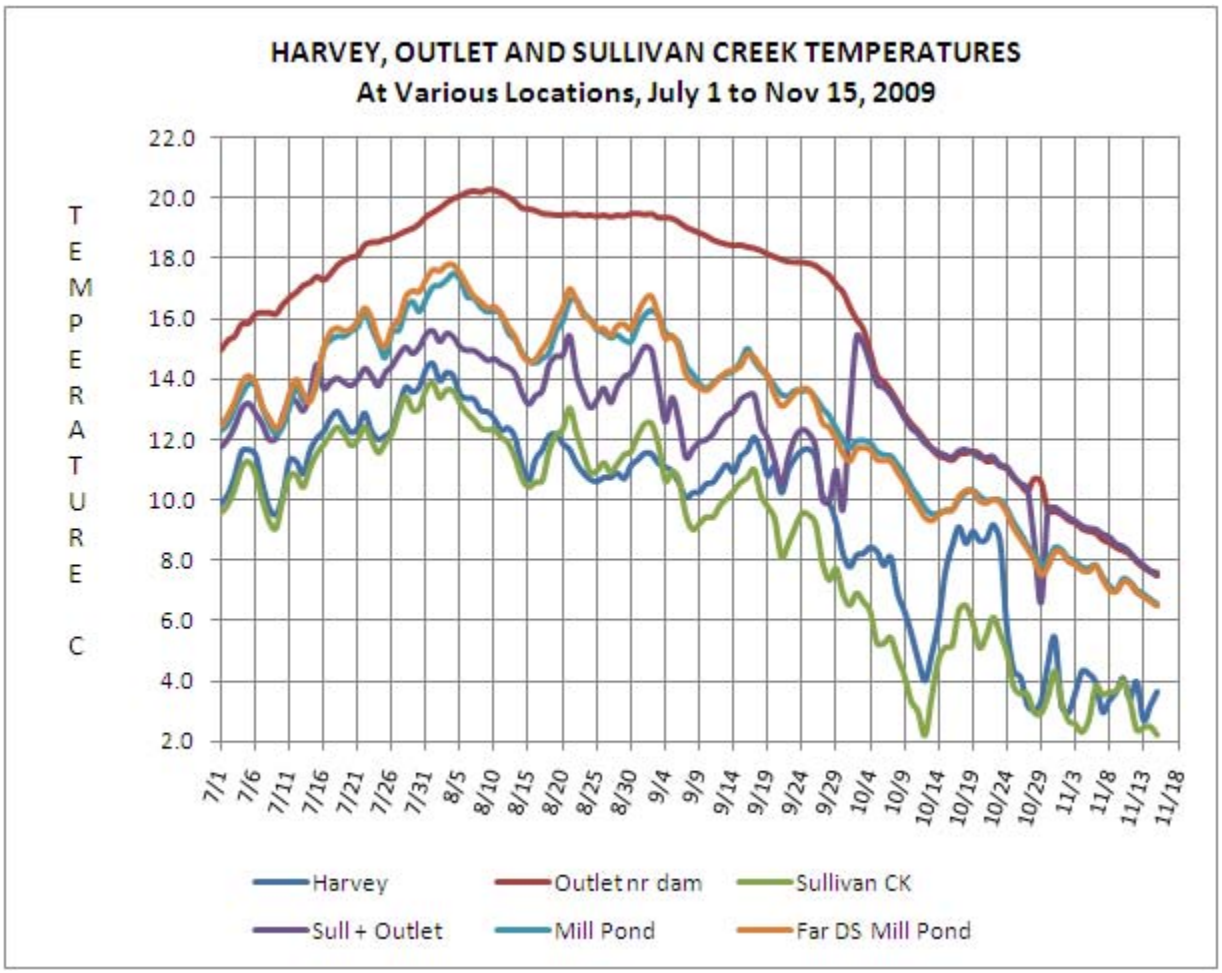


Figure 2
Harvey, Outlet and Sullivan Creek Temperatures at Various Locations, July 1 to November 15, 2009

Of interest to note in this data are the following points:

1. Harvey Creek and Sullivan Creek (upstream of confluence) temperatures (green and dark blue lines) are the coolest of all creek waters and are very similar.

2. Outlet Creek water temperatures are the warmest of the creeks, mainly due to releasing of the water warmed in Sullivan Lake.

3. Mill Pond near its outlet has considerably warmer water than Sullivan Creek upstream of the confluence with Outlet Creek. But when Sullivan lake begins to drain in the fall, the mixed temperature of Outlet + Sullivan jumps rapidly (purple line). The combined Sullivan and Outlet waters are warmed up quickly by the warm Sullivan Lake water. This is shown in more detail below. In 2009, Sullivan Creek flows were about 70% of the long term average for the Fall, and these low flows were rapidly warmed by the Sullivan lake releases. But, this warm water was moderated by Mill Pond, as Mill Pond temperature did not show any jump when Sullivan Lake began to drain.

4. Water temperature in Sullivan Creek 1.5 km downstream of Mill Pond dam appears to be almost the same as the temperature in Mill Pond. Data taken in 1996 as part of the POPUD License Amendment process at that time showed that 1 to 2 degrees C of change was typical between Mill Pond and the confluence of Sullivan Creek with the Pend Oreille River (about 4 miles or 6.5 km downstream). In future temperature studies, a data recorder located at the mouth of Sullivan Creek at the Pend Oreille River would provide further useful information.

As described in item 3 above, when draining of Sullivan Lake began around October 1, warm water from Sullivan Lake mixed with cool water in Sullivan Creek, and the mixed water temperature rose very quickly to almost match the Outlet Creek temperature. From spot flow readings taken by the Kalispel Tribe in Sullivan Creek, 2009 Sullivan Creek flows were quite low, about 70% of average for October, and in the range of 25 to 28 cfs during October. When close to 200 cfs of warm water was added from Sullivan Lake, the mixed temperature jumped. This is shown clearly in Figure 3.

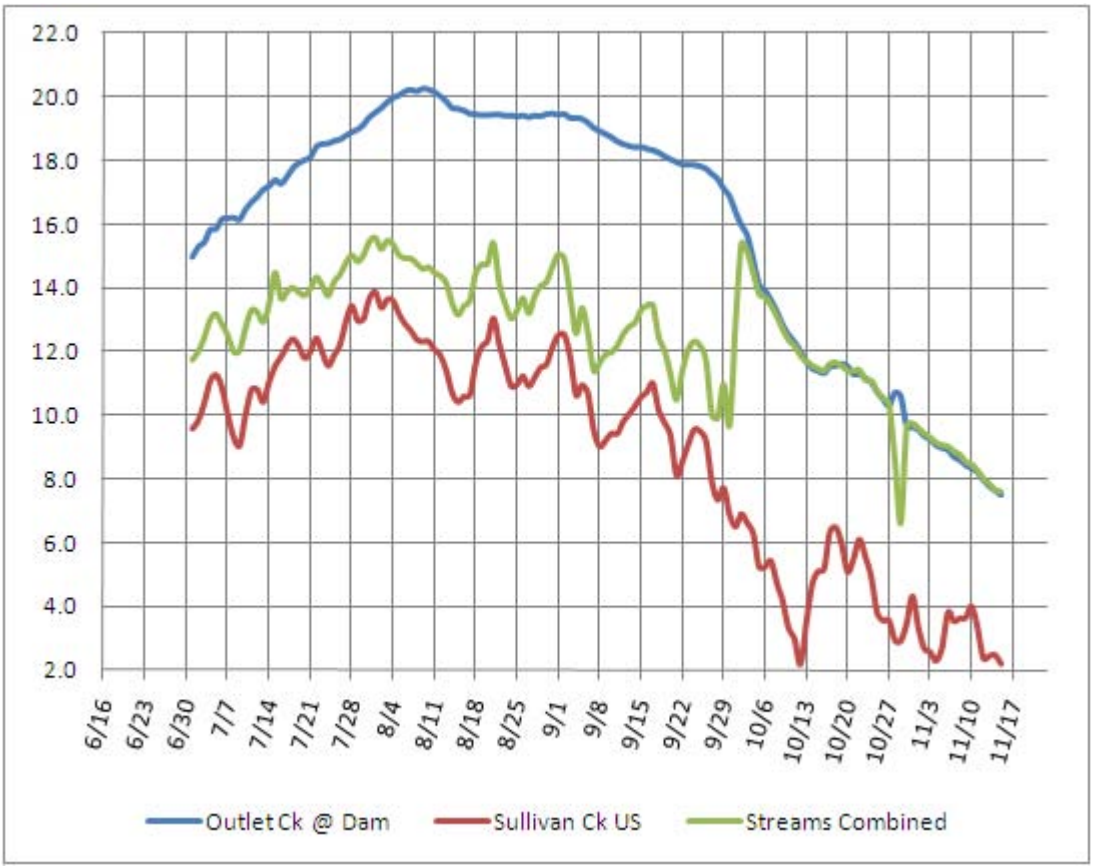


Figure 3
Temperatures in Outlet and Sullivan Creeks and Mixed Temperatures
June 16 through November 17, 2009

Until all this simultaneous data was gathered by WDFW, it was unclear how the Outlet Creek temperature related to the actual measured Sullivan Lake temperature. To examine that, we plotted Outlet Creek temperature against lake water temperatures at various depths. This is shown in Figure 4, below.

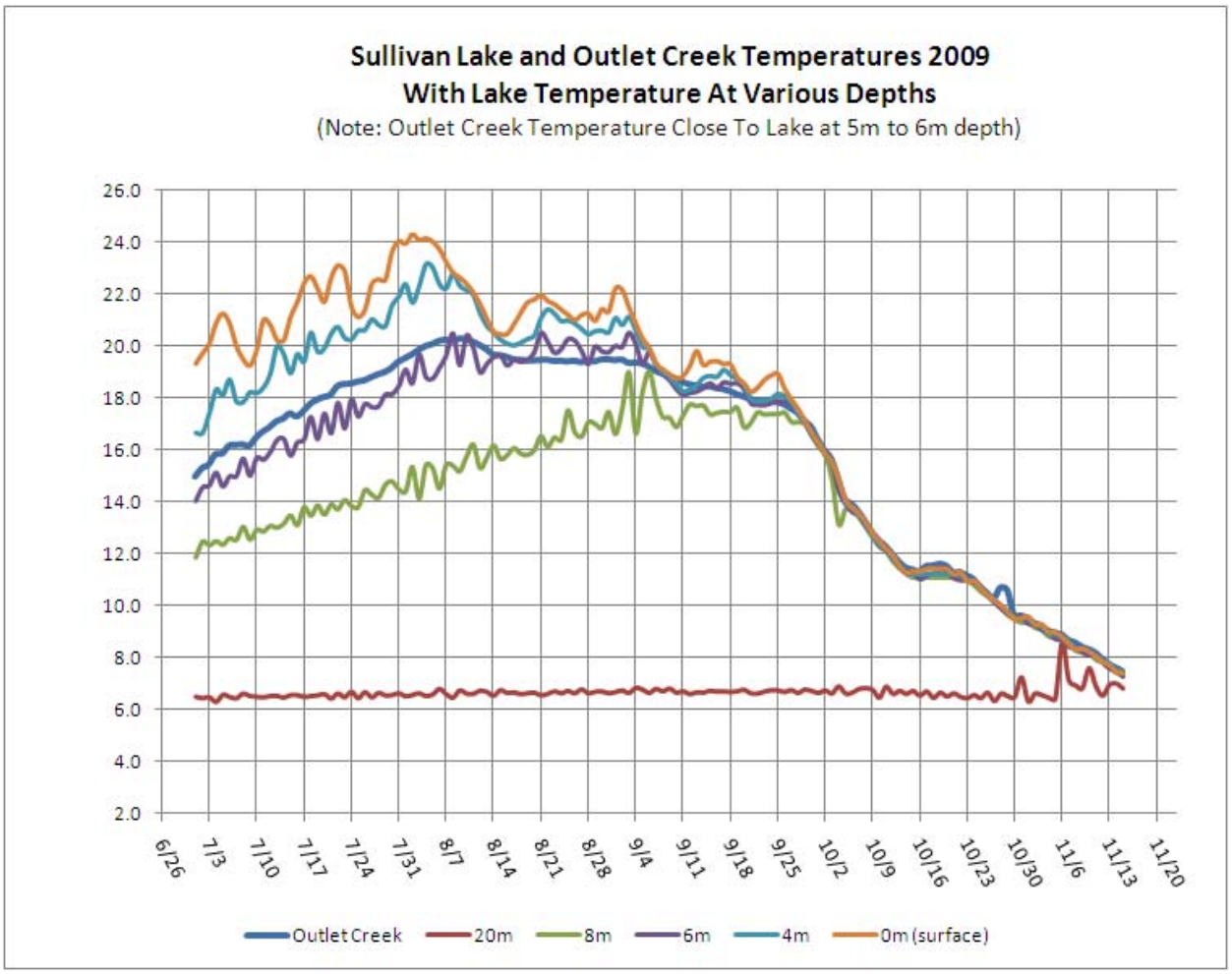


Figure 4
Sullivan Lake and Outlet Creek Temperatures 2009 with Lake Temperature at Various Depths

The graph shows that the Outlet Creek temperature (dark blue smooth line) does not correspond to the Sullivan Lake surface temperature (orange). Instead, Outlet Creek temperature most closely tracks the lake temperatures recorded around 6 m below the lake surface (purple line). This makes sense because the Sullivan Dam outlet gates are at the base of the dam at an invert elevation of 2563.6 MSL. This is 25 feet (7.6 m) below the surface of the full pool on October 1, so it should be expected that water released at this time would be cooler as it was coming from deeper within the lake. The data confirm this.

Finally, we compared Sullivan Creek and Harvey Creek natural temperatures with the lake temperatures. This data is shown in Figure 5, below.

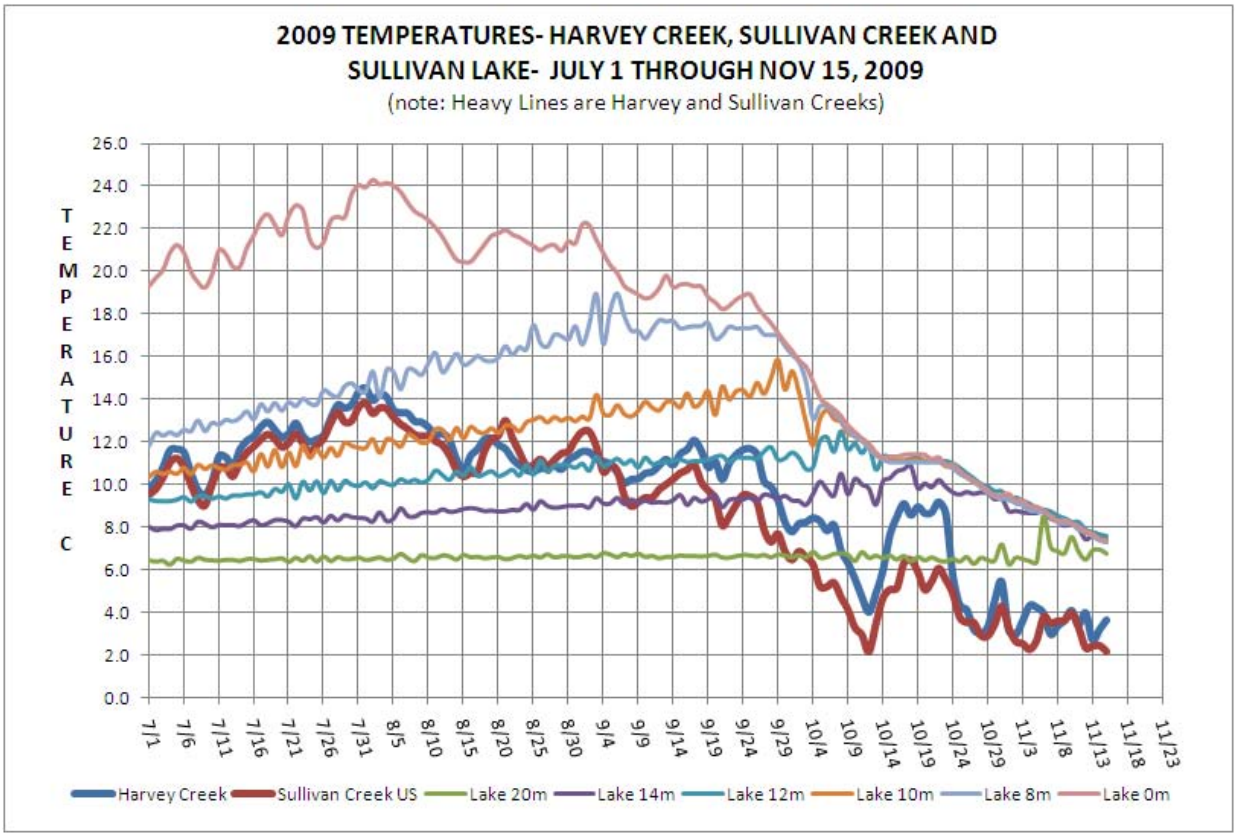


Figure 5
2009 Temperatures-Harvey Creek, Sullivan Creek and Sullivan Lake
July1 through November 15, 2009

Sullivan and Harvey Creeks (bold red and dark blue lines in Fig. 5 above) had temperatures that corresponded to lake temperatures down at around the 8 m to 10 m depth level through August 10. After August 10, the creeks began to cool slowly due presumably to cooler nights that began to occur, but the lake stayed warm. By September 15, the creek temperatures were most similar to lake temperatures at depths between 12 m and 14 m.

3.0 Basic Model Development

With simultaneous water temperature data available, there was a unique opportunity to construct a water temperature prediction model, and use the simultaneous data to calibrate the model. The goal of the model was to be able to select any outlet flow from Sullivan Lake, and model with precision the combined water temperature downstream of the confluence of Outlet and Sullivan Creeks.

EES Consulting was retained to build the model. The model was developed using the EXCEL spreadsheet software. The basic idea of the model was to input any desired flow regime for releases from Sullivan Dam into Outlet Creek, and then to calculate what the mixed temperature would be downstream of Sullivan Creek's confluence with Outlet Creek. The basic math of the mixing of warm and cool water is straightforward. It is a simple energy balance of flow #1 at

temperature A, plus flow #2 at temperature B, combining into flow #3 (sum of #1 and #2) with temperature C equal to the weighted average of the temperatures of #1 and #2. The model was constructed to model only from July 1 through November 15, to correspond to the date range of the actual data gathered.

Modeling mixed temperature requires the temperature of each water stream (WDFW data) and the flow rate in each stream. At POPUD's request, the USGS downloaded the Outlet Creek USGS gauge station, and provided the daily average flow data for July 1 through November 15, 2009. Sullivan Creek actual measured flow data was not available. To establish the flows in Sullivan Creek, we first obtained the existing 20 years of USGS gauge data on Sullivan Creek (gauge removed in 1996). By averaging this data, we obtained daily average flows for July 1 through Nov 15. However, to refine these flows further, we compared these average daily flows to about 6 spot flow readings taken by the Kalispel Tribe in Sullivan Creek during this period. The actual flow data indicated that flows in Sullivan at this time were around 70% of the long term average flows. During the fall of 2009, there was an extended period of hot, dry weather that would seem to support the conclusion that flows were below average in the July through November period.

The model was constructed using Sullivan Creek daily flows of 70% of the long term average. We input the actual measured flows released from Sullivan Dam as measured in Outlet Creek, and the actual temperatures measured by WDFW in Outlet Creek, as well as measured temperatures from Sullivan Creek. The resulting predicted mixed temperatures were graphed and compared to the actual measured mixed temperatures, shown below in Figure 6.

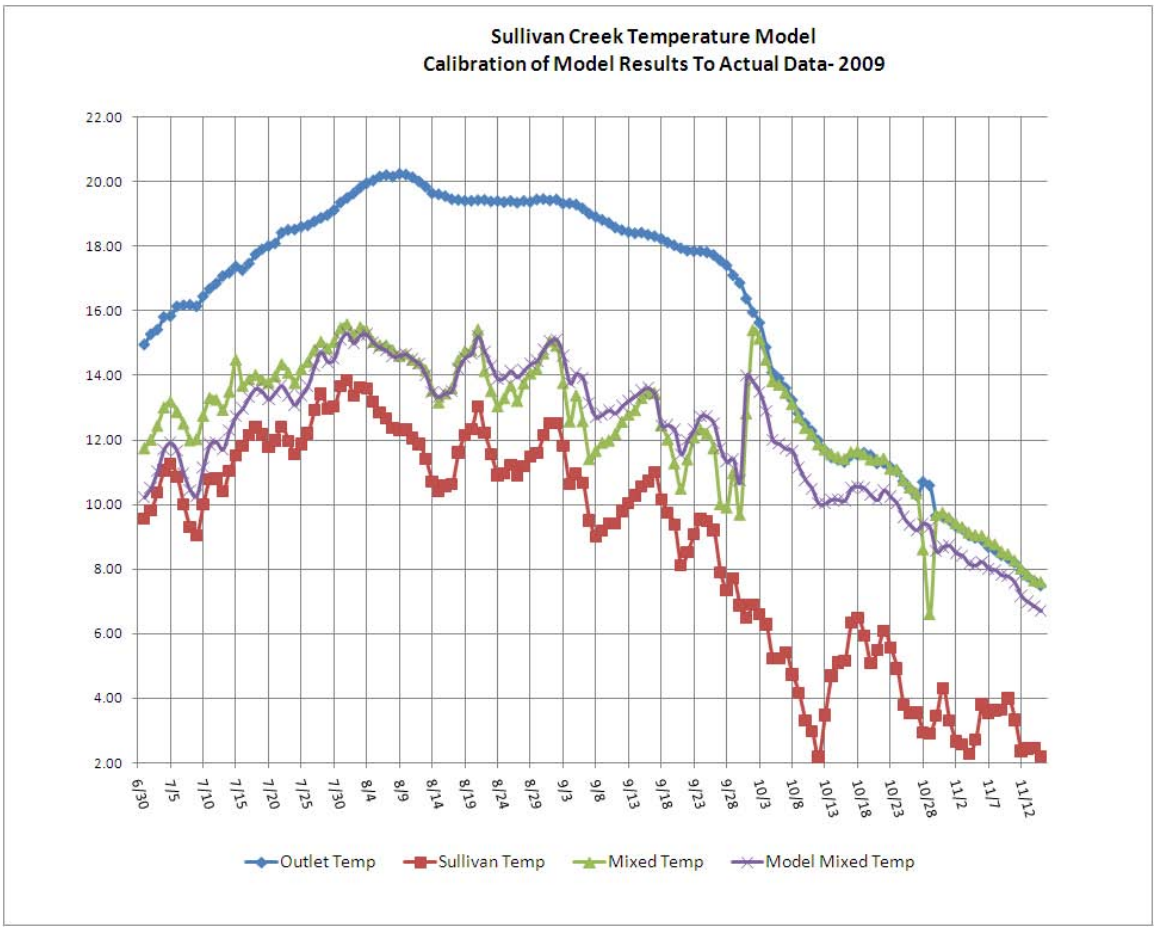


Figure 6
Sullivan Creek Temperature Model Calibration of Model Results to Actual Data-2009

The model results are shown by the purple line and the actual measured results for mixed temperature are represented by the green line. The model does a good job of predicting mixed water temperature. The differences between predicted and actual measured temperatures are due to actual stream flows being slightly different than the average flows used here. Without actual concurrent and simultaneous stream flow measurements in Sullivan Creek, this is the best calibration possible. The model works very well between July 1 and October 1, but under-predicts mixed temperature by ½ to 1 degree C during Sullivan Lake draining. We attempted to use other flow corrections for Sullivan Creek flows (instead of 70%) but 70% produced the closest correlation to measured temperatures. We decided to set up the model to allow the user to vary the "percent of long-term average flow" in Sullivan Creek to test percentages other than 70% if so desired, and this feature was added to the model. With completion of the calibration process described above, the model was considered functional.

4.0 Other Model Features

Other features and user inputs were added to the model to allow examination of a variety of scenarios. Features that were added included:

1) Flows to be released at Sullivan Dam were set up in an input table that allows a different flow to be used every week, from July 1 through November 15.

2) Five different scenarios for releases were set up in a second input table. The user can switch between these scenarios by simple input of the desired scenario number in the input table. The five scenarios were; 1-Wet Year; 2- Average Year; 3- Dry Year; 4-Actual 2009 year; and 5-Pre-project conditions with no dam. Use of scenario 5 allows examination of "without dam" conditions.

3) The impact of a potential cold water release pipe was added to the model. The user can select the fixed percentage of the release flow to come from the cold water pipe, and the depth from which the cold water would be withdrawn. By selecting different depths for the source of cold water, and different percentages of the total being released, the user can examine effectiveness of the cold water pipe. Setting the cold water percentage as zero reflects current conditions (no cold water pipe).

4) A table was set up to display the average number of degree-days that the mixed water was warmer than the Sullivan Creek upstream cool water. This allows the user to quickly see the impact of various flow scenario changes in a numerical format.

5) Results were also set up to be displayed graphically, so any changes made by the user could instantly be seen in the graph.

6) The final feature of the model is the ability to examine any scenario for flow releases, not just one of the 5 pre-established scenarios. To examine a scenario, the user can select any of the pre-set scenarios, such as scenario 2 (average year). Then, in the scenario table, the release flow can be changed to any desired value, and the values will be automatically updated in the input table and displayed on the graph.

The scenario input table in the model with the five Outlet Flow Scenarios is shown in Figure 7, below.

	Dam Outlet Flow Scenarios- (pick the one you want to test and put number 1,2,3,4, or 5 in cell D10 abo					
	1- Wet Year	2- Average Year	3- Dry Year	4- Actual 2009	5- Pre-Project-No Dam	
July Week 1	40	40	40	18.2	102.8	
July Week 2	35	35	35	18.9	76.9	
July Week 3	30	30	30	18.7	58.7	
July Week 4	30	30	30	15.03	45.9	
Aug Week 1	30	30	30	15.0	37.8	
Aug Week 2	30	30	30	15.2	32.6	
Aug Week 3	30	30	30	15.7	29.4	
Aug Week 4	30	30	30	16.00	26.1	
Sep Week 1	30	30	30	15.9	24.0	
Sep Week 2	60	60	60	15.0	22.7	
Sep Week 3	90	90	90	15.0	27.0	
Sep Week 4	120	120	120	15.84	23.1	
Oct Week 1	225	200	200	80.58	22.8	
Oct Week 2	225	200	200	108.4	23.8	
Oct Week 3	225	200	200	103.0	22.7	
Oct Week 4	225	200	200	126.52	22.9	
Nov Week 1	225	200	150	177.95	23.9	
Nov Week 2	225	180	100	189.5	27.2	
Nov Week 3	170	90	80	230	28.7	= estimated
Nov Week 4	119	70	60	150	27.6	
				(Uses Outlet Synthesized Ave Flows)		
Target Drain Ac-Ft	27,280	23,360	21,100	(and assumes water comes from 2m depth)		
Drain Ac-Ft here	27,873	23,365	21,104			
CRI Ac-Ft June- Aug 3rd wk	3,031	3,031	3,031			
(CRI Totals only correct for scenarios 1,2 or3)						

Figure 7
Temperature Model Dam Outlet Flow Scenario Table (Example)

In the example shown above, flows include potential CRI flow releases that might be made for sale to downstream users, in addition to minimum instream flow releases, in Scenarios 1, 2, and 3. These scenarios are simply examples. The user may change any flow in this table to observe the impact on mixed temperatures. Changes to any flow will automatically change the total run-off acre-feet shown at the bottom, and therefore the total seasonal run-off in any scenario should be adjusted to match the target run-off, to keep the scenario realistic. If, for example, a flow in August is increased, a flow at a later date should be reduced to keep the total drainage for the season unchanged. Scenarios 4 and 5 are for specific circumstances and should not be changed by the user.

The User input table appears as shown below.

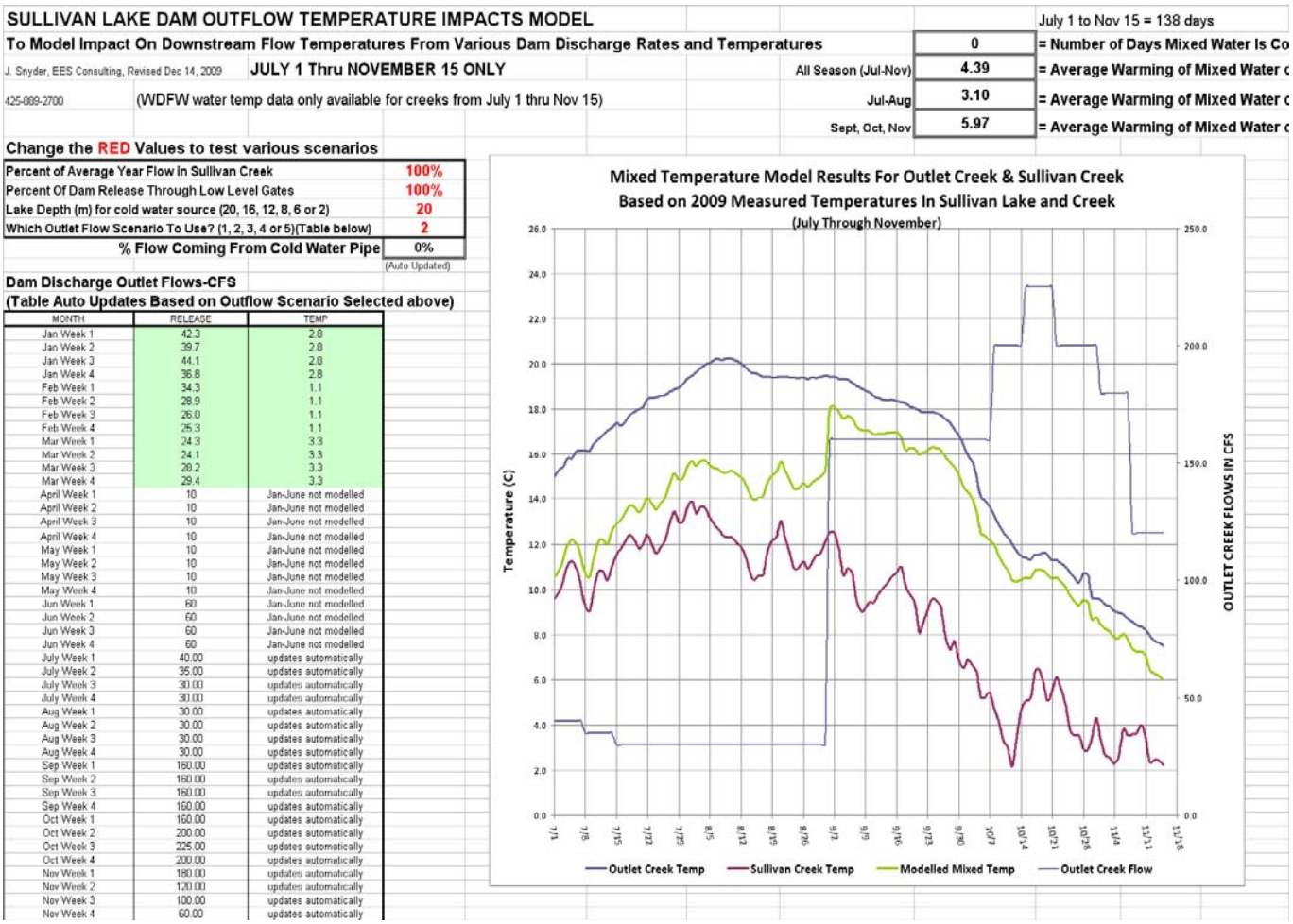
Change the RED Values to test various scenarios	
Percent of Average Year Flow in Sullivan Creek	70%
Percent Of Dam Release Through Low Level Gates	100%
Lake Depth (m) for cold water source (20, 16, 12, 8, 6 or 2)	20
Which Outlet Flow Scenario To Use? (1, 2, 3, 4 or 5)(Table below)	3
% Flow Coming From Cold Water Pipe	0%
	(Auto Updated)

Figure 8
Sullivan Temperature Model User Input Table (Example)

In this table, the user can select which of the above scenarios to model by simply selecting the scenario number, ("#3" in this example). Cold water releases can also be modeled by selecting the depth for the source of the cold water (20 m in this example), and the percentage of the total release coming through the existing gate (100% here). The remainder will automatically be assumed to be coming from the cold water pipe.

5.0 Modeling Results

Following are some examples of model output for various scenarios. In Figure 9, Scenario 2, Average Year hydrology, is modeled, with no cold water pipe (100% through the low level gates).



SULLIVAN LAKE DAM OUTFLOW TEMPERATURE IMPACTS MODEL

To Model Impact On Downstream Flow Temperatures From Various Dam Discharge Rates and Temperatures

J. Snyder, EES Consulting, Revised Dec 14, 2009 — JULY 1 Thru NOVEMBER 15 ONLY

425-889-2700 — (WDFW water temp data only available for creeks from July 1 thru Nov 15)

July 1 to Nov 15 = 138 days

	0	= Number of Days Mixed Water Is Co
All Season (Jul-Nov)	4.39	= Average Warming of Mixed Water c
Jul-Aug	3.10	= Average Warming of Mixed Water c
Sept, Oct, Nov	5.97	= Average Warming of Mixed Water c

Change the RED Values to test various scenarios

Percent of Average Year Flow In Sullivan Creek	100%
Percent Of Dam Release Through Low Level Gates	100%
Lake Depth (m) for cold water source (20, 16, 12, 8, 6 or 2)	20
Which Outlet Flow Scenario To Use? (1, 2, 3, 4 or 5)(Table below)	2
% Flow Coming From Cold Water Pipe	0%
	(Auto Updated)

Dam Discharge Outlet Flows-CFS

(Table Auto Updates Based on Outflow Scenario Selected above)

MONTH	RELEASE	TEMP
Jan Week 1	42.3	2.8
Jan Week 2	39.7	2.8
Jan Week 3	44.1	2.8
Jan Week 4	36.8	2.8
Feb Week 1	34.3	1.1
Feb Week 2	28.9	1.1
Feb Week 3	26.0	1.1
Feb Week 4	25.3	1.1
Mar Week 1	24.3	3.3
Mar Week 2	24.1	3.3
Mar Week 3	28.2	3.3
Mar Week 4	29.4	3.3
April Week 1	10	Jan-June not modelled
April Week 2	10	Jan-June not modelled
April Week 3	10	Jan-June not modelled
April Week 4	10	Jan-June not modelled
May Week 1	10	Jan-June not modelled
May Week 2	10	Jan-June not modelled
May Week 3	10	Jan-June not modelled
May Week 4	10	Jan-June not modelled
Jun Week 1	60	Jan-June not modelled
Jun Week 2	60	Jan-June not modelled
Jun Week 3	60	Jan-June not modelled
Jun Week 4	60	Jan-June not modelled
July Week 1	40.00	updates automatically
July Week 2	35.00	updates automatically
July Week 3	30.00	updates automatically
July Week 4	30.00	updates automatically
Aug Week 1	30.00	updates automatically
Aug Week 2	30.00	updates automatically
Aug Week 3	30.00	updates automatically
Aug Week 4	30.00	updates automatically
Sep Week 1	160.00	updates automatically
Sep Week 2	160.00	updates automatically
Sep Week 3	160.00	updates automatically
Sep Week 4	160.00	updates automatically
Oct Week 1	160.00	updates automatically
Oct Week 2	200.00	updates automatically
Oct Week 3	225.00	updates automatically
Oct Week 4	200.00	updates automatically
Nov Week 1	180.00	updates automatically
Nov Week 2	120.00	updates automatically
Nov Week 3	100.00	updates automatically
Nov Week 4	60.00	updates automatically

Figure 9
Sullivan Dam Outflow Temperature Model Output for Scenario 2, Average Year Hydrology

Outlet Creek flow is graphed as a purple line, using the scale on the right side of the graph. The increase in flow as the lake is drained can be clearly seen. In this example, ramping up lake drainage flows very slowly, starting Sept. 15, allows mixed water temperature to be held at no more than 16 degrees C, while flows are steadily ramped up as Sullivan Lake cools. After about October 3, the lake has cooled to below 16 C, and lake drainage rates can be increased further without concern for exceeding the 16 C mixed temperature limit (WAC 173-201A-200). Note that in this example, the all-season average warming of the downstream mixed temperature is 4.39 degrees C (from table at top). When changes in scenario flows are made, this number is re-

calculated so the user can see quickly whether the flows being tested improve or degrade downstream temperatures.

For comparison purposes, the model allows the user to run the pre-project or "without dam" scenario (Scenario 5). In this scenario, it is assumed that the lake outflow is equal to inflow for the entire modeling period (July 1 through November 15). Outlet Creek flows are obtained for this scenario from the unregulated Outlet Creek flows developed as part of the Lake Level Modeling efforts completed earlier this year. In this scenario, the model assumes that water leaving Sullivan Lake would be surface water or water from very near the surface. We used water temperature data taken by WDFW from the 2 m depth, but this may be slightly conservative (actual water may be warmer). The results are shown in Figure 10, below.

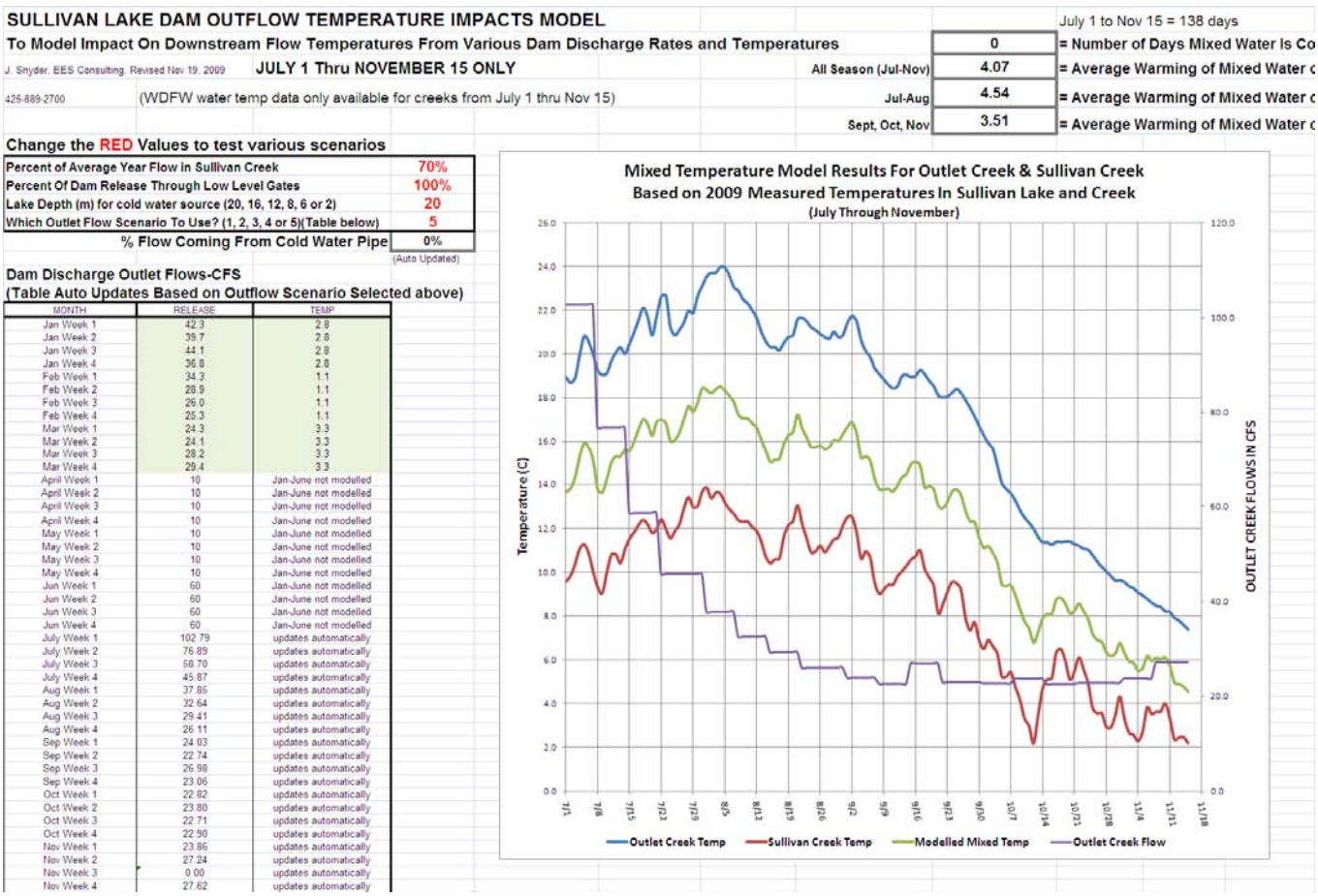


Figure 10
Sullivan Dam Outflow Temperature Model Output for "Without Dam" Scenario

As can be seen, under this scenario, the all-season, average temperature increase downstream is 4.07 C, which is slightly lower than the Scenario 2 example shown above. This is because flow releases in the fall are much less under natural conditions compared to flows required to drain the Lake after it has been held full in the summer months. As expected, mixed temperature is just about midway between Lake temperature and Sullivan Creek upstream temperature, since the flows are similar from these two sources. However, Outlet Creek temperatures are much higher under the "no dam" scenario, because the water leaving the lake is all surface (warmest) waters.

As discussed above, the impact of a cold water release pipe can also be modeled. In the example below, using average-year flows (Scenario 2), a cold water pipe is modeled, coming from the 20 m depth in Sullivan Lake; 30% of water released comes from the cold water pipe and 70% leaves through the existing low level gates. The results can be seen both graphically and numerically in Figure 11, below:

SULLIVAN LAKE DAM OUTFLOW TEMPERATURE IMPACTS MODEL

To Model Impact On Downstream Flow Temperatures From Various Dam Discharge Rates and Temperatures

J. Snyder, EES Consulting, Revised Dec 14, 2009 — **JULY 1 Thru NOVEMBER 15 ONLY**

425-889-2700 — (WDFW water temp data only available for creeks from July 1 thru Nov 15)

July 1 to Nov 15 = 138 days

	0	= Number of Days Mixed Water Is Co
All Season (Jul-Nov)	2.89	= Average Warming of Mixed Water c
Jul-Aug	1.60	= Average Warming of Mixed Water c
Sept, Oct, Nov	4.48	= Average Warming of Mixed Water c

Change the RED Values to test various scenarios

Percent of Average Year Flow in Sullivan Creek	100%
Percent Of Dam Release Through Low Level Gates	70%
Lake Depth (m) for cold water source (20, 16, 12, 8, 6 or 2)	20
Which Outlet Flow Scenario To Use? (1, 2, 3, 4 or 5)(Table below)	2
% Flow Coming From Cold Water Pipe	30%

(Auto Updated)

Dam Discharge Outlet Flows-CFS
(Table Auto Updates Based on Outflow Scenario Selected above)

MONTH	RELEASE	TEMP
Jan Week 1	42.3	2.8
Jan Week 2	39.7	2.8
Jan Week 3	44.1	2.8
Jan Week 4	36.8	2.8
Feb Week 1	34.3	1.1
Feb Week 2	28.9	1.1
Feb Week 3	26.0	1.1
Feb Week 4	25.3	1.1
Mar Week 1	24.3	3.3
Mar Week 2	24.1	3.3
Mar Week 3	28.2	3.3
Mar Week 4	29.4	3.3
April Week 1	10	Jan-June not modelled
April Week 2	10	Jan-June not modelled
April Week 3	10	Jan-June not modelled
April Week 4	10	Jan-June not modelled
May Week 1	10	Jan-June not modelled
May Week 2	10	Jan-June not modelled
May Week 3	10	Jan-June not modelled
May Week 4	10	Jan-June not modelled
Jun Week 1	60	Jan-June not modelled
Jun Week 2	60	Jan-June not modelled
Jun Week 3	60	Jan-June not modelled
Jun Week 4	60	Jan-June not modelled
July Week 1	40.00	updates automatically
July Week 2	35.00	updates automatically
July Week 3	30.00	updates automatically
July Week 4	30.00	updates automatically
Aug Week 1	30.00	updates automatically
Aug Week 2	30.00	updates automatically
Aug Week 3	30.00	updates automatically
Aug Week 4	30.00	updates automatically
Sep Week 1	160.00	updates automatically
Sep Week 2	160.00	updates automatically
Sep Week 3	160.00	updates automatically
Sep Week 4	160.00	updates automatically
Oct Week 1	160.00	updates automatically
Oct Week 2	200.00	updates automatically
Oct Week 3	225.00	updates automatically
Oct Week 4	200.00	updates automatically
Nov Week 1	180.00	updates automatically
Nov Week 2	120.00	updates automatically
Nov Week 3	100.00	updates automatically
Nov Week 4	60.00	updates automatically

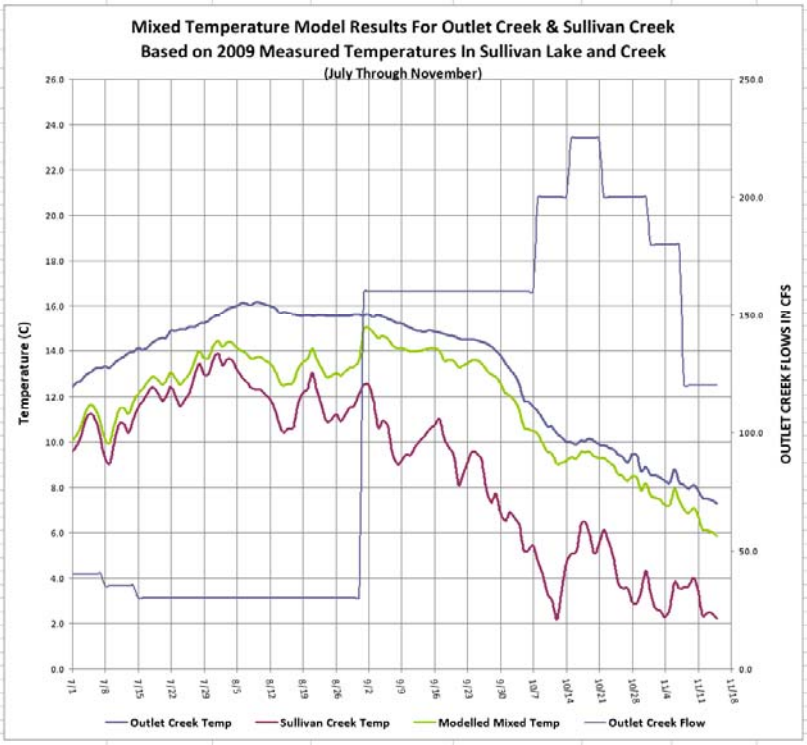


Figure 11
Sullivan Temperature Model Results-Scenario 2 with Cold Water Release

The predicted all-season mixed water temperature increase is 2.89 C in this example. Mixed water temperatures only briefly go above 14 C, about a 2C improvement from current operations. The user can adjust the gate opening percentage and source depth for the cool water to examine the impact on mixed temperatures by adjusting these parameters.

6.0 Cold Water Release Pipe Detailed Modeling

After review of the modeling results by the District and various agencies in the Sullivan Settlement discussions, interest in cold water release pipe options required some additional features be added to the model. Using the model described above, the following features were added:

1. The ability was added to permit the % of flow coming from Sullivan Lake to be split between the low level outlet and the cold water pipe with different flows *each week*, from 7/1 to 11/15.

2. The model now also calculates the Sullivan Lake level at the end of every week, so it can be sure any scenarios we look at have the lake down to elevation 2577.0 by November 15, the target elevation indicated by WDFW.

3. The Fall drawdown in all cases now starts the 8th of September in the model.

4. The Fall drawdown period does not necessarily reach 2570.0 by November 30, but it definitely gets there by December 31. All Parties agreed this was acceptable. This extra time to drawdown makes the peak flows during lake draining quite a bit lower than in previous model runs, and helps make it possible to control temperature better.

5. The cold water pipe design is based upon a 48" pipe with inlet fish screens, placed at a depth of 20m or more. As lake levels drop during draining, there is less driving pressure head on the cold water release pipe and its flow capacity begins to fall as lake levels fall. A check was added in the model to be sure that any flow the user asks for from the cold water pipe is actually possible based on the 48" design now being considered, since the cold pipe capacity drops as the lake level drops. If the user asks for too much flow, the model will indicate a problem and the user will have to increase flow through the low level gates until the problem clears.

6. For wet and dry years, the model uses 1999 and 1970 lake inflow data from Outlet Creek Unregulated Flows data file. These years were 141.2% and 66.6% of average, respectively. For "Average" runs, the average of 19 years of data was used.

7. The agencies were interested to know how much the low level outlet gates would actually be open (in inches) to release any particular flow. It is believed that smaller gate openings would likely result in less fish entrainment during releases. We have added a table right in the model that gives the capacity of the low level gates at full pond depending on opening. That data is as follows:

One Gate Opening (inches)	Calculated Discharge (cfs)
4	36
8	71
12	107
16	144
20	182
24	223
28	267
31	313
35	363
39	417

Figure 12
Flow vs. Gate Opening

8. Recreational boaters and kayakers noted that release flows from Sullivan Lake during draining in the range of 200 cfs were preferred for best boating conditions. In the lake draining scenarios used, a few weeks were included at close to or at 200 cfs to provide these recreational optimum flows.

9. It was noted that during summer and fall, some water from Sullivan Lake seeps underground and enters Outlet Creek just downstream of the dam. Because of this seepage, not 100% of water releases at the dam would come from the gates or the cold water pipe, and the seepage needs to be accounted for in the model. Checks of USGS gauge data show that in the summer season in 2009, seepage flows were between 10 and 15 cfs. Temperature data confirmed this seepage water was about the same temperature as water released from the low level gates (roughly equivalent to lake temperatures at a depth of 6m). The modeled flow releases were adjusted to simulate at least 15 cfs at all times from the low level gates (which would be equivalent to 15 cfs of seepage).

Included in the following pages are some example model runs of the revised model, examining in detail the capability of the proposed cold water release pipe.

In the first examples, using Scenario 3 (dry flow year) two output runs are shown below. One run shows the absolute maximum amount of water cooling that would be possible from the cold water pipe, and then a second run was made adjusting the amount released from the low level gate in order to achieve a mixed water temperature that was both a) within 1 degree C of the upstream Sullivan Creek water temperature; and b) never above 14 C. As can be seen in Figure 13, the cold water pipe has plenty of capacity to cool down the Sullivan dam discharge, and achieve the goals, in almost all situations. During September, for example, the cooled waters actually cool Sullivan Creek well below its temperature upstream of the confluence. In practice, this would not be done. Figure 14 below shows a more optimized operation. You can see that the combined waters match the Sullivan Creek upstream temperatures very closely. This demonstrates the flexibility of the proposed cold water release pipe design. It should be noted, however, that after about November 1 each year, Sullivan Lake has turned over and all of its waters are around 6C, and when Sullivan Creek subsequently drops below 6C, it is no longer possible to cool it down, and in fact, the dam releases warm it up slightly from around 4C up to near 6C. This is unavoidable and the cold water pipe cannot assist in this situation.

SULLIVAN LAKE DAM OUTFLOW TEMPERATURE IMPACTS MODEL

To Model Impact On Downstream Flow Temperatures From Various Dam Discharge Rates and Temperatures

J. Snyder, EES Consulting, Revised Jan 25, 2010 — **JULY 1 Thru NOVEMBER 15 ONLY**

425-889-2700 — (WDFW water temp data only available for creeks from July 1 thru Nov 15)

July 1 to Nov 15 = 138 days

	37	= Number of Days Mixed Water Is Cooler than Sullivan Creek Natural Temperature
All Season (Jul-Nov)	1.04	= Average Warming of Mixed Water compared to Sullivan Creek Natural Temps (July 1 to
Jul-Aug	0.18	= Average Warming of Mixed Water compared to Sullivan Creek Natural Temps (July 1 to
Sept, Oct, Nov	2.10	= Average Warming of Mixed Water compared to Sullivan Creek Natural Temps (Sept 15 t

Percent of Average Year Flow in Sullivan Creek	74%
Change the RED Values to test various scenarios	
Percent Of Dam Release Through Low Level Gates	per below
Lake Depth (m) for cold water source (20, 16, 12, 8, 6 or 2)	20
Which Outlet Flow Scenario To Use? (1, 2, or 3)(Table below)	3
% Flow Coming From Cold Water Pipe	Calc below (Auto Updated)

1=Wet (1999), 2=Average, 3=Dry(1970)

Dam Discharge Outlet Flows-CFS
(Table Auto Updates Based on Outflow Scenario Selected above)

MONTH	RELEASE	TEMP	USER INPUT Seepage or Out of Gate	(CALCULATED) Out of Cold Water Pipe	Check- Is Cold Pipe Flow OK?	Lake Level at End of Week
Jan Week 1	42.3	2.8				
Jan Week 2	39.7	2.8				
Jan Week 3	44.1	2.8				
Jan Week 4	36.8	2.8				
Feb Week 1	34.3	1.1				
Feb Week 2	28.9	1.1				
Feb Week 3	26.0	1.1				
Feb Week 4	25.3	1.1				
Mar Week 1	24.3	3.3				
Mar Week 2	24.1	3.3				
Mar Week 3	28.2	3.3				
Mar Week 4	29.4	3.3				
April Week 1	10	Jan-June not modelled				
April Week 2	10	Jan-June not modelled				
April Week 3	10	Jan-June not modelled				
April Week 4	10	Jan-June not modelled				
May Week 1	10	Jan-June not modelled				
May Week 2	10	Jan-June not modelled				
May Week 3	10	Jan-June not modelled				
May Week 4	10	Jan-June not modelled				
Jun Week 1	60	Jan-June not modelled				
Jun Week 2	60	Jan-June not modelled				
Jun Week 3	60	Jan-June not modelled				
Jun Week 4	60	Jan-June not modelled				
July Week 1	40.00	updates automatically	15.0	25.0	YES	2588.66
July Week 2	35.00	updates automatically	15.0	20.0	YES	2588.66
July Week 3	30.00	updates automatically	15.0	15.0	YES	2588.66
July Week 4	30.00	updates automatically	15.0	15.0	YES	2588.66
Aug Week 1	30.00	updates automatically	15.0	15.0	YES	2588.60
Aug Week 2	30.00	updates automatically	15.0	15.0	YES	2588.53
Aug Week 3	30.00	updates automatically	15.0	15.0	YES	2588.43
Aug Week 4	30.00	updates automatically	15.0	15.0	YES	2588.24
Sep Week 1	30.00	updates automatically	15.0	15.0	YES	2588.16
Sep Week 2	160.00	updates automatically	15.0	145.0	YES	2586.59
Sep Week 3	160.00	updates automatically	15.0	145.0	YES	2585.01
Sep Week 4	160.00	updates automatically	15.0	145.0	YES	2583.00
Oct Week 1	160.00	updates automatically	21.0	139.0	YES	2581.38
Oct Week 2	160.00	updates automatically	29.0	131.0	YES	2579.78
Oct Week 3	200.00	updates automatically	81.0	119.0	YES	2577.71
Oct Week 4	200.00	updates automatically	101.0	99.0	YES	2574.77
Nov Week 1	150.00	updates automatically	63.0	87.0	YES	2573.25
Nov Week 2	130.00	updates automatically	54.0	76.0	YES	2571.96
Nov Week 3	100.00	updates automatically	32.0	68.0	YES	2571.01
Nov Week 4	70.00	updates automatically	15.0	55.0	YES	2570.19
Dec Week 1	50.00	3.3	15.0	35.0	YES	2569.83
Dec Week 2	40.00	3,3	15.0	25.0	YES	2569.58
Dec Week 3	30.00	3.3	15.0	15.0	YES	2569.43
Dec Week 4	14.00	3.3	15.0	-1.0	YES	2569.41

One Gate Opening (inches)	Calculated Discharge (cfs)
4	36
8	71
12	107
16	144
20	182
24	223
28	267
31	313
35	363
39	417

LAKE ELEVATION	Assumes Lake Level July 1 (Full)
On Nov. 15th	2588.6
2571.96	
Target 2577.0 or less	

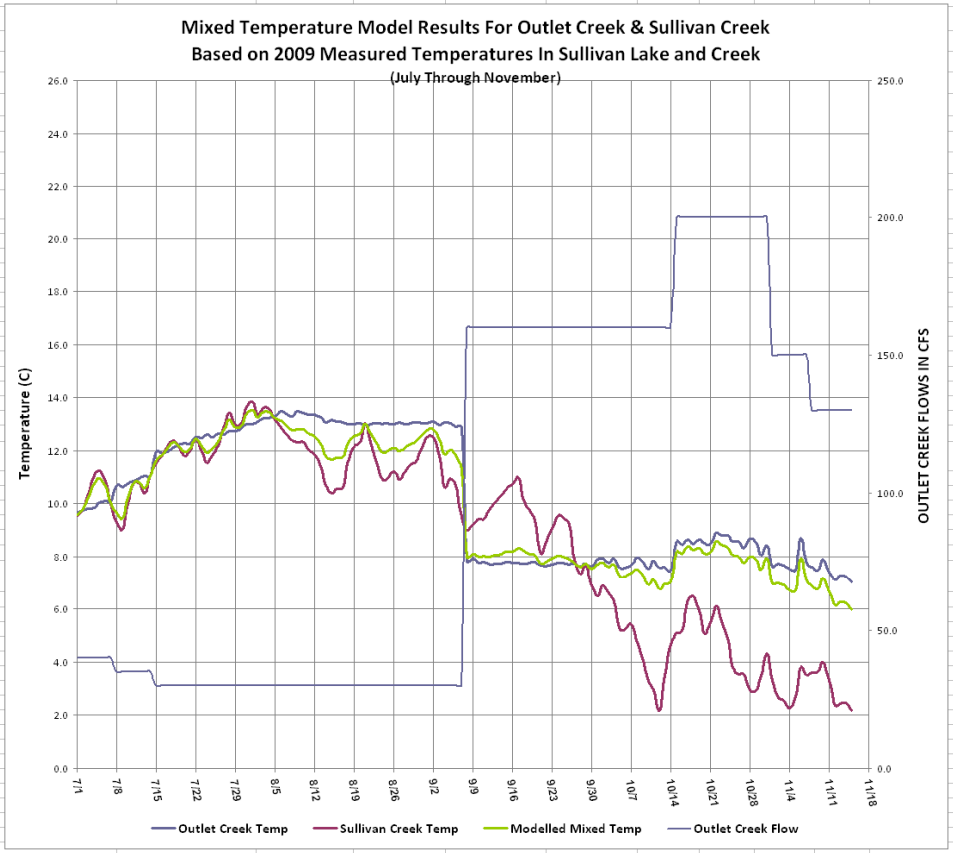


Figure 13
Sullivan Temperature Model Results-Scenario 3 (Dry Year) with Cold Water Release and Maximum Possible Cooling

SULLIVAN LAKE DAM OUTFLOW TEMPERATURE IMPACTS MODEL

To Model Impact On Downstream Flow Temperatures From Various Dam Discharge Rates and Temperatures

J. Snyder, EES Consulting, Revised Jan 25, 2010 — **JULY 1 Thru NOVEMBER 15 ONLY**

425-889-2700 — (WDFW water temp data only available for creeks from July 1 thru Nov 15)

July 1 to Nov 15 = 138 days

	27	= Number of Days Mixed Water Is Cooler than Sullivan Creek Natural Temperature
All Season (Jul-Nov)	1.29	= Average Warming of Mixed Water compared to Sullivan Creek Natural Temps (July 1 to
Jul-Aug	0.33	= Average Warming of Mixed Water compared to Sullivan Creek Natural Temps (July 1 to
Sept, Oct, Nov	2.48	= Average Warming of Mixed Water compared to Sullivan Creek Natural Temps (Sept 15 t

Percent of Average Year Flow in Sullivan Creek	74%	
Change the RED Values to test various scenarios		
Percent Of Dam Release Through Low Level Gates	per below	
Lake Depth (m) for cold water source (20, 16, 12, 8, 6 or 2)	20	
Which Outlet Flow Scenario To Use? (1, 2, or 3)(Table below)	3	1=Wet (1999), 2=Average, 3=Dry(1970)
% Flow Coming From Cold Water Pipe	Calc below (Auto Updated)	

Dam Discharge Outlet Flows-CFS
(Table Auto Updates Based on Outflow Scenario Selected above)

MONTH	RELEASE	TEMP	USER INPUT Seepage or Out of Gate	(CALCULATED) Out of Cold Water Pipe	Check- Is Cold Pipe Flow OK?	Lake Level at End of Week
Jan Week 1	42.3	2.8				
Jan Week 2	39.7	2.8				
Jan Week 3	44.1	2.8				
Jan Week 4	36.8	2.8				
Feb Week 1	34.3	1.1				
Feb Week 2	28.9	1.1				
Feb Week 3	26.0	1.1				
Feb Week 4	25.3	1.1				
Mar Week 1	24.3	3.3				
Mar Week 2	24.1	3.3				
Mar Week 3	28.2	3.3				
Mar Week 4	29.4	3.3				
April Week 1	10	Jan-June not modelled				
April Week 2	10	Jan-June not modelled				
April Week 3	10	Jan-June not modelled				
April Week 4	10	Jan-June not modelled				
May Week 1	10	Jan-June not modelled				
May Week 2	10	Jan-June not modelled				
May Week 3	10	Jan-June not modelled				
May Week 4	10	Jan-June not modelled				
Jun Week 1	60	Jan-June not modelled				
Jun Week 2	60	Jan-June not modelled				
Jun Week 3	60	Jan-June not modelled				
Jun Week 4	60	Jan-June not modelled				
July Week 1	40.00	updates automatically	15.0	25.0	YES	2588.66
July Week 2	35.00	updates automatically	15.0	20.0	YES	2588.66
July Week 3	30.00	updates automatically	15.0	15.0	YES	2588.66
July Week 4	30.00	updates automatically	15.0	15.0	YES	2588.66
Aug Week 1	30.00	updates automatically	15.0	15.0	YES	2588.60
Aug Week 2	30.00	updates automatically	15.0	15.0	YES	2588.53
Aug Week 3	30.00	updates automatically	15.0	15.0	YES	2588.43
Aug Week 4	30.00	updates automatically	15.0	15.0	YES	2588.24
Sep Week 1	30.00	updates automatically	15.0	15.0	YES	2588.16
Sep Week 2	160.00	updates automatically	40.0	120.0	YES	2586.59
Sep Week 3	160.00	updates automatically	52.0	108.0	YES	2585.01
Sep Week 4	160.00	updates automatically	30.0	130.0	YES	2583.00
Oct Week 1	160.00	updates automatically	21.0	139.0	YES	2581.38
Oct Week 2	160.00	updates automatically	29.0	131.0	YES	2579.78
Oct Week 3	200.00	updates automatically	81.0	119.0	YES	2577.71
Oct Week 4	200.00	updates automatically	101.0	99.0	YES	2574.77
Nov Week 1	150.00	updates automatically	63.0	87.0	YES	2573.25
Nov Week 2	130.00	updates automatically	54.0	76.0	YES	2571.96
Nov Week 3	100.00	updates automatically	32.0	68.0	YES	2571.01
Nov Week 4	70.00	updates automatically	15.0	55.0	YES	2570.19
Dec Week 1	50.00	3.3	15.0	35.0	YES	2569.83
Dec Week 2	40.00	3,3	15.0	25.0	YES	2569.58
Dec Week 3	30.00	3.3	15.0	15.0	YES	2569.43
Dec Week 4	14.00	3.3	15.0	-1.0	YES	2569.41

One Gate Opening (inches)	Calculated Discharge (cfs)
4	36
8	71
12	107
16	144
20	182
24	223
28	267
31	313
35	363
39	417

LAKE ELEVATION	Assumes Lake Level July 1 (Full)
On Nov. 15th	2588.6
2571.96	
Target 2577.0 or less	

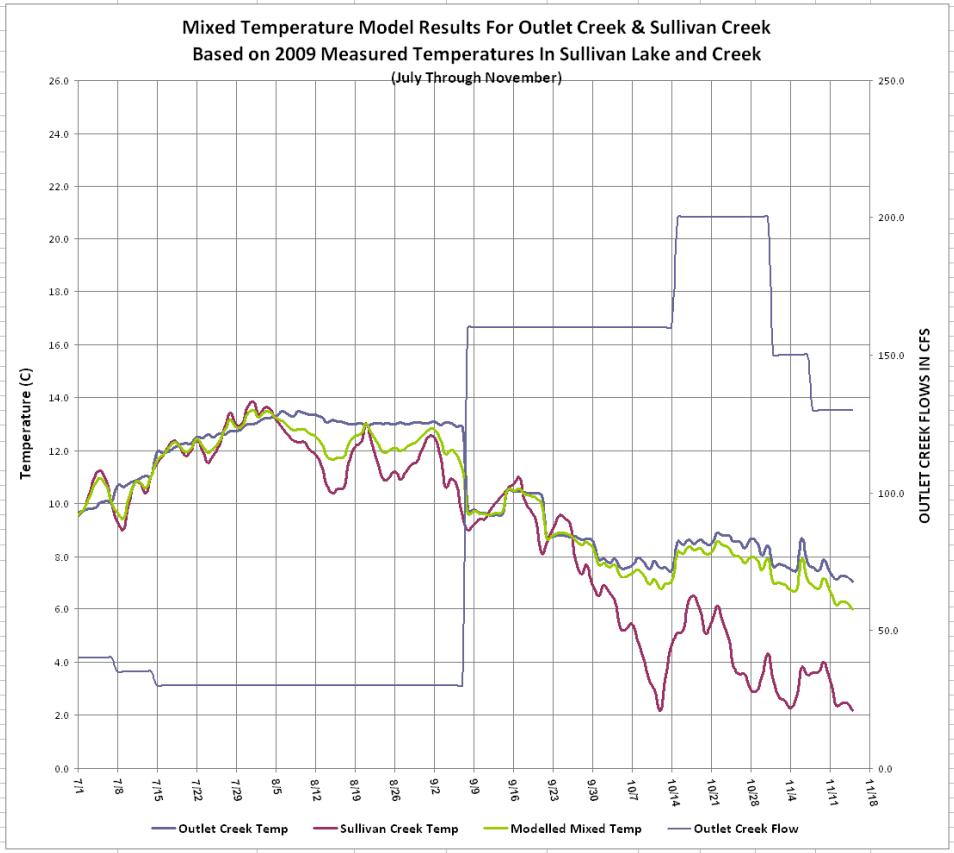


Figure 14
Sullivan Temperature Model Results-Scenario 3 (Dry Year) with Cold Water Release and Optimized Cooling

Two additional model runs are displayed as Figures 15 and 16 below, showing optimized cooling in average flow years and wet flow years. These runs demonstrate that the cold water pipe is very effective over a range of hydrologic conditions.

SULLIVAN LAKE DAM OUTFLOW TEMPERATURE IMPACTS MODEL

To Model Impact On Downstream Flow Temperatures From Various Dam Discharge Rates and Temperatures

J. Snyder, EES Consulting, Revised Jan 25, 2010 — **JULY 1 Thru NOVEMBER 15 ONLY**

425-889-2700 — (WDFW water temp data only available for creeks from July 1 thru Nov 15)

July 1 to Nov 15 = 138 days

	29	= Number of Days Mixed Water Is Cooler than Sullivan Creek Natural Temperature
All Season (Jul-Nov)	0.93	= Average Warming of Mixed Water compared to Sullivan Creek Natural Temps (July 1 to
Jul-Aug	0.16	= Average Warming of Mixed Water compared to Sullivan Creek Natural Temps (July 1 to
Sept, Oct, Nov	1.88	= Average Warming of Mixed Water compared to Sullivan Creek Natural Temps (Sept 15 t

Percent of Average Year Flow in Sullivan Creek	100%
Change the RED Values to test various scenarios	
Percent Of Dam Release Through Low Level Gates	per below
Lake Depth (m) for cold water source (20, 16, 12, 8, 6 or 2)	20
Which Outlet Flow Scenario To Use? (1, 2, or 3)(Table below)	2
% Flow Coming From Cold Water Pipe	Calc below (Auto Updated)

1=Wet (1999), 2=Average, 3=Dry(1970)

Dam Discharge Outlet Flows-CFS
(Table Auto Updates Based on Outflow Scenario Selected above)

MONTH	RELEASE	TEMP	USER INPUT Seepage or Out of Gate	(CALCULATED) Out of Cold Water Pipe	Check- Is Cold Pipe Flow Ok?	Lake Level at End of Week
Jan Week 1	42.3	2.8				
Jan Week 2	39.7	2.8				
Jan Week 3	44.1	2.8				
Jan Week 4	36.8	2.8				
Feb Week 1	34.3	1.1				
Feb Week 2	28.9	1.1				
Feb Week 3	26.0	1.1				
Feb Week 4	25.3	1.1				
Mar Week 1	24.3	3.3				
Mar Week 2	24.1	3.3				
Mar Week 3	28.2	3.3				
Mar Week 4	29.4	3.3				
April Week 1	10	Jan-June not modelled				
April Week 2	10	Jan-June not modelled				
April Week 3	10	Jan-June not modelled				
April Week 4	10	Jan-June not modelled				
May Week 1	10	Jan-June not modelled				
May Week 2	10	Jan-June not modelled				
May Week 3	10	Jan-June not modelled				
May Week 4	10	Jan-June not modelled				
Jun Week 1	60	Jan-June not modelled				
Jun Week 2	60	Jan-June not modelled				
Jun Week 3	60	Jan-June not modelled				
Jun Week 4	60	Jan-June not modelled				
July Week 1	40.00	updates automatically	15.0	25.0	YES	2588.66
July Week 2	35.00	updates automatically	15.0	20.0	YES	2588.66
July Week 3	30.00	updates automatically	15.0	15.0	YES	2588.66
July Week 4	30.00	updates automatically	15.0	15.0	YES	2588.66
Aug Week 1	30.00	updates automatically	15.0	15.0	YES	2588.66
Aug Week 2	30.00	updates automatically	15.0	15.0	YES	2588.66
Aug Week 3	30.00	updates automatically	15.0	15.0	YES	2588.61
Aug Week 4	30.00	updates automatically	15.0	15.0	YES	2588.55
Sep Week 1	30.00	updates automatically	15.0	15.0	YES	2588.48
Sep Week 2	180.00	updates automatically	22.0	158.0	YES	2586.72
Sep Week 3	200.00	updates automatically	47.0	153.0	YES	2584.78
Sep Week 4	200.00	updates automatically	57.0	143.0	YES	2582.23
Oct Week 1	157.00	updates automatically	21.0	136.0	YES	2580.73
Oct Week 2	140.00	updates automatically	15.0	125.0	YES	2579.43
Oct Week 3	130.00	updates automatically	15.0	115.0	YES	2578.23
Oct Week 4	130.00	updates automatically	18.0	112.0	YES	2576.52
Nov Week 1	125.00	updates automatically	21.0	104.0	YES	2575.38
Nov Week 2	122.00	updates automatically	26.0	96.0	YES	2574.32
Nov Week 3	120.00	updates automatically	32.0	88.0	YES	2573.30
Nov Week 4	115.00	updates automatically	38.0	77.0	YES	2572.04
Dec Week 1	72.00	3.3	15.0	57.0	YES	2571.54
Dec Week 2	68.00	3.3	15.0	53.0	YES	2571.04
Dec Week 3	64.00	3.3	15.0	49.0	YES	2570.61
Dec Week 4	58.00	3.3	15.0	43.0	YES	2570.02

One Gate Opening (inches)	Calculated Discharge (cfs)
4	36
8	71
12	107
16	144
20	182
24	223
28	267
31	313
35	363
39	417

LAKE ELEVATION	Assumes Lake Level July 1 (Full)
On Nov. 15th	2588.6
2574.32	
Target 2577.0 or less	

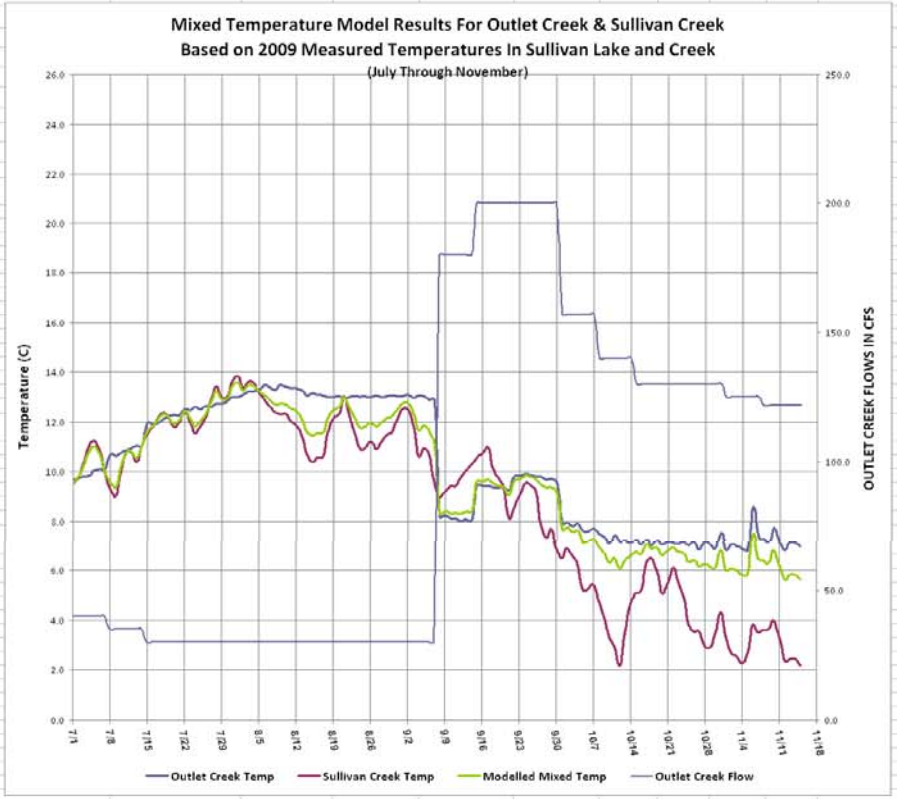


Figure 15
Sullivan Temperature Model Results-Scenario 2 (Average Year) with Cold Water Release and Optimized Cooling

SULLIVAN LAKE DAM OUTFLOW TEMPERATURE IMPACTS MODEL

To Model Impact On Downstream Flow Temperatures From Various Dam Discharge Rates and Temperatures

J. Snyder, EES Consulting, Revised Jan 25, 2010 **JULY 1 Thru NOVEMBER 15 ONLY**

425-889-2700 (WDFW water temp data only available for creeks from July 1 thru Nov 15)

July 1 to Nov 15 = 138 days

	30	= Number of Days Mixed Water Is Cooler than Sullivan Creek Natural Temperature
All Season (Jul-Nov)	1.26	= Average Warming of Mixed Water compared to Sullivan Creek Natural Temps (July 1 to Nov 30)
Jul-Aug	0.21	= Average Warming of Mixed Water compared to Sullivan Creek Natural Temps (July 1 to Sept 14)
Sept, Oct, Nov	2.55	= Average Warming of Mixed Water compared to Sullivan Creek Natural Temps (Sept 15 to Nov 30

Percent of Average Year Flow in Sullivan Creek	134%	
Change the RED Values to test various scenarios		
Percent Of Dam Release Through Low Level Gates	per below	
Lake Depth (m) for cold water source (20, 16, 12, 8, 6 or 2)	20	
Which Outlet Flow Scenario To Use? (1, 2, or 3)(Table below)	1	1=Wet (1999), 2=Average, 3=Dry(1970)
% Flow Coming From Cold Water Pipe	Calc below (Auto Updated)	

Dam Discharge Outlet Flows-CFS
(Table Auto Updates Based on Outflow Scenario Selected above)

MONTH	RELEASE	TEMP	USER INPUT Seepage or Out of Gate	(CALCULATED) Out of Cold Water Pipe	Check- Is Cold Pipe Flow OK?	Lake Level at End of Week
Jan Week 1	42.3	2.8				
Jan Week 2	39.7	2.8				
Jan Week 3	44.1	2.8				
Jan Week 4	36.8	2.8				
Feb Week 1	34.3	1.1				
Feb Week 2	28.9	1.1				
Feb Week 3	26.0	1.1				
Feb Week 4	25.3	1.1				
Mar Week 1	24.3	3.3				
Mar Week 2	24.1	3.3				
Mar Week 3	28.2	3.3				
Mar Week 4	29.4	3.3				
April Week 1	10	Jan-June not modelled				
April Week 2	10	Jan-June not modelled				
April Week 3	10	Jan-June not modelled				
April Week 4	10	Jan-June not modelled				
May Week 1	10	Jan-June not modelled				
May Week 2	10	Jan-June not modelled				
May Week 3	10	Jan-June not modelled				
May Week 4	10	Jan-June not modelled				
Jun Week 1	60	Jan-June not modelled				
Jun Week 2	60	Jan-June not modelled				
Jun Week 3	60	Jan-June not modelled				
Jun Week 4	60	Jan-June not modelled				
July Week 1	40.00	updates automatically	15.0	25.0	YES	2588.66
July Week 2	35.00	updates automatically	15.0	20.0	YES	2588.66
July Week 3	30.00	updates automatically	15.0	15.0	YES	2588.66
July Week 4	30.00	updates automatically	15.0	15.0	YES	2588.66
Aug Week 1	30.00	updates automatically	15.0	15.0	YES	2588.66
Aug Week 2	30.00	updates automatically	15.0	15.0	YES	2588.66
Aug Week 3	30.00	updates automatically	15.0	15.0	YES	2588.66
Aug Week 4	30.00	updates automatically	15.0	15.0	YES	2588.66
Sep Week 1	30.00	updates automatically	15.0	15.0	YES	2588.66
Sep Week 2	160.00	updates automatically	35.0	125.0	YES	2587.17
Sep Week 3	160.00	updates automatically	45.0	115.0	YES	2585.70
Sep Week 4	180.00	updates automatically	32.0	148.0	YES	2583.49
Oct Week 1	200.00	updates automatically	60.0	140.0	YES	2581.53
Oct Week 2	225.00	updates automatically	96.0	129.0	YES	2579.34
Oct Week 3	225.00	updates automatically	110.0	115.0	YES	2577.10
Oct Week 4	200.00	updates automatically	104.0	96.0	YES	2574.32
Nov Week 1	180.00	updates automatically	98.0	82.0	YES	2572.59
Nov Week 2	130.00	updates automatically	55.0	75.0	YES	2571.83
Nov Week 3	100.00	updates automatically	28.0	72.0	YES	2571.46
Nov Week 4	100.00	updates automatically	35.0	65.0	YES	2570.67
Dec Week 1	70.00	3.3	15.0	55.0	YES	2570.35
Dec Week 2	60.00	3.3	15.0	45.0	YES	2570.09
Dec Week 3	50.00	3.3	15.0	35.0	YES	2569.92
Dec Week 4	31.00	3.3	15.0	16.0	YES	2569.92

One Gate Opening (inches)	Calculated Discharge (cfs)
4	36
8	71
12	107
16	144
20	182
24	223
28	267
31	313
35	363
39	417

LAKE ELEVATION	Assumes Lake Level July 1 (Full)
On Nov. 15th **2571.83**	**2588.6**
Target 2577.0 or less	

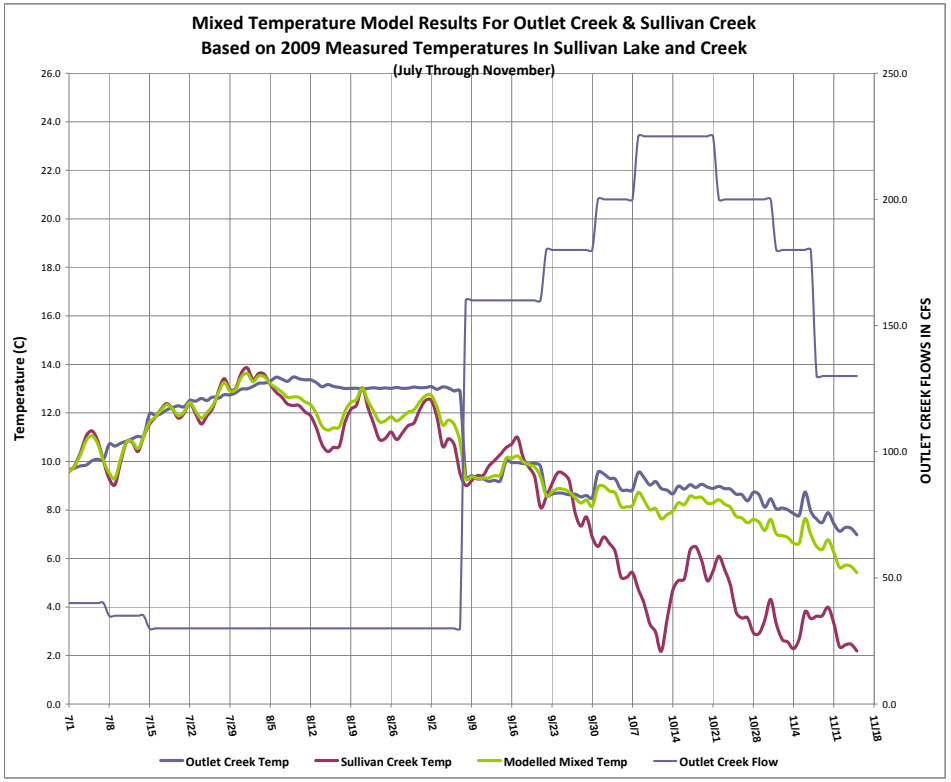


Figure 16

Sullivan Temperature Model Results-Scenario 1 (Wet Year) with Cold Water Release and Optimized Cooling

7.0 Results and Recommendations

This Sullivan Lake outflow temperature model can be used to examine rates of lake draining in the fall and impacts on downstream mixed water temperature. This model can also be used to examine the use of a cold water discharge pipe, and to see how successful this cold water pipe can be in lowering downstream temperatures, based on how deep in Sullivan Lake cold water is drawn from, and how much cold water flow is added. The model also can be used to examine pre-project or "without dam" conditions, to compare current operations with natural flow conditions.

The cold water release pipe was examined. It was found that using 2009 stream flow and temperature data, that the cold water release pipe could achieve a mixed water temperature (downstream of the confluence of Sullivan and Outlet Creeks) that was both a) within 1 degree C of the upstream Sullivan Creek water temperature; and b) never above 14 C. This includes accounting for groundwater seepage into Outlet Creek. The system actually demonstrated some excess capability that indicates additional cooling may be possible if needed under other hydrologic conditions. This capability is shown by the model to be adequate in dry, wet and average flow years.

To be able to monitor the system if a cold water pipe is installed, temperature recorders should be installed in Sullivan Creek both upstream and downstream of the confluence with Outlet Creek.

We recommend that in any future studies, when temperature data is gathered, simultaneous water flow measurements be taken in both Outlet Creek and Sullivan Creek. This will allow closer model calibration. In addition, we recommend that a simultaneous temperature measurement be made at the mouth of Sullivan Creek where it enters the Pend Oreille River, and also in the Pend Oreille River upstream and downstream of the Sullivan Creek confluence, so that a complete record of all temperature-related parameters for this system can be obtained simultaneously.

A copy of the EXCEL temperature model has been provided to all the agencies and the Tribe during Sullivan Dam talks. A copy is available to any interested Party.

8.0 Model Limitations

In using this model, several model limitations should be kept in mind:

1) This model is based on data gathered in one year, 2009. Therefore, the dates for some parameters, such as the date that the lake hits maximum temperature, the temperatures in Sullivan Creek, the maximum lake temperature, can be expected to be somewhat different in different years.

2) This model only works from July 1 through November 15, the time period of the available data upon which it was constructed. It could be easily modified to model longer periods if more data becomes available.

3) The calculations of mixed water temperature results are accurate, but the calibration results in this model are based on "inferred" flows in Sullivan Creek, based on some spot flow measurements and not a continuous flow record. In any future modeling, flow recorders should be installed on Sullivan Creek during the data gathering to improve accuracy of results.

Appendix A

WDFW Water Temperature Data
Collected between May 8 and November 16, 2009

SULLIVAN LAKE AND CREEK TEMPERATURE DATA

Collected by WDFW 2009

Converted to daily data by EESC Nov 17 2009

	Lake 20m	Lake 18m	Lake 16m	Lake 14m	Lake 12m	Lake 10m	Lake 8m	Lake 6m	Lake 4m	Lake 2m	Lake 0m		50m US Confluence Sullivan Creek 1	50m US Confluence Sullivan Creek 2	75m DS Confluence Sullivan Creek 4	DS Mill Pond 1.5 km Sullivan Creek 5	DS Mill Pond 1.5 km Sullivan Creek 6	75m DS of Dam Outlet Creek 1	75m DS of Dam Outlet Creek 2	In Lake Just US of Dam 15m Mill Pond 1	In Lake Just US of Dam 15m Mill Pond 2	Harvey 1	Harvey 2
5/8/2009	5.5	5.5	5.4	5.6	5.7	5.7	5.6	5.7	5.8	6.1	6.2		-	-	-	-	-	-	-	-	-	-	-
5/9/2009	5.1	5.1	5.3	5.5	5.8	5.7	5.7	6.0	6.2	6.5	6.7		-	-	-	-	-	-	-	-	-	-	-
5/10/2009	5.0	5.2	5.4	5.7	6.0	6.0	6.1	6.5	6.9	7.2	7.6		-	-	-	-	-	-	-	-	-	-	-
5/11/2009	4.9	5.1	5.0	5.3	5.6	5.7	6.0	6.5	6.9	7.4	7.6		-	-	-	-	-	-	-	-	-	-	-
5/12/2009	5.4	5.4	5.4	5.6	5.9	5.8	6.0	6.2	6.6	6.9	7.0		-	-	-	-	-	-	-	-	-	-	-
5/13/2009	5.6	5.7	5.9	6.3	6.6	6.5	6.5	6.7	6.8	6.9	6.9		-	-	-	-	-	-	-	-	-	-	-
5/14/2009	5.0	5.1	5.3	5.9	6.4	6.5	6.5	6.6	6.8	7.0	7.2		-	-	-	-	-	-	-	-	-	-	-
5/15/2009	5.1	5.1	5.1	5.5	6.0	6.2	6.4	6.6	6.9	7.2	8.0		-	-	-	-	-	-	-	-	-	-	-
5/16/2009	5.4	5.5	5.5	5.7	6.0	6.2	6.5	7.0	7.6	8.4	9.3		-	-	-	-	-	-	-	-	-	-	-
5/17/2009	5.1	5.2	5.3	5.5	6.0	6.3	7.2	7.9	8.4	8.7	9.4		-	-	-	-	-	-	-	-	-	-	-
5/18/2009	5.3	5.4	5.5	5.9	6.6	7.0	7.6	8.3	8.7	9.2	9.6		-	-	-	-	-	-	-	-	-	-	-
5/19/2009	6.3	6.4	6.6	6.9	7.4	7.7	8.2	8.8	9.0	9.1	9.4		-	-	-	-	-	-	-	-	-	-	-
5/20/2009	5.9	6.0	6.1	6.4	6.9	6.9	7.0	7.2	7.4	7.6	7.6		-	-	-	-	-	-	-	-	-	-	-
5/21/2009	5.4	5.6	5.8	6.3	6.8	7.0	7.3	7.6	7.8	8.1	8.9		-	-	-	-	-	-	-	-	-	-	-
5/22/2009	6.1	6.1	6.2	6.5	6.9	6.9	7.1	7.4	7.8	8.4	10.4		-	-	-	-	-	-	-	-	-	-	-
5/23/2009	5.9	6.0	6.1	6.4	6.8	6.9	7.1	7.5	8.1	9.4	12.1		-	-	-	-	-	-	-	-	-	-	-
5/24/2009	6.0	6.2	6.3	6.5	6.9	7.0	7.2	7.6	8.2	9.8	12.1		-	-	-	-	-	-	-	-	-	-	-
5/25/2009	6.0	6.1	6.2	6.5	6.8	6.9	7.1	7.6	9.2	12.0	13.0		-	-	-	-	-	-	-	-	-	-	-
5/26/2009	6.2	6.3	6.4	6.8	7.5	8.0	8.6	9.2	9.7	11.2	12.8		-	-	-	-	-	-	-	-	-	-	-
5/27/2009	6.0	6.2	6.4	7.0	7.5	8.0	8.7	9.6	10.6	11.1	11.3		-	-	-	-	-	-	-	-	-	-	-
5/28/2009	6.0	6.2	6.3	6.7	7.2	7.6	8.3	9.1	10.4	11.5	12.2		-	-	-	-	-	-	-	-	-	-	-
5/29/2009	6.0	6.2	6.3	6.7	7.2	7.5	8.3	9.2	10.4	12.1	14.1		-	-	-	-	-	-	-	-	-	-	-
5/30/2009	6.0	6.2	6.4	6.8	7.3	7.8	8.3	9.3	10.8	13.8	15.4		-	-	-	-	-	-	-	-	-	-	-
5/31/2009	6.1	6.2	6.4	6.8	7.4	7.8	8.4	9.1	10.1	13.3	15.7		-	-	-	-	-	-	-	-	-	-	-
6/1/2009	6.0	6.2	6.4	6.8	7.4	7.7	8.4	9.3	10.3	12.4	14.6		-	-	-	-	-	-	-	-	-	-	-
6/2/2009	6.4	6.6	6.8	7.1	7.7	7.8	8.2	8.7	9.6	10.7	11.4		-	-	-	-	-	-	-	-	-	-	-
6/3/2009	5.6	5.9	6.1	6.7	7.7	8.9	10.0	10.7	11.5	12.5	13.9		-	-	-	-	-	-	-	-	-	-	-
6/4/2009	6.4	6.5	6.7	7.0	7.7	8.3	9.3	10.7	12.1	13.4	15.5		-	-	-	-	-	-	-	-	-	-	-
6/5/2009	6.1	6.3	6.6	7.2	8.1	8.9	9.6	10.6	11.7	13.3	17.1		-	-	-	-	-	-	-	-	-	-	-
6/6/2009	6.3	6.5	6.8	7.4	8.1	8.7	9.3	10.2	11.5	13.3	14.5		-	-	-	-	-	-	-	-	-	-	-
6/7/2009	6.0	6.3	6.5	7.1	7.8	8.6	10.1	11.6	12.7	13.3	13.6		-	-	-	-	-	-	-	-	-	-	-
6/8/2009	6.4	6.7	7.0	7.6	8.3	9.0	10.0	11.1	12.1	13.2	14.0		-	-	-	-	-	-	-	-	-	-	-
6/9/2009	6.1	6.4	6.6	7.1	8.0	9.0	10.2	11.5	12.5	13.4	13.5		-	-	-	-	-	-	-	-	-	-	-
6/10/2009	6.2	6.5	6.7	7.3	8.2	9.2	10.6	11.6	12.7	13.5	14.8		-	-	-	-	-	-	-	-	-	-	-
6/11/2009	6.3	6.5	6.8	7.4	8.4	9.1	10.1	11.8	13.7	14.8	16.4		-	-	-	-	-	-	-	-	-	-	-
6/12/2009	6.2	6.5	6.7	7.5	8.5	9.6	10.4	11.4	13.4	15.6	17.9		-	-	-	-	-	-	-	-	-	-	-
6/13/2009	6.3	6.4	6.7	7.3	8.2	9.1	10.6	11.9	13.4	16.0	17.6		-	-	-	-	-	-	-	-	-	-	-
6/14/2009	6.3	6.5	6.8	7.4	8.3	9.3	10.8	12.4	14.7	16.9	17.4		-	-	-	-	-	-	-	-	-	-	-
6/15/2009	6.4	6.7	7.0	7.8	8.7	9.5	10.4	11.5	13.3	17.4	17.9		-	-	-	-	-	-	-	-	-	-	-
6/16/2009	6.3	6.4	6.7	7.3	8.1	9.4	10.9	12.7	14.8	16.6	17.9		-	-	-	-	-	-	-	-	-	-	-
6/17/2009	6.3	6.6	6.9	7.6	8.6	9.4	10.6	12.0	15.1	18.1	18.4		-	-	-	-	-	-	-	-	-	-	-
6/18/2009	6.3	6.6	7.0	7.7	8.6	9.7	11.0	12.7	15.6	17.9	18.4		-	-	-	-	-	-	-	-	-	-	-
6/19/2009	6.4	6.6	7.0	7.6	8.8	9.8	10.9	12.3	14.6	17.4	18.2		-	-	-	-	-	-	-	-	-	-	-
6/20/2009	6.3	6.5	6.8	7.4	8.4	9.6	11.1	12.6	15.1	17.3	17.5		-	-	-	-	-	-	-	-	-	-	-
6/21/2009	6.3	6.6	6.9	7.8	9.0	10.1	12.0	14.1	16.3	17.3	17.5		-	-	-	-	-	-	-	-	-	-	-
6/22/2009	6.5	6.7	7.0	7.7	8.5	9.5	10.8	14.8	16.7	16.9	16.8		-	-	-	-	-	-	-	-	-	-	-
6/23/2009	6.4	6.6	7.0	7.8	9.0	10.0	11.0	13.0	15.4	16.4	16.8		-	-	-	-	-	-	-	-	-	-	-
6/24/2009	6.3	6.5	6.9	7.6	8.7	10.0	11.8	13.4	15.2	16.8	17.1		-	-	-	-	-	-	-	-	-	-	-
6/25/2009	6.3	6.6	6.9	7.7	8.8	10.0	12.2	14.6	16.3	17.2	17.3		-	-	-	-	-	-	-	-	-	-	-
6/26/2009	6.6	6.9	7.3	8.2	9.2	10.0	11.1	12.7	15.4	16.9	17.2		-	-	-	-	-	-	-	-	-	-	-
6/27/2009	6.3	6.6	6.8	7.5	8.7	10.2	12.6	14.4	15.8	16.6	17.1		-	-	-	-	-	-	-	-	-	-	-
6/28/2009	7.2	7.8	8.4	9.6	11.2	11.9	12.9	14.1	17.0	17.4	17.8		-	-	-	-	-	-	-	-	-	-	-
6/29/2009	8.3	9.3	10.2	11.5	13.4	14.3	14.4	14.2	17.0	18.0	18.2		-	-	-	-	-	-	-	-	-	-	-
6/30/2009	6.5	6.7	7.1	7.9	9.0	10.5	12.2	14.2	17.1	18.7	18.8		-	-	-	-	-	-	-	-	-	-	-
7/1/2009	6.5	6.7	7.1	8.0	9.3	10.4	11.8	14.0	16.7	18.9	19.3	7/1/2009	9.6	9.6	11.7	12.4	12.4	15.0	14.8	12.3	12.3	9.9	9.9
7/2/2009	6.4	6.7	7.0	7.9	9.2	10.6	12.5	14.5	16.6	18.7	19.7	7/2/2009	9.8	9.8	12.0	12.8	12.8	15.3	15.1	12.5	12.5	10.2	10.2
7/3/2009	6.5	6.8	7.1	7.9	9.2	10.5	12.3	14.6	17.4	18.9	20.1	7/3/2009	10.4	10.4	12.4	13.3	13.2	15.4	15.2	13.1	13.0	10.8	10.8
7/4/2009	6.3	6.6	7.0	7.9	9.2	10.6	12.5	15.1	18.3	19.9	20.9	7/4/2009	11.1	11.1	13.0	13.9	13.8	15.8	15.6	13.5	13.5	11.6	11.6
7/5/2009	6.5	6.9	7.2	8.1	9.3	10.5	12.3	14.6	18.1	20.8	21.2	7/5/2009	11.3	11.2	13.2	14.1	14.1	15.8	15.6	13.9	13.9	11.7	11.7
7/6/2009	6.5	6.8	7.3	8.1	9.4	10.8	12.6	15.0	18.7	20.5	20.9	7/6/2009	10.9	10.9	12.9	13.9	13.8	16.1	15.9	13.8	13.8	11.5	11.5
7/7/2009	6.4	6.7	7.1	7.9	9.2	10.5	12.5	15.0	17.9	20.0	20.0	7/7/2009	10.0	10.0	12.5	13.1	13.0	16.2	16.0	13.1	13.1	10.5	10.6
7/8/2009	6.6	6.9	7.3	8.3	9.5	10.9	13.0	15.6	17.8	19.2	19.5	7/8/2009	9.3	9.3	12.0	12.7	12.7	16.2	16.0	12.5	12.6	9.7	9.8
7/9/2009	6.5	6.8	7.3	8.2	9.5	10.8	12.5	15.0	18.2	19.0	19.2	7/9/2009	9.0	9.0	12.0	12.3	12.3	16.1	15.9	12.2	12.3	9.5	9.5
7/10/2009	6.5	6.7	7.2	8.0	9.3	10.9	12.9	15.7	18.2	19.1	19.8	7/10/2009	10.0	10.0	12.8	12.7	12.6	16.5	16.2	12.4	12.5	10.1	10.2
7/11/2009	6.5	6.7	7.2	8.1	9.4	10.8	12.8	15.6	18.4	19.7	21.0	7/11/2009	10.8	10.8	13.3	13.5	13.5	16.7	16.5	13.1	13.1	11.3	11.4

SULLIVAN LAKE AND CREEK TEMPERATURE DATA

Collected by WDFW 2009

Converted to daily data by EESC Nov 17 2009

	Lake 20m	Lake 18m	Lake 16m	Lake 14m	Lake 12m	Lake 10m	Lake 8m	Lake 6m	Lake 4m	Lake 2m	Lake 0m		50m US Confluence Sullivan Creek 1	50m US Confluence Sullivan Creek 2	75m DS Confluence Sullivan Creek 4	DS Mill Pond 1.5 km Sullivan Creek 5	DS Mill Pond 1.5 km Sullivan Creek 6	75m DS of Dam Outlet Creek 1	75m DS of Dam Outlet Creek 2	In Lake Just US of Dam 15m Mill Pond 1	In Lake Just US of Dam 15m Mill Pond 2	Harvey 1	Harvey 2
7/12/2009	6.5	6.8	7.3	8.1	9.3	10.7	13.1	15.9	18.9	20.1	20.8	7/12/2009	10.8	10.8	13.3	14.0	13.9	16.9	16.7	13.8	13.8	11.3	11.3
7/13/2009	6.5	6.8	7.1	8.1	9.5	10.9	13.0	16.4	20.0	20.3	20.2	7/13/2009	10.4	10.4	12.9	13.5	13.5	17.1	16.9	13.3	13.3	10.9	10.9
7/14/2009	6.4	6.8	7.2	8.1	9.5	10.9	13.1	16.4	19.7	20.0	20.2	7/14/2009	11.0	11.1	13.5	13.2	13.2	17.2	17.0	13.4	13.4	11.6	11.7
7/15/2009	6.5	6.9	7.3	8.2	9.5	11.1	13.5	15.8	19.0	20.5	21.1	7/15/2009	11.5	11.6	14.5	14.0	14.0	17.4	17.2	13.9	13.9	12.0	12.1
7/16/2009	6.5	6.9	7.4	8.3	9.5	10.6	13.1	16.3	19.7	21.0	21.7	7/16/2009	11.8	11.9	13.7	15.0	15.0	17.3	17.2	15.0	15.1	12.3	12.3
7/17/2009	6.5	6.7	7.2	8.1	9.6	11.4	13.8	16.4	19.4	21.6	22.4	7/17/2009	12.2	12.2	13.9	15.5	15.5	17.5	17.3	15.3	15.3	12.7	12.7
7/18/2009	6.5	6.9	7.3	8.2	9.4	10.9	13.4	17.2	20.5	22.1	22.7	7/18/2009	12.4	12.4	14.0	15.7	15.6	17.8	17.6	15.4	15.4	12.9	12.9
7/19/2009	6.5	6.8	7.4	8.4	9.8	11.6	13.8	16.4	19.8	21.7	22.2	7/19/2009	12.2	12.1	13.9	15.6	15.6	17.9	17.7	15.4	15.4	12.6	12.6
7/20/2009	6.6	6.9	7.3	8.4	9.6	10.8	13.5	17.4	19.9	20.9	21.7	7/20/2009	11.8	11.8	13.8	15.6	15.6	18.0	17.8	15.6	15.6	12.2	12.3
7/21/2009	6.4	6.7	7.2	8.3	10.0	11.5	13.9	16.6	20.5	21.8	22.6	7/21/2009	12.0	12.0	14.0	15.9	15.9	18.1	17.9	15.8	15.7	12.4	12.4
7/22/2009	6.6	6.9	7.3	8.1	9.3	10.9	13.7	17.8	20.7	22.6	23.1	7/22/2009	12.4	12.5	14.4	16.3	16.3	18.4	18.2	16.3	16.3	12.9	12.9
7/23/2009	6.5	6.8	7.3	8.4	10.1	11.8	14.1	16.8	20.3	22.7	22.9	7/23/2009	12.0	12.0	14.1	16.0	16.0	18.5	18.3	15.7	15.8	12.3	12.3
7/24/2009	6.7	7.0	7.5	8.4	9.7	11.3	13.8	17.9	20.3	21.2	21.5	7/24/2009	11.5	11.6	13.8	15.3	15.3	18.5	18.4	15.2	15.2	12.0	12.0
7/25/2009	6.4	6.7	7.3	8.5	10.1	11.7	13.8	17.3	20.6	20.9	21.1	7/25/2009	11.9	11.9	14.2	15.1	15.0	18.6	18.4	14.7	14.8	12.1	12.1
7/26/2009	6.7	6.9	7.4	8.2	9.6	11.3	14.4	17.8	20.6	21.1	21.4	7/26/2009	12.2	12.2	14.4	15.7	15.7	18.7	18.4	15.6	15.6	12.3	12.4
7/27/2009	6.4	6.8	7.3	8.5	10.2	11.7	14.3	17.6	21.0	21.5	22.4	7/27/2009	12.9	12.9	14.8	16.0	15.9	18.8	18.5	15.6	15.7	13.1	13.1
7/28/2009	6.6	6.9	7.4	8.3	9.7	11.4	14.1	17.7	20.8	22.0	22.6	7/28/2009	13.4	13.4	15.1	16.7	16.7	18.9	18.7	16.3	16.4	13.7	13.8
7/29/2009	6.5	6.9	7.4	8.6	10.2	12.0	14.6	18.1	20.8	21.9	22.5	7/29/2009	13.0	13.0	14.8	16.9	16.9	19.0	18.8	16.6	16.6	13.6	13.6
7/30/2009	6.5	6.9	7.4	8.5	10.0	11.8	14.8	18.1	21.6	22.6	23.6	7/30/2009	13.0	13.0	15.1	16.9	16.8	19.1	18.9	16.3	16.3	13.7	13.7
7/31/2009	6.6	7.0	7.5	8.4	9.9	11.7	14.5	18.4	21.9	23.1	24.0	7/31/2009	13.7	13.7	15.5	17.3	17.3	19.4	19.1	16.7	16.7	14.3	14.4
8/1/2009	6.5	6.8	7.3	8.4	10.1	11.7	14.4	19.1	22.4	23.5	23.9	8/1/2009	13.9	13.9	15.6	17.6	17.6	19.5	19.3	17.1	17.1	14.5	14.5
8/2/2009	6.5	6.8	7.3	8.3	9.8	12.1	15.3	18.5	21.7	23.7	24.3	8/2/2009	13.4	13.4	15.2	17.6	17.5	19.6	19.4	17.1	17.1	13.9	13.9
8/3/2009	6.6	7.0	7.6	8.7	10.1	11.5	14.1	19.7	22.3	23.7	24.1	8/3/2009	13.6	13.7	15.5	17.8	17.7	19.8	19.7	17.3	17.3	14.2	14.3
8/4/2009	6.5	6.8	7.2	8.3	10.0	12.1	15.4	18.8	23.2	24.0	24.1	8/4/2009	13.6	13.6	15.4	17.8	17.7	20.0	19.8	17.5	17.5	14.1	14.1
8/5/2009	6.6	6.9	7.4	8.4	10.0	12.1	15.3	18.7	23.0	23.9	24.0	8/5/2009	13.2	13.2	15.1	17.5	17.4	20.0	19.9	17.3	17.3	13.5	13.5
8/6/2009	6.8	7.3	7.8	8.9	10.2	11.8	14.5	19.1	22.4	23.6	23.7	8/6/2009	12.9	12.9	14.9	17.1	17.0	20.2	20.0	16.7	16.8	13.4	13.4
8/7/2009	6.6	7.0	7.5	8.5	10.1	12.4	15.4	19.6	22.2	23.0	23.2	8/7/2009	12.7	12.7	14.9	16.7	16.7	20.2	20.1	16.7	16.7	13.3	13.4
8/8/2009	6.4	6.8	7.3	8.5	10.2	12.2	15.4	20.5	22.8	22.9	22.8	8/8/2009	12.4	12.4	14.8	16.5	16.5	20.2	20.0	16.4	16.4	13.0	13.0
8/9/2009	6.7	7.2	7.7	8.7	10.1	12.0	15.2	19.2	22.3	22.5	22.6	8/9/2009	12.3	12.4	14.6	16.3	16.3	20.3	20.1	16.2	16.2	12.9	13.0
8/10/2009	6.6	7.0	7.6	8.7	10.2	12.1	15.7	20.4	22.2	22.3	22.4	8/10/2009	12.3	12.3	14.7	16.4	16.3	20.2	20.1	16.3	16.3	12.7	12.7
8/11/2009	6.6	7.0	7.5	8.7	10.7	12.6	16.2	19.9	22.0	22.0	22.1	8/11/2009	12.1	12.1	14.5	16.2	16.1	20.1	20.0	16.1	16.2	12.3	12.3
8/12/2009	6.7	7.2	7.8	8.9	10.4	12.6	15.3	19.0	21.3	21.6	21.6	8/12/2009	11.9	11.9	14.4	15.7	15.7	20.0	19.8	15.6	15.6	12.4	12.4
8/13/2009	6.7	7.0	7.6	8.7	10.2	12.1	15.7	19.3	20.8	21.0	21.0	8/13/2009	11.4	11.4	14.2	15.4	15.4	19.9	19.7	15.3	15.3	12.1	12.1
8/14/2009	6.5	6.9	7.4	8.8	10.6	12.7	16.2	19.5	20.5	20.6	20.5	8/14/2009	10.7	10.7	13.5	14.8	14.8	19.7	19.4	14.9	14.9	11.2	11.2
8/15/2009	6.7	7.2	7.8	8.9	10.4	12.2	15.6	19.6	20.2	20.3	20.4	8/15/2009	10.4	10.4	13.2	14.6	14.5	19.6	19.5	14.6	14.6	10.6	10.7
8/16/2009	6.6	7.0	7.7	8.9	10.8	12.7	15.8	19.2	20.1	20.3	20.5	8/16/2009	10.6	10.6	13.4	14.6	14.6	19.6	19.4	14.5	14.6	11.3	11.3
8/17/2009	6.6	7.1	7.7	8.9	10.4	12.5	16.1	19.4	20.0	20.2	20.8	8/17/2009	10.6	10.7	13.6	15.0	14.9	19.5	19.3	14.7	14.7	11.7	11.7
8/18/2009	6.6	7.0	7.6	8.8	10.5	12.4	15.8	19.4	20.1	20.5	21.3	8/18/2009	11.6	11.7	14.5	15.3	15.3	19.4	19.2	14.9	14.9	12.1	12.2
8/19/2009	6.6	7.0	7.6	8.8	10.6	12.7	15.8	19.4	20.3	20.8	21.7	8/19/2009	12.1	12.2	14.8	15.9	15.9	19.4	19.2	15.6	15.6	12.2	12.2
8/20/2009	6.6	7.1	7.7	8.7	10.4	12.4	16.0	19.7	20.4	20.9	21.8	8/20/2009	12.3	12.4	14.8	16.4	16.3	19.4	19.2	15.9	16.0	11.9	11.9
8/21/2009	6.5	6.9	7.6	8.8	10.5	12.8	16.5	20.5	21.1	21.6	21.9	8/21/2009	13.0	13.1	15.4	17.0	16.9	19.4	19.2	16.6	16.6	11.7	11.7
8/22/2009	6.6	7.0	7.6	8.8	10.7	12.7	16.1	20.1	21.4	21.6	21.7	8/22/2009	12.2	12.2	14.1	16.6	16.6	19.4	19.2	16.6	16.7	11.2	11.2
8/23/2009	6.7	7.1	7.8	8.8	10.4	12.5	16.5	19.7	21.2	21.5	21.6	8/23/2009	11.5	11.5	13.5	16.1	16.1	19.4	19.2	16.2	16.3	10.9	10.9
8/24/2009	6.6	7.0	7.7	9.1	10.9	12.9	16.4	19.9	21.0	21.2	21.4	8/24/2009	10.9	10.9	13.0	15.9	15.9	19.4	19.2	16.0	16.0	10.7	10.7
8/25/2009	6.7	7.1	7.7	8.8	10.4	13.0	17.5	20.2	21.0	21.1	21.2	8/25/2009	11.0	11.0	13.3	15.7	15.6	19.4	19.2	15.7	15.7	10.6	10.6
8/26/2009	6.6	7.1	7.8	9.2	11.1	13.2	16.7	20.2	20.9	20.9	21.0	8/26/2009	11.2	11.3	13.7	15.7	15.6	19.4	19.2	15.6	15.6	10.7	10.7
8/27/2009	6.8	7.1	7.8	9.0	10.6	12.9	16.5	19.8	20.7	20.8	21.2	8/27/2009	10.9	10.9	13.2	15.4	15.4	19.4	19.2	15.4	15.4	10.7	10.7
8/28/2009	6.6	7.0	7.8	8.9	10.9	13.2	17.1	19.3	20.5	20.7	21.2	8/28/2009	11.2	11.2	13.8	15.8	15.7	19.4	19.3	15.5	15.5	10.9	10.9
8/29/2009	6.7	7.0	7.7	9.0	10.9	13.0	17.0	19.9	20.6	21.0	21.0	8/29/2009	11.5	11.5	14.1	15.8	15.7	19.4	19.2	15.3	15.3	10.7	10.7
8/30/2009	6.7	7.1	7.8	9.0	10.9	13.1	16.8	19.8	20.6	20.8	21.4	8/30/2009	11.6	11.6	14.2	15.6	15.6	19.5	19.3	15.3	15.3	11.1	11.2
8/31/2009	6.6	7.1	7.8	9.0	10.8	13.0	17.4	19.7	20.5	20.9	21.3	8/31/2009	12.1	12.1	14.7	16.2	16.2	19.5	19.3	15.8	15.8	11.3	11.4
9/1/2009	6.7	7.1	7.8	9.0	11.0	13.2	16.6	20.0	21.1	21.4	22.2	9/1/2009	12.5	12.5	15.1	16.6	16.6	19.4	19.3	16.1	16.2	11.5	11.6
9/2/2009	6.7	7.1	7.8	8.9	10.6	13.1	17.5	19.9	20.8	21.7	22.2	9/2/2009	12.5	12.6	14.9	16.7	16.7	19.5	19.3	16.3	16.3	11.5	11.5
9/3/2009	6.6	7.2	8.0	9.4	11.3	14.2	19.0	20.5	21.1	21.5	21.5	9/3/2009	11.8	11.8	13.8	16.1	16.0	19.3	19.2	16.1	16.2	11.2	11.3
9/4/2009	6.8	7.2	7.9	9.1	10.8	13.4	16.6	20.0	20.6	20.6	20.9	9/4/2009	10.6	10.6	12.6	15.3	15.3	19.3	19.2	15.6	15.6	11.1	11.1
9/5/2009	6.7	7.2	7.9	9.1	11.0	13.3	18.2	19.3	20.0	20.1	20.3	9/5/2009	10.9	11.0	13.4	15.4	15.4	19.3	19.2	15.4	15.5	10.9	11.0
9/6/2009	6.6	7.3	8.1	9.4	11.2	13.7	19.0	19.7	19.9	19.9	19.9	9/6/2009	10.7	10.7	12.6	15.0	15.0	19.2	19.0	15.2	15.2	10.6	10.6
9/7/2009	6.8	7.2	7.9	9.1	11.0	13.3	17.9	19.2	19.3	19.3	19.3	9/7/2009	9.5	9.5	11.4	14.1	14.1	19.0	18.8	14.5	14.5	10.1	10.1
9/8/2009	6.7	7.2	8.0	9.3	11.1	13.2	17.2	18.9	19.0	19.1	19.1	9/8/2009	9.0	9.0	11.7	13.8	13.8	18.9	18.8	14.2	14.2	10.2	10.3
9/9/2009	6.8	7.3	8.0	9.2	10.8	13.5	17.2	18.7	18.8	18.8	18.9	9/9/2009	9.2	9.3	11.9	13.7	13.7	18.8	18.6	13.9	13.9	10.3	10.3
9/10/2009	6.6	7.1	7.9	9.3	11.3	13.9	16.9	18.3	18.5	18.6	18.7	9/10/2009	9.4	9.5	12.0	13.6	13.6	18.7	18.6	13.7	13.7	10.5	10.5
9/11/2009	6.7	7.1	7.9	9.2	11.0	13.6	17.3	18.1	18.3	18.4	18.8	9/11/2009	9.4	9.4	12.2	13.8	13.8	18.6	18.4	13.9	13.9	10.6	10.6
9/12/2009	6.6	7.1	7.9	9.2	11.0	13.5	17.7	18.2	18.3	18.5	19.2	9/12/2009	9.8	9.8	12.6	14.1	14.0	18.5	18.3	14.1	14.1	10.9	10.9

SULLIVAN LAKE AND CREEK TEMPERATURE DATA

Collected by WDFW 2009

Converted to daily data by EESC Nov 17 2009

	Lake 20m	Lake 18m	Lake 16m	Lake 14m	Lake 12m	Lake 10m	Lake 8m	Lake 6m	Lake 4m	Lake 2m	Lake 0m		50m US Confluence Sullivan Creek 1	50m US Confluence Sullivan Creek 2	75m DS Confluence Sullivan Creek 4	DS Mill Pond 1.5 km Sullivan Creek 5	DS Mill Pond 1.5 km Sullivan Creek 6	75m DS of Dam Outlet Creek 1	75m DS of Dam Outlet Creek 2	In Lake Just US of Dam 15m Mill Pond 1	In Lake Just US of Dam 15m Mill Pond 2	Harvey 1	Harvey 2
9/13/2009	6.6	7.1	7.9	9.2	11.0	13.9	17.7	18.2	18.5	19.0	19.8	9/13/2009	10.0	10.1	12.8	14.2	14.2	18.4	18.3	14.2	14.2	11.2	11.2
9/14/2009	6.6	7.1	7.9	9.3	11.1	13.9	17.7	18.4	18.8	19.0	19.3	9/14/2009	10.3	10.3	12.9	14.3	14.3	18.4	18.2	14.3	14.3	10.9	10.9
9/15/2009	6.7	7.3	8.2	9.5	11.2	13.6	17.3	18.5	18.9	18.9	19.4	9/15/2009	10.6	10.6	13.3	14.4	14.4	18.4	18.3	14.6	14.6	11.4	11.4
9/16/2009	6.7	7.1	7.7	9.1	11.0	14.3	17.4	18.3	18.8	19.0	19.4	9/16/2009	10.7	10.7	13.5	14.8	14.8	18.4	18.2	15.0	15.1	11.6	11.6
9/17/2009	6.7	7.2	8.1	9.4	11.1	13.7	17.5	18.6	19.1	19.3	19.3	9/17/2009	11.0	11.0	13.5	14.7	14.7	18.3	18.2	14.6	14.7	12.1	12.1
9/18/2009	6.7	7.1	7.9	9.2	11.1	13.9	17.4	18.5	18.9	19.1	19.3	9/18/2009	10.1	10.2	12.5	14.4	14.3	18.2	18.0	14.3	14.4	11.6	11.6
9/19/2009	6.7	7.1	7.9	9.3	11.2	14.4	17.6	18.5	18.7	18.8	18.8	9/19/2009	9.8	9.8	12.0	14.1	14.1	18.1	18.0	14.1	14.1	10.8	10.8
9/20/2009	6.7	7.3	8.1	9.5	11.3	13.3	16.9	18.3	18.5	18.5	18.6	9/20/2009	9.4	9.4	11.3	13.4	13.4	18.0	17.9	13.8	13.8	11.1	11.1
9/21/2009	6.6	7.1	7.8	9.0	11.3	14.6	17.0	17.8	18.0	18.1	18.2	9/21/2009	8.1	8.1	10.5	13.1	13.0	17.9	17.7	13.5	13.5	10.2	10.2
9/22/2009	6.6	7.1	7.9	9.3	11.1	14.0	17.4	17.7	17.9	18.0	18.4	9/22/2009	8.5	8.5	11.4	13.2	13.2	17.9	17.7	13.5	13.5	11.0	10.9
9/23/2009	6.7	7.2	8.0	9.3	11.3	14.4	17.3	17.7	17.9	18.0	18.7	9/23/2009	9.1	9.1	12.1	13.5	13.5	17.9	17.7	13.6	13.6	11.4	11.4
9/24/2009	6.7	7.2	8.0	9.3	11.2	14.4	17.4	17.8	18.0	18.2	18.9	9/24/2009	9.5	9.6	12.3	13.7	13.6	17.9	17.6	13.6	13.6	11.6	11.6
9/25/2009	6.7	7.2	8.1	9.5	11.3	14.1	17.4	17.8	18.2	18.4	18.9	9/25/2009	9.5	9.5	12.2	13.6	13.6	17.8	17.6	13.6	13.7	11.7	11.6
9/26/2009	6.7	7.1	7.9	9.2	11.2	14.8	17.4	17.9	18.1	18.2	18.4	9/26/2009	9.2	9.2	11.7	13.2	13.2	17.7	17.6	13.4	13.4	11.4	11.3
9/27/2009	6.7	7.2	8.1	9.6	11.5	14.3	17.1	17.7	17.8	17.9	17.9	9/27/2009	7.9	7.9	10.0	12.5	12.5	17.6	17.4	13.0	13.1	10.1	10.0
9/28/2009	6.6	7.1	8.0	9.5	11.7	15.0	17.0	17.4	17.4	17.5	17.6	9/28/2009	7.3	7.4	9.9	12.4	12.3	17.4	17.3	12.8	12.8	9.9	9.7
9/29/2009	6.8	7.3	8.1	9.4	11.2	15.9	17.0	17.0	17.1	17.1	17.1	9/29/2009	7.7	7.7	11.0	12.0	12.0	17.1	17.0	12.4	12.4	9.3	9.2
9/30/2009	6.7	7.2	8.1	9.5	11.2	14.4	16.5	16.6	16.6	16.7	16.7	9/30/2009	6.9	6.9	9.7	11.5	11.5	16.9	16.7	12.0	12.0	8.2	8.2
10/1/2009	6.6	7.1	7.8	9.3	11.5	15.3	16.1	16.2	16.3	16.3	16.3	10/1/2009	6.5	6.5	12.8	11.3	11.2	16.4	16.2	11.7	11.7	7.8	7.7
10/2/2009	6.7	7.2	8.0	9.3	11.3	14.3	15.8	15.8	15.8	15.9	15.8	10/2/2009	6.9	6.9	15.4	11.7	11.6	16.0	15.8	12.0	12.0	8.2	8.1
10/3/2009	6.6	7.1	7.9	9.1	10.7	12.9	14.8	15.5	15.5	15.6	15.5	10/3/2009	6.6	6.6	15.1	11.7	11.7	15.6	15.4	12.0	12.0	8.2	8.2
10/4/2009	6.9	7.5	8.4	9.6	10.8	11.8	13.1	14.4	14.8	14.9	14.8	10/4/2009	6.3	6.3	14.5	11.6	11.6	14.9	14.7	11.9	11.9	8.4	8.2
10/5/2009	6.6	7.2	8.5	10.2	12.0	13.1	13.7	13.9	14.0	14.1	14.1	10/5/2009	5.2	5.2	13.8	11.3	11.3	14.1	13.9	11.6	11.6	8.3	8.1
10/6/2009	6.6	7.2	8.0	9.8	12.2	13.5	13.7	13.6	13.7	13.8	13.8	10/6/2009	5.2	5.2	13.7	11.3	11.2	13.9	13.7	11.5	11.5	7.8	7.6
10/7/2009	6.8	7.3	8.1	9.5	11.5	13.1	13.4	13.5	13.5	13.6	13.5	10/7/2009	5.4	5.4	13.5	11.3	11.2	13.6	13.4	11.5	11.5	8.1	8.0
10/8/2009	6.8	7.4	8.7	10.5	12.5	12.9	13.0	13.1	13.1	13.2	13.2	10/8/2009	4.7	4.8	13.1	10.9	10.8	13.2	13.0	11.2	11.2	6.9	7.0
10/9/2009	6.7	7.2	7.9	9.6	11.6	12.4	12.6	12.7	12.7	12.8	12.8	10/9/2009	4.2	4.2	12.7	10.6	10.5	12.8	12.6	10.9	10.9	6.3	6.5
10/10/2009	6.4	7.0	8.3	10.3	11.9	12.3	12.3	12.3	12.4	12.5	12.5	10/10/2009	3.3	3.3	12.4	10.1	10.1	12.5	12.3	10.4	10.5	5.6	5.7
10/11/2009	6.9	7.4	8.2	10.0	11.5	12.0	12.1	12.1	12.2	12.3	12.2	10/11/2009	3.0	3.0	12.2	9.8	9.8	12.3	12.1	10.1	10.2	4.7	5.1
10/12/2009	6.6	7.0	8.0	9.8	11.8	11.8	11.7	11.8	11.8	12.0	11.9	10/12/2009	2.2	2.2	11.9	9.4	9.4	12.0	11.8	9.7	9.8	4.0	4.5
10/13/2009	6.7	7.2	8.0	9.1	10.7	11.4	11.4	11.5	11.5	11.6	11.5	10/13/2009	3.5	3.5	11.7	9.3	9.3	11.7	11.4	9.5	9.5	4.9	5.0
10/14/2009	6.6	7.2	8.4	10.2	11.3	11.2	11.2	11.3	11.2	11.4	11.3	10/14/2009	4.7	4.7	11.6	9.5	9.4	11.5	11.2	9.6	9.6	6.0	6.0
10/15/2009	6.7	7.3	8.4	10.3	11.3	11.2	11.1	11.2	11.2	11.4	11.3	10/15/2009	5.1	5.1	11.5	9.6	9.6	11.4	11.1	9.6	9.7	7.6	7.6
10/16/2009	6.5	7.0	7.9	10.7	11.1	11.2	11.1	11.0	11.2	11.3	11.3	10/16/2009	5.2	5.2	11.4	9.6	9.6	11.3	11.2	9.7	9.7	8.5	8.4
10/17/2009	6.7	7.2	8.4	10.7	11.1	11.2	11.1	11.2	11.2	11.4	11.4	10/17/2009	6.3	6.3	11.6	10.1	10.1	11.5	11.3	10.0	10.0	9.1	9.1
10/18/2009	6.4	6.9	8.1	10.9	11.2	11.2	11.1	11.3	11.2	11.4	11.4	10/18/2009	6.5	6.5	11.7	10.3	10.3	11.5	11.3	10.3	10.3	8.6	8.6
10/19/2009	6.6	7.0	7.7	9.8	11.3	11.2	11.1	11.3	11.2	11.4	11.4	10/19/2009	5.9	6.0	11.6	10.3	10.2	11.6	11.4	10.3	10.4	9.0	9.0
10/20/2009	6.5	7.0	7.8	10.1	11.1	11.2	11.1	11.3	11.2	11.4	11.4	10/20/2009	5.1	5.1	11.4	9.9	9.9	11.5	11.3	10.1	10.2	8.6	8.6
10/21/2009	6.6	7.1	7.9	9.9	11.1	11.1	11.1	11.1	11.2	11.3	11.2	10/21/2009	5.5	5.5	11.4	9.9	9.9	11.3	11.1	10.0	10.0	8.7	8.7
10/22/2009	6.5	7.0	7.8	10.2	11.1	11.1	11.1	11.0	11.1	11.2	11.3	10/22/2009	6.1	6.1	11.4	10.0	10.0	11.3	11.1	10.0	10.1	9.2	9.2
10/23/2009	6.4	6.8	7.7	9.9	11.1	10.9	11.0	11.0	10.9	11.1	10.9	10/23/2009	5.6	5.6	11.1	9.9	9.9	11.2	10.8	10.0	10.0	8.6	8.6
10/24/2009	6.5	7.1	7.9	9.7	11.0	10.9	10.8	10.9	10.9	11.0	11.0	10/24/2009	4.9	4.9	11.1	9.5	9.5	11.0	10.8	9.7	9.8	5.8	5.8
10/25/2009	6.4	6.9	7.7	9.6	10.8	10.6	10.5	10.7	10.6	10.8	10.6	10/25/2009	3.8	3.8	10.8	9.0	9.0	10.7	10.5	9.3	9.3	4.4	4.4
10/26/2009	6.6	7.1	8.1	9.7	10.5	10.4	10.4	10.4	10.4	10.5	10.4	10/26/2009	3.6	3.5	10.5	8.7	8.7	10.5	10.3	8.9	8.9	4.1	4.2
10/27/2009	6.3	6.8	7.9	9.6	10.3	10.1	10.1	10.1	10.2	10.2	10.2	10/27/2009	3.6	3.6	10.3	8.4	8.3	10.3	10.1	8.5	8.5	3.2	3.3
10/28/2009	6.6	7.0	7.7	9.7	10.0	10.0	9.9	9.9	10.0	10.1	10.0	10/28/2009	2.9	2.9	8.6	8.0	8.0	10.7	10.5	8.2	8.3	3.0	3.1
10/29/2009	6.5	7.0	8.1	9.6	9.9	9.7	9.6	9.7	9.8	9.8	9.7	10/29/2009	2.9	2.9	6.6	7.5	7.4	10.6	10.4	7.8	7.9	3.3	3.3
10/30/2009	6.5	6.9	7.7	9.3	9.7	9.5	9.4	9.5	9.5	9.6	9.5	10/30/2009	3.5	3.5	9.7	7.8	7.8	9.6	9.4	8.0	8.0	4.5	4.6
10/31/2009	7.2	7.9	8.5	9.4	9.7	9.4	9.3	9.5	9.5	9.6	9.5	10/31/2009	4.3	4.4	9.7	8.2	8.2	9.6	9.4	8.4	8.4	5.4	5.4
11/1/2009	6.3	7.1	7.7	8.8	9.3	9.4	9.3	9.3	9.5	9.6	9.6	11/1/2009	3.3	3.3	9.6	8.2	8.2	9.5	9.4	8.3	8.4	3.2	3.2
11/2/2009	6.6	7.2	8.0	8.8	9.4	9.2	9.1	9.3	9.3	9.4	9.3	11/2/2009	2.7	2.7	9.4	7.9	7.9	9.3	9.1	8.1	8.1	3.0	3.0
11/3/2009	6.5	7.1	7.8	8.7	9.2	9.1	9.1	9.1	9.2	9.3	9.3	11/3/2009	2.6	2.5	9.3	7.8	7.8	9.2	9.0	8.0	8.0	3.6	3.6
11/4/2009	6.4	6.9	7.6	8.7	9.1	8.9	8.8	9.0	8.9	9.1	9.0	11/4/2009	2.3	2.3	9.1	7.6	7.6	9.0	8.8	7.8	7.8	4.3	4.3
11/5/2009	6.4	6.8	7.5	8.7	8.9	8.9	8.8	8.7	8.9	9.0	9.0	11/5/2009	2.7	2.7	9.0	7.6	7.6	9.0	8.7	7.7	7.7	4.2	4.3
11/6/2009	8.6	8.7	8.6	8.8	8.8	8.8	8.7	8.7	8.8	8.8	8.8	11/6/2009	3.8	3.8	9.0	7.8	7.8	8.9	8.7	7.8	7.8	4.0	4.0
11/7/2009	7.1	7.6	8.1	8.4	8.7	8.6	8.5	8.4	8.6	8.6	8.5	11/7/2009	3.5	3.5	8.9	7.3	7.3	8.7	8.5	7.4	7.5	3.0	3.0
11/8/2009	6.9	7.6	8.1	8.3	8.5	8.3	8.3	8.4	8.3	8.5	8.3	11/8/2009	3.6	3.6	8.8	7.0	7.0	8.6	8.4	7.1	7.2	3.4	3.4
11/9/2009	6.8	7.2	7.6	8.1	8.4	8.3	8.2	8.2	8.3	8.4	8.3	11/9/2009	3.6	3.7	8.5	6.9	6.9	8.4	8.2	7.0	7.0	3.6	3.7
11/10/2009	7.6	7.8	7.9	8.2	8.2	8.2	8.2	8.1	8.2	8.2	8.2	11/10/2009	4.0	4.0	8.4	7.3	7.3	8.3	8.1	7.4	7.4	4.1	4.1
11/11/2009	6.9	7.1	7.3	7.9	8.2	8.0	7.9	8.1	8.0	8.2	8.0	11/11/2009	3.3	3.3	8.3	7.2	7.2	8.2	7.9	7.3	7.3	3.4	3.5
11/12/2009	6.5	6.8	7.1	7.4	7.9	7.8	7.8	7.8	7.8	7.9	7.8	11/12/2009	2.4	2.4	8.0	6.9	6.9	8.0	7.7	7.0	7.0	4.0	4.0
11/13/2009	6.9	7.1	7.4	7.6	7.8	7.7	7.6	7.6	7.7	7.8	7.7	11/13/2009	2.4	2.4	7.8	6.8	6.7	7.8	7.5	6.9	6.9	2.7	2.8
11/14/2009	7.0	7.3	7.4	7.5	7.7	7.4	7.4	7.5	7.5	7.6	7.5	11/14/2009	2.5	2.5	7.6	6.6	6.6	7.6	7.4	6.7	6.7	3.2	3.2
11/15/2009	6.8	7.2	7.3	7.4	7.6	7.4	7.3	7.3	7.4	7.4	7.4	11/15/2009	2.2	2.2	7.6	6.5	6.4	7.5	7.3	6.5	6.6	3.7	3.7

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

APPENDIX E.3-4
WASHINGTON DEPARTMENT OF ECOLOGY
TOXICS MONITORING: FRESHWATER FISH, JANUARY 2009

Washington State Toxics Monitoring Program: Freshwater Fish Tissue Component, 2007

DEPARTMENT OF ECOLOGY
State of Washington

January 2009
Publication No. 09-03-003

Publication and Contact Information

This report is available on the Department of Ecology's website at
www.ecy.wa.gov/biblio/0903003.html

Data for this project are available on Ecology's Environmental Information Management (EIM) website at www.ecy.wa.gov/eim/index.htm. Search User Study ID: WSTMP07.

Ecology's Project Tracker Code for this study is 02-500-01-06.

For more information contact:

Publications Coordinator
Environmental Assessment Program
P.O. Box 47600, Olympia, WA 98504-7600
Phone: (360) 407-6764

Washington State Department of Ecology - www.ecy.wa.gov/

- Headquarters, Olympia (360) 407-6000
- Northwest Regional Office, Bellevue (425) 649-7000
- Southwest Regional Office, Olympia (360) 407-6300
- Central Regional Office, Yakima (509) 575-2490
- Eastern Regional Office, Spokane (509) 329-3400

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Washington State Toxics Monitoring Program: Freshwater Fish Tissue Component, 2007

by
Keith Seiders and Casey Deligeannis

Toxics Studies Unit
Statewide Coordination Section
Environmental Assessment Program
Washington State Department of Ecology
Olympia, Washington 98504-7710

Waterbody Number(s): See Appendix A

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Abstract

Results of freshwater fish tissue sampling conducted in 2007 as part of the Washington State Toxics Monitoring Program (WSTMP) are reported. The "exploratory" monitoring component is a screening-level effort which targets areas across Washington where historical data are lacking. Results are used primarily to identify areas of concern for follow-up actions. Because the program is not designed to assess trends, caution should be used in comparing results from year to year.

Sixteen sites across Washington State representing 12 resident freshwater species of fish were sampled in 2007. Contaminants assessed include persistent, bioaccumulative, and toxic chemicals (PBTs) such as mercury, PCBs, dioxins and furans, chlorinated pesticides, and PBDE flame retardants.

Most sample results were within the lower range of values found in other studies of fish tissue in Washington. Mercury was detected in 100%, PBDEs in 97%, and PCBs in 91% of the 35 samples analyzed. Pesticides in the DDT and chlordane groups were detected in 63% and 6% of the 35 samples, respectively.

Twenty-eight percent of all samples did not meet Washington State water quality standards for contaminants in fish tissue. Total PCBs and 2,3,7,8-TCDD accounted for most of these exceedances. Other contaminants exceeding water quality standards were mercury and hexachlorobenzene.

This study recommends that five lakes and one river be added to the federal Clean Water Act Section 303(d) List for Washington State. These sites are: Ozette, Samish, Big, Campbell, and Sullivan Lakes, and the Samish River. Samples collected from the other ten sites met Washington State water quality standards.

Acknowledgements

The authors of this report would like to thank the following people for their contribution to this study:

- Mark Downen, Washington Department of Fish and Wildlife (WDFW), for providing fish from Ross Lake, and other WDFW staff for providing site information and fish age data.
- Dwayne Paige, senior watershed ecologist with Seattle Public Utilities, for providing fish from Chester Morse Reservoir.
- Phil Kincare, Jan Degroat, and Tom Shuhda, U.S. Forest Service, for providing site information, boat launch access, and bunkhouse lodging.
- Pat Crain and Brian Winter, Olympic National Park, for providing site information.
- Rick Foster, Washington State Department of Natural Resources, for providing site information.
- Sonia Mumford, U.S. Fish and Wildlife Service, for coordinating fish organ tissue sampling and supplies.
- Marcia House, Northwest Indian Fisheries Commission, for assisting with fish organ tissue processing.
- Ed Chad, Clallam County Stream Keeper, for site information.
- Dave King, owner of Olympic Raft and Kayak, for providing site information.
- Washington State Department of Ecology Staff:
    - Water Quality Program staff for review of the draft report: Christine Hempleman, Dave Rountry, and Karin Baldwin.
    - Manchester Environmental Laboratory staff for analytical services: Myrna Mandjikov, Debi Case, Dean Momohara, Dolores Montgomery, John Weakland, Kelly Donegan, Karin Feddersen, Stuart Magoon, Aileen Richmond, and Leon Weiks.
    - Environmental Assessment Program staff for sample collection, processing, and data management: Dave Serdar, Patti Sandvik, Chad Furl, Brandee Era-Miller, Carolyn Lee, Randy Coots, Art Johnson, Kristin Carmak, Paul Anderson, Callie Meredith, Chris Moore, Brandon Sloan, and Nuri Mathieu.
    - Other Environmental Assessment Program staff: Dale Norton for project guidance and design and review of the report; Chad Furl for reviewing the report; and Joan LeTourneau, Cindy Cook, and Gayla Lord for formatting and editing the final report.

Background

During the 1980s and 1990s, the Washington State Department of Ecology (Ecology) and other agencies found toxic contaminants in fish, water, and sediment throughout Washington at varied levels of concern (www.ecy.wa.gov/toxics.html). In 2000, renewed concern about toxic contaminants in the environment led Ecology to revitalize a program to address toxic contaminants: the Washington State Toxics Monitoring Program (WSTMP).

The goals of the WSTMP are to:

- Conduct exploratory monitoring to characterize toxic contaminants in freshwater fish across Washington where historical data are lacking (the subject of this report).
- Conduct trend monitoring for persistent toxic chemicals.
- Improve access to information about monitoring contaminants in Washington: www.ecy.wa.gov/programs/eap/toxics/index.html.
- Establish cooperative efforts with other agencies and develop monitoring efforts to address topics of concern.

Between 2001 and 2007, 232 fish tissue samples from 104 sites were analyzed for various contaminants as part of the WSTMP Exploratory Monitoring component. Five annual reports have been published (www.ecy.wa.gov/programs/eap/toxics/wstmp.htm). Nearly 40,000 results are now available in Ecology's Environmental Information Management database (EIM) at www.ecy.wa.gov/eim/.

Ecology and the Washington State Department of Health (DOH) are developing strategies to address persistent, bioaccumulative, and toxic chemicals (PBTs) in our environment. These strategies involve learning more about the sources, uses, risks, and fate of these compounds. Mercury and flame retardants were the first PBTs for which chemical action plans were developed (www.ecy.wa.gov/programs/swfa/pbt/).

Fish are an important indicator of contaminant levels in the environment. Ecology evaluates fish tissue contaminant data to determine whether Washington State water quality standards are being met.

Contaminant concentrations in fish tissue that do not meet water quality standards are not necessarily high enough to warrant a fish consumption advisory to eat less fish. DOH evaluates the need for consumption advice based on multiple factors, including the benefits of eating fish as part of a healthy diet (www.doh.wa.gov/ehp/oehas/fish/advisoriesmap.htm).

This report summarizes results of analyses of freshwater fish samples collected from 16 sites in 2007 (Figure 1 and Appendix A).

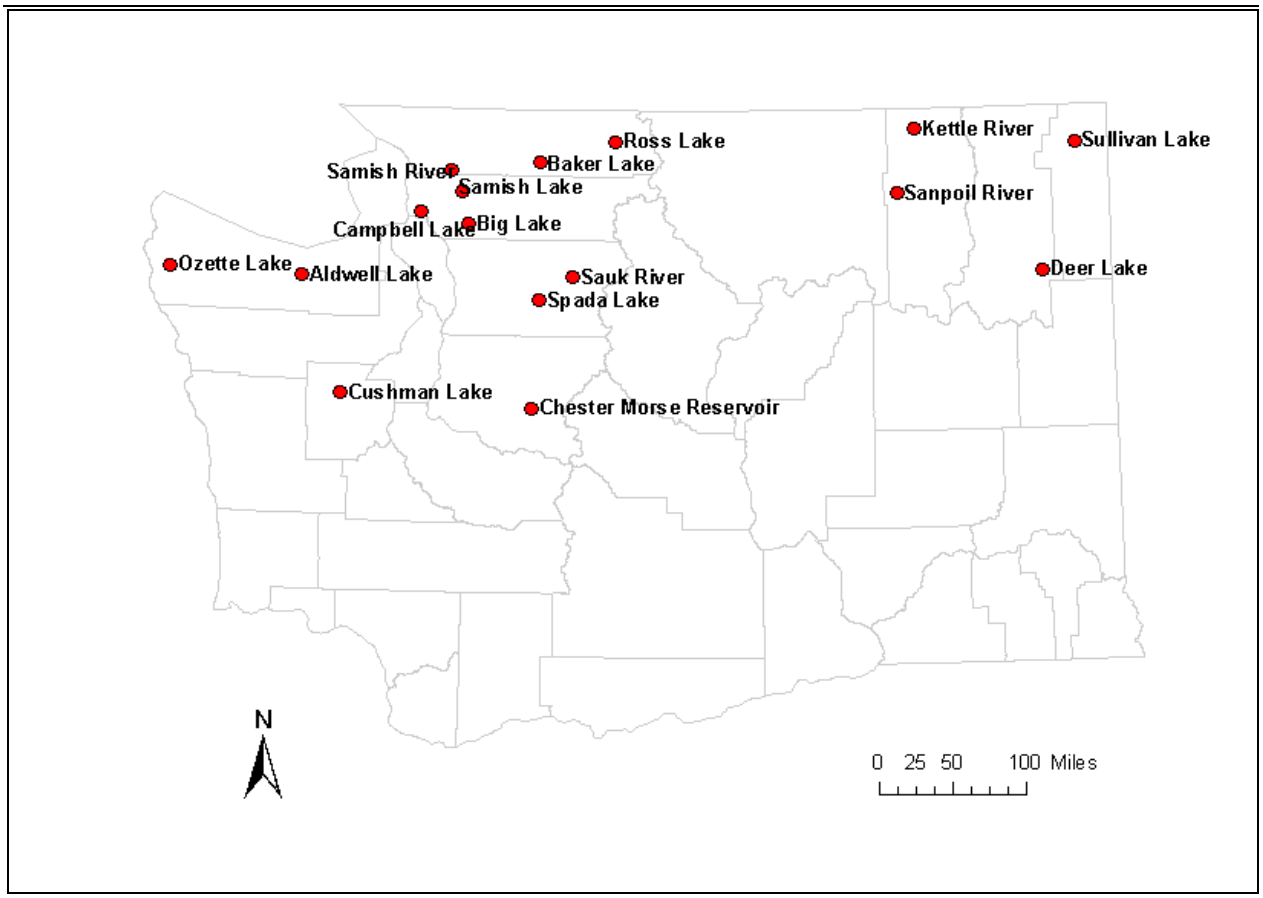

Figure 1. Sample Sites for the WSTMP, 2007.

Study Design

This exploratory monitoring component of the WSTMP targets resident freshwater fish from Washington. The primary purpose is to screen for PBT chemicals from areas with limited data available on toxic chemicals in fish. The project plan describes the program in more detail (Seiders and Yake, 2002).

Contaminants Assessed

An overview of target analytes for this component of the program is given below.

Mercury

Mercury occurs in the earth's crust and is released to the environment from natural events (e.g., volcanoes, weathering, and forest fires) and human activities (e.g., fossil fuel combustion, mining, and industrial processes).

Methylmercury is the toxic form of mercury which persists in the environment as it accumulates in the food web. Eating fish and shellfish contaminated with methylmercury is the primary route for exposure to mercury for most people (ATSDR, 1999; Ecology and DOH, 2003; EPA, 2007).

PCBs

Polychlorinated biphenyls (PCBs) are synthetic organic compounds historically used as cooling fluids in electrical equipment, and in inks, paints, and plastics. PCBs are stable, have low solubility in water, and have a high affinity for sediments and animal fats. The production of PCBs was banned in the U.S. in 1979 due to their persistence and toxicity (ATSDR, 2000).

There are 209 individual PCBs, or congeners. Commercial mixtures of PCB congeners were manufactured under various trade names. The most common in the United States used the trade name Aroclor. PCB Aroclors were analyzed in all 35 WSTMP samples from 2007; individual PCB congeners were analyzed in 27 (about 68%) of these samples.

Dioxins and Furans (PCDD/Fs)

Dioxins and furans, or polychlorinated dibenzo-p-dioxins and -furans (PCDD/Fs), are unintentional byproducts of combustion processes (e.g., burning household trash, forest fires, waste incineration), chlorine bleaching in paper production, and chemical and pesticide manufacturing. Agent Orange, which was used as a defoliant in the Vietnam War, contained dioxins (ATSDR, 2006).

Twenty seven of the 35 samples from 2007 were analyzed for the 17 most toxic congeners. These congeners have different levels of toxicity compared to 2,3,7,8-TCDD, the most toxic congener. The cumulative toxicity of mixtures of congeners in a sample can be expressed as a

toxic equivalent (TEQ) to 2,3,7,8-TCDD. The TEQ is calculated by multiplying the result for each congener by its congener-specific Toxicity Equivalent Factor (TEF) and then summing these products to obtain the 2,3,7,8-TCDD TEQ. The 1998 World Health Organization TEFs (Van den Berg et al., 1998) were used in this report.

Chlorinated Pesticides

Pesticides include insecticides, herbicides, fungicides, and related chemicals used to control pests. Chlorinated pesticides were analyzed for in this study because of their widespread occurrence and persistence in the environment.

Many of these pesticides are neurotoxins and are suspected or known carcinogens (EPA, 2000). Some pesticides were banned from use in the United States during the 1970s and 1980s as their hazards became evident (e.g., DDT, chlordane, and dieldrin).

PBDE Flame Retardants

Flame retardants, specifically poly-brominated diphenyl ethers (PBDEs), are compounds added to plastic and foam products such as electronic enclosures, wire insulation, adhesives, textile coatings, foam cushions, and carpet padding. Increasing concentrations of PBDEs in humans and wildlife worldwide continue to raise concerns about their health effects. The highest levels of PBDEs in human tissue have been found in the U.S. and Canada (Ecology and DOH, 2006).

Similar to PCBs, there are theoretically 209 individual congeners of PBDEs. Thirteen of these congeners were analyzed for during this study: PBDE-47, 49, 66, 71, 99, 100, 138, 153,154, 183, 184, 191, 209.

Site Selection

Sites are selected for sampling by examining various factors, such as the type of species present, the presence or absence of historical data, the value of the site for fishing, and the ability to cooperate with other monitoring or watershed planning efforts.

One of these efforts was a study of fish in Ross Lake in eastern Whatcom County. Mark Downen of the Washington Department of Fish and Wildlife (WDFW) provided bull trout, rainbow trout, and redside shiner to Ecology for tissue analysis. This is the first time that bull trout, a threatened species, has been included in Ecology's fish tissue monitoring efforts.

Appendix A lists the sample site locations and species of fish sampled. Additional site and sample information, including analytical results, are available in Ecology's Environmental Information Management (EIM) database at www.ecy.wa.gov/eim/index.htm. Search User Study ID: WSTMP07.

Field Procedures

Target fish species were chosen based on recommendations from the U.S. Environmental Protection Agency (EPA, 2000) and previous experience with fish collection efforts. Most fish were collected in late summer or fall by electro-fishing, gill netting, angling, or trapping. Fish kept for analyses were given a unique identifying code, measured for length and weight, individually wrapped in aluminum foil and put in plastic bags, and transported to freezer storage.

Fish were later processed at Ecology facilities. Composite samples were made up of skin-on fillets from five to ten fish of the same species from the same site. The sex of each fish was determined. Samples were then sent to laboratories for chemical analyses. Redside shiner from Ross Lake were processed as whole fish at the request of WDFW. Sample collection and processing details are described in a standard operating procedure (SOP) (Sandvik, 2006).

Analytical Methods

Table 1 describes analytical methods. Most analyses were performed by Ecology's Manchester Environmental Laboratory (MEL). Pace Analytical Services of Minneapolis, MN, conducted analyses for PCB congeners and PCDD/Fs. At Ecology's request, PCDD/Fs results were reported down to the limit of detection, with values qualified as estimates if they were between the limit of detection and the quantitation limit.

Table 1. Analytical Methods for Fish Tissue Samples, WSTMP 2007.

Parameter	Description	Method	Reporting Limit
PCB Aroclors	GC/ECD	EPA 8082	0.9 ug/kg, wet wt
PCB Congeners	HiRes GC/MS	EPA 1668A	0.05 - 1.2 ug/kg, wet wt
Chlorinated pesticides	GC/ECD	EPA 8081 [1]	0.25 -15 ug/kg, wet wt
PBDEs	GC/MS SIM	EPA 8270 [2]	0.1 - 2.6 ug/kg, wet wt
PCDD/PCDFs	HiRes GC/MS	EPA 1613B	0.1 - 1.0 ng/kg, wet wt
Mercury (total mercury)	CVAA	EPA 245.6	0.017 mg/kg, wet wt
Lipids - percent	gravimetric	MEL SOP 730009	0.1 percent

1. MEL 730073, a modification of EPA 8081 and others, was used in sample analyses.
2. MEL SOP 730096, a modification of EPA 8270, was used in sample analyses.

SOP = Standard Operating Procedure.
GC = Gas Chromatography.
MS = Mass Spectrometry.
ECD = Electron Capture Detection.
SIM = Single Ion Monitoring.
HiRes = High Resolution.
CVAA = Cold Vapor Atomic Absorbance.

Fish tissue was analyzed for total mercury because the analytical costs for methylmercury are prohibitively high. Methylmercury is also the predominant form of mercury found in free-swimming fish accounting for 95-100% of total mercury (Bloom, 1995). Both mercury and methylmercury are used as the basis for various water quality criteria or threshold values for the protection of human health and aquatic life.

Data Quality

Data quality was assessed by reviewing laboratory case narratives, analytical results, and field replicate data. Case narratives were written by MEL analytical staff. The narratives described the condition of samples upon receipt, analytical quality control procedures, and data qualifications. Quality control procedures included a mixture of analyses such as: method blanks, calibration and control standards, matrix spikes, matrix spike duplicates, surrogate recoveries, and laboratory and field duplicates.

Overall, the 2007 data met most quality control criteria defined by MEL and the Quality Assurance Project Plan. All results are usable as qualified. Initial analyses for PCB aroclors did not meet reporting limits, so samples were re-analyzed and met the desired reporting limits. No other data were rejected or re-analyzed. Some data were qualified due to challenges encountered in analyses. Estimates of precision were mixed, ranging from poor to good, and appear typical for samples of fish tissue.

Appendix B summarizes results from quality control and quality assurance procedures. Other quality assurance information is available by contacting the authors of this report.

Water Quality Criteria

Fish tissue results were compared to Washington's water quality standards to determine how sites should be assessed in Washington's Statewide Water Quality Assessment (the 303(d) assessment). This assessment also describes sampling requirements and other details about how environmental results are reviewed (Ecology, 2006).

Washington adopted the National Toxics Rule criteria (NTR) as the water quality standards for toxic compounds associated with human-health concerns. These criteria are one set of values that can be used in gauging the potential for human health risks from eating contaminated fish. EPA developed more recent criteria and guidance values which are described below. (See *EPA Recommended Water Quality Criteria* and *EPA Screening Values*).

The NTR criteria, EPA's recommended criteria, and EPA's screening values exist because of changing knowledge about the toxic effects of chemicals and subsequent risks to consumers of fish. The various criteria and screening values are often based on different assumptions used in determining risk, such as daily consumption rates, toxicological data used in calculations, and risk levels.

Results of this 2007 study are not compared to these other two EPA values because Ecology lacks authority to begin corrective actions where these criteria are exceeded. Yet the EPA recommended criteria and screening values can be used by state, tribal, and local health jurisdictions in evaluating risks to human health from the consumption of contaminated fish.

Appendix C describes how Ecology and DOH evaluate fish tissue data. Table 2 shows the NTR (Washington's water quality standards criteria) and other EPA criteria and screening values for contaminants detected in this study.

Table 2. Criteria and Guidelines Used for the Protection of Human Health for Contaminants Detected in Fish Tissue, WSTMP 2007.

Analyte[1]	National Toxics Rule	National Recommended Water Quality Criteria [2]	EPA Screening Values			
			Subsistence Fishers		Recreational Fishers	
			Non-carcino-gens	Carcino-gens	Non-carcino-gens	Carcino-gens
Mercury	825	300	49	-	400	-
Total PCBs [3]	5.3	2.0	9.83	2.45	80	20
2,3,7,8-TCDD [4]	0.07	-	-	-	-	-
2,3,7,8-TCDD TEQ [4, 5]	-	0.026	-	0.0315	-	0.256
4,4'-DDD	45	17	-	-	-	-
4,4'-DDE	32	12	-	-	-	-
4,4'-DDT	32	12	-	-	-	-
Total DDT [6]	-	-	245	14.4	2000	117
Chlordane [7]	8.3	11	245	14.0	2000	114
Chlordane (technical)	-	-	-	-	-	-
Dieldrin	0.65	0.25	24	0.307	200	2.5
DDMU [8]	-	-	-	-	-	-
Hexachlorobenzene	6.7	2.5	393	3.07	3200	25.0
Pentachloroanisole	-	-	-	-	-	-
PBDEs	-	-	-	-	-	-

1. Values in parts per billion wet weight (ug/kg ww) unless otherwise noted.
2. EPA (2001) for methylmercury, EPA (2002) for others.
3. Total PCBs is sum of Aroclors or congeners.
4. Values in parts per trillion wet weight (ng/kg ww).
5. The cumulative toxicity of a mixture of congeners in a sample can be expressed as a Toxic Equivalent (TEQ) to 2,3,7,8-TCDD.
6. Total DDT is the sum of 2,4'- and 4,4'- isomers of DDD, DDE, and DDT. DDD = 4,4'-dichlorodiphenyldichloroethane. DDE = 4,4'-dichlorodiphenyldichloroethylene. DDT = 4,4'-dichlorodiphenyltrichloroethane.
7. The NTR criterion for chlordane is interpreted as the sum of five chlordane components: these can be individually quantified through laboratory analyses while chlordane cannot. The EPA Screening Values are for "Total Chlordanes" which is the sum of five compounds: cis- and trans- chlordane, cis- and trans- nonachlor, and oxychlordane.
8. DDMU (1-chloro-2,2-bis(p-chlorophenyl)ethene) is another breakdown product of DDT.

National Toxics Rule (NTR)

Washington State's water quality standards for toxic substances (WAC 173-201A-040[5]) define human health-based water quality criteria by referencing 40 CFR 131.36, also known as the National Toxics Rule.

The NTR criteria were issued by EPA to Washington State in 1992. These criteria are designed to minimize the risk of adverse effects occurring to humans from chronic (lifetime) exposure to toxic substances through the ingestion of drinking water and contaminated fish and shellfish obtained from surface waters. The NTR criteria are regulatory values used by Ecology for a number of different purposes, including permitting wastewater discharges and assessing when waterbodies are adversely impacted by contaminants.

The NTR criteria values are based on a daily fish consumption rate of 6.5 grams/day and a risk level of 10^{-6}. A risk level is an estimate of the number of cases of adverse health effects (e.g. cancer) that could be caused by exposure to a specific contaminant. At a risk level of 10^{-6}, one person in a million would be expected to contract cancer due to long-term exposure to a specific contaminant.

Ecology expresses the NTR water column criteria as tissue concentrations in order to compare the criteria to laboratory results from fish tissue samples (Ecology, 2006). These tissue concentrations are derived by multiplying the NTR water quality criterion for "human health for consumption of organisms only" by the bioconcentration factor (BCF) for the specific contaminant. The BCFs for specific contaminants are found in EPA's 1980 Ambient Water Quality Criteria documents (EPA, 1980).

EPA Recommended Water Quality Criteria

EPA has published *National Recommended Water Quality Criteria* for some substances such as mercury and pesticides (EPA, 2001, 2002, and 2003). These recommended criteria are updates to previously developed criteria that occur on an ongoing basis. EPA recommends these criteria be used when states and tribes revise their regulatory criteria. These EPA recommended criteria are not regulatory levels. Most of EPA's *Recommended Water Quality Criteria* are based on a daily fish consumption rate of 17.5 grams/day and a risk level of 10^{-6}.

EPA Screening Values

Screening values (SVs) for carcinogenic and non-carcinogenic effects of substances were developed by EPA to help prioritize areas that may present risks to humans from fish consumption. The EPA SVs are considered guidance only; they are not regulatory thresholds (EPA, 2000). The approach in developing the EPA SVs was similar to the approach used for developing the NTR, yet differs in two key assumptions:

- A cancer risk level of 10^{-5}.
- Two consumption rates: 17.5 grams/day for recreational fishers, and 142.4 grams/day for subsistence fishers.

A difference between the EPA SVs and NTR relating to PCDD/Fs is that the SVs use the 2,3,7,8-TCDD TEQ value while Ecology uses the single congener (2,3,7,8-TCDD) for 303(d) assessments (Ecology, 2006).

Results and Discussion

In 2007 sixteen sites were sampled yielding 35 sample results representing 12 freshwater species of fish. Most results from the 2007 WSTMP were within the lower range of values found in other studies of fish tissue in Washington.

Bull trout were included in the 2007 samples and represent the first known case of this species being analyzed for contaminants in fillet tissue. Contaminant levels were generally low in this sample except for mercury which was moderately elevated. These fish were from Ross Lake and were provided by the Washington Department of Fish and Wildlife (WDFW).

The concentrations of contaminants in fish tissue are expressed in wet weight using these units of measure:

- mg/kg = ppm, or parts per million
- ug/kg = ppb, or parts per billion
- ng/kg = ppt, or parts per trillion

Table 3 shows summary statistics for key contaminants in freshwater fish. Mercury was detected in 100% of the 35 samples, PBDEs in 97%, and PCBs in 91%. Pesticides in the DDT and chlordane groups were detected in 63% and 6% of the samples, respectively. Twenty-seven samples were analyzed for PCB congeners and dioxins/furans with all samples having detectable levels.

Concentrations of PCBs in 26% of the samples exceeded the NTR criterion. Nineteen percent of the samples tested for 2,3,7,8-TCDD exceeded the NTR criterion. Total PCBs and 2,3,7,8-TCDD accounted for most of the NTR exceedances.

Appendix D shows results for key analytes in fish tissue samples.

Table 3. Summary Statistics for Fish Tissue Samples, WSTMP 2007.

Parameter [1]	n	Min	Max	Median	Mean	Standard Deviation	Detection Frequency	NTR Criteria Exceedance Frequency
Total PCB Aroclors [2]	35	0.97 U	28.4 J	3.7	4.53	4.94	77%	26%
Total PCB Congeners [2]	27	0.31 J	19.1 J	2.6	3.72	4.11	100%	19%
Total DDT [3]	35	0.85 U	24.2	1.8	2.68	3.96	63%	NC
Total Chlordane [4]	35	0.85 U	1.3 J	0.95	0.95	0.08	6%	0%
Total PBDE [5]	35	0.16 J	4.3	1.3	1.60	1.07	97%	NC
2,3,7,8-TCDD TEQ [6] (ng/kg)	27	0.010 J	0.911 J	0.149	0.2253	0.2191	100%	78% [7]
2,3,7,8-TCDD (ng/kg)	27	0.014 NJ	0.195 J	0.038	0.0522	0.0394	63%	19%
Mercury	35	41	1600	130	236.5	300.8	100%	3%

1. Values in parts per billion wet weight (ug/kg ww) unless otherwise noted.
2. Total PCBs is the sum of the individual Aroclors or congeners.
3. Total DDT is the sum of 4,4' and 2,4' isomers of DDT, DDD, and DDE.
4. Total PBDE is the sum of the 13 individual congeners that were analyzed for.
5. Total chlordane is the sum of: cis- and trans- chlordane, cis- and trans- nonachlor, and oxychlordane
6 . 2,3,7,8-TCDD TEQ, is the sum of the 17 PCDD/F congener results using TEFs by Van den Berg et al., 1998.
7. Washington discontinued using the TEQ value for comparison to the NTR in 2006. The exceedance values given here are so that comparisons to historical data can be made. The summing process used only values qualified as estimates: non-detect values were excluded.

U = The analyte was not detected at or above the reported value.
J = The analyte was positively identified. The associated numerical result is an estimate.
NJ = The analyte was tentatively identified and the associated numerical value represents an approximate concentration.
NC = No criteria for this parameter.

Contaminants in Freshwater Fish

Mercury

Mercury was detected in all samples. Only one sample exceeded the NTR criterion of 825 ug/kg while seven others were greater than EPA's *Recommended Water Quality Criterion* for methylmercury of 300 ug/kg (EPA, 2001). The range of values was similar to those seen in past WSTMP samples (Figure 2) as well as in other mercury monitoring efforts in Washington (Furl and Meredith, 2008).

Older and larger piscivorous (fish-eating) fish tended to have higher mercury levels. The highest levels were found in samples of northern pikeminnow and largemouth bass with mean ages ranging from 5.8 – 15.8 years old. The highest level of mercury, 1600 ug/kg, was in the northern pikeminnow sample from Lake Ozette. Largemouth bass from Big, Campbell, and Samish Lakes had mercury levels of 497-754 ug/kg. Mercury levels in other fish from Samish Lake were also elevated: 575 ug/kg in northern pikeminnow and 429 ug/kg in peamouth.

Rainbow trout from Chester Morse Reservoir had the highest level of mercury (407 ug/kg) found in 56 samples of five species of trout analyzed in the WSTMP since 2001. Brook trout from the Sanpoil River (234 ug/kg) and bull trout from Ross Lake (216 ug/kg) also had some of the highest mercury levels found in trout species collected thus far (89th and 88th percentile, respectively).

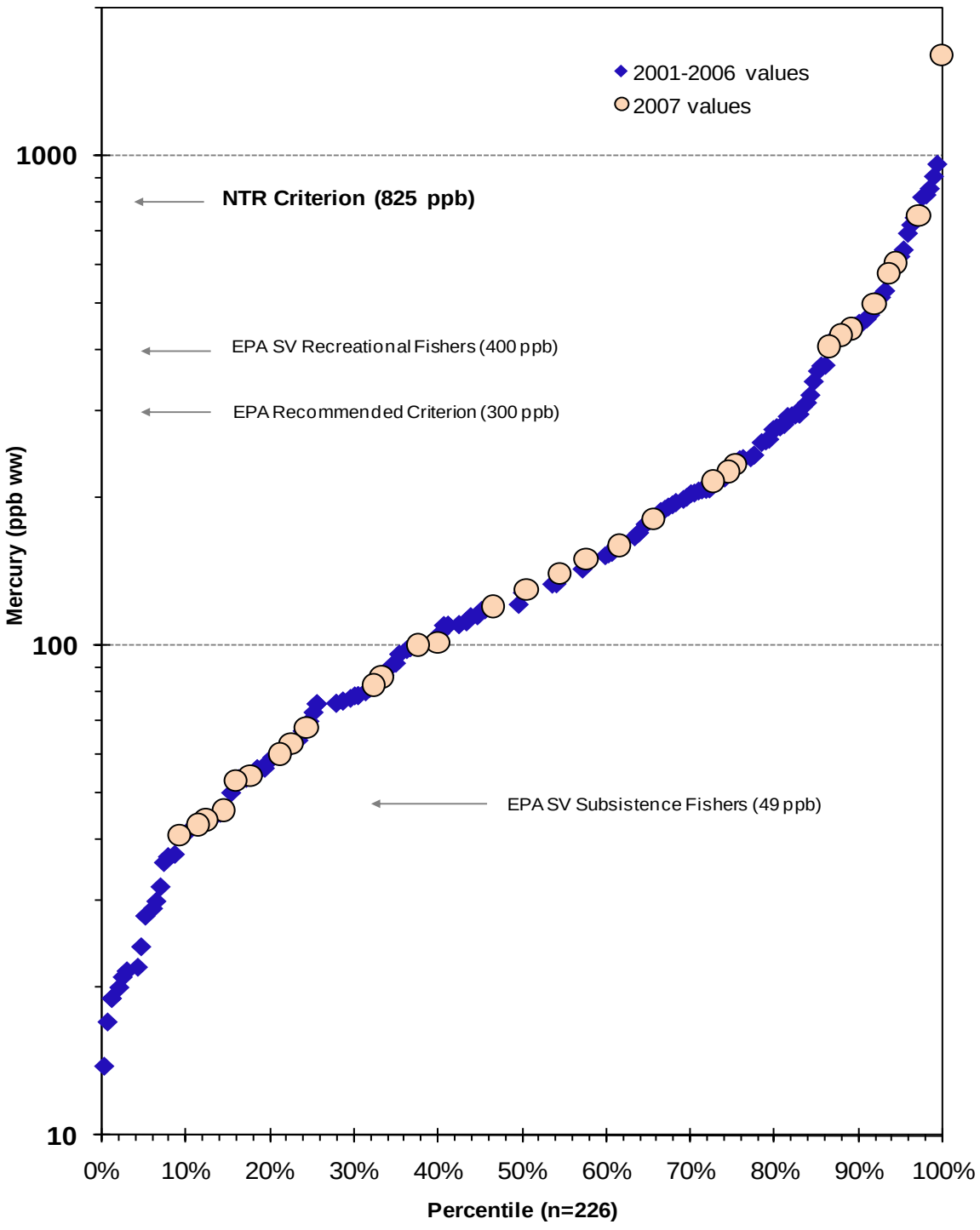

Figure 2. Distribution of Mercury in Edible Fish Tissue, WSTMP 2001-2007.

PCBs

PCBs were detected in 91% of the 35 samples with 26% of the samples exceeding the NTR criterion of 5.3 ug/kg total PCBs. The highest levels of total PCBs were found in brown trout from Sullivan Lake and northern pikeminnow from Samish Lake (28.4 ug/kg Aroclors and 12.6 ug/kg Aroclors, respectively). Fish from the remaining sites had total PCB levels below 10 ug/kg.

Figure 3 shows total PCB levels in edible fish tissue from 218 samples collected during the 2001-2007 WSTMP. Most results from the 2007 sampling effort fell below the median (50th percentile) while two samples discussed above ranked at the 81st and 68th percentiles. For all fish analyzed for PCBs during the WSTMP from 2001-2007, about 55% of samples exceed the NTR criterion of 5.3 ppb wet weight (ww) for the protection of human health. About 85% of fish also exceed EPA's lower SV for Subsistence Fishers (2.45 ppb ww).

Dioxins and Furans (PCDD/Fs)

Dioxins and furans were detected in all samples with 19% of samples exceeding the NTR criterion for 2,3,7,8-TCDD of 0.07 ng/kg. The highest levels of 2,3,7,8-TCDD were found in Samish Lake northern pikeminnow (0.195 ng/kg), Samish Lake cutthroat trout (0.12 ng/kg), Sullivan Lake brown trout (0.1 ng/kg), and Big Lake cutthroat trout (0.099 ng/kg). Corresponding 2,3,7,8-TCDD TEQ values for these samples ranged from 0.665-0.911 ng/kg.

Figure 4 shows 2,3,7,8-TCDD TEQ values for all results from the WSTMP. The TEQ value, instead of the single 2,3,7,8-TCDD congener, is shown here because the TEQ is a more conservative expression of the risks posed by all 17 toxic dioxin and furan congeners. The 2007 results have a broad distribution compared to all results from the WSTMP. Overall, about 80% of fish sampled for PCDD/Fs during the WSTMP exceeded the NTR criterion of 0.07 ppt ww for the single congener 2,3,7,8-TCDD. TEQ values for about 90% of the WSTMP samples exceeded EPA's SV for Subsistence Fishers (0.032 ppt ww).

Chlorinated Pesticides

The most frequently detected chlorinated pesticide was 4,4'-DDE. Eight other pesticides or breakdown products were detected at frequencies less than 10%. These were: 4,4'-DDD, 4,4'-DDT, DDMU, technical grade chlordane, trans-nonachlor, hexachlorobenzene, dieldrin, and pentachloroanisole.

While DDT compounds were detected in 63% of the samples, none of the samples exceeded NTR criteria for individual DDT compounds. The highest levels of total DDT were found in Sullivan Lake brown trout (24.2 ug/kg) and Samish Lake northern pikeminnow (5.2 ug/kg). The remaining sites had fish containing less than 5 ug/kg total DDT. DDT compounds found in this 2007 study were generally at lower levels than found in other Ecology studies conducted in Washington.

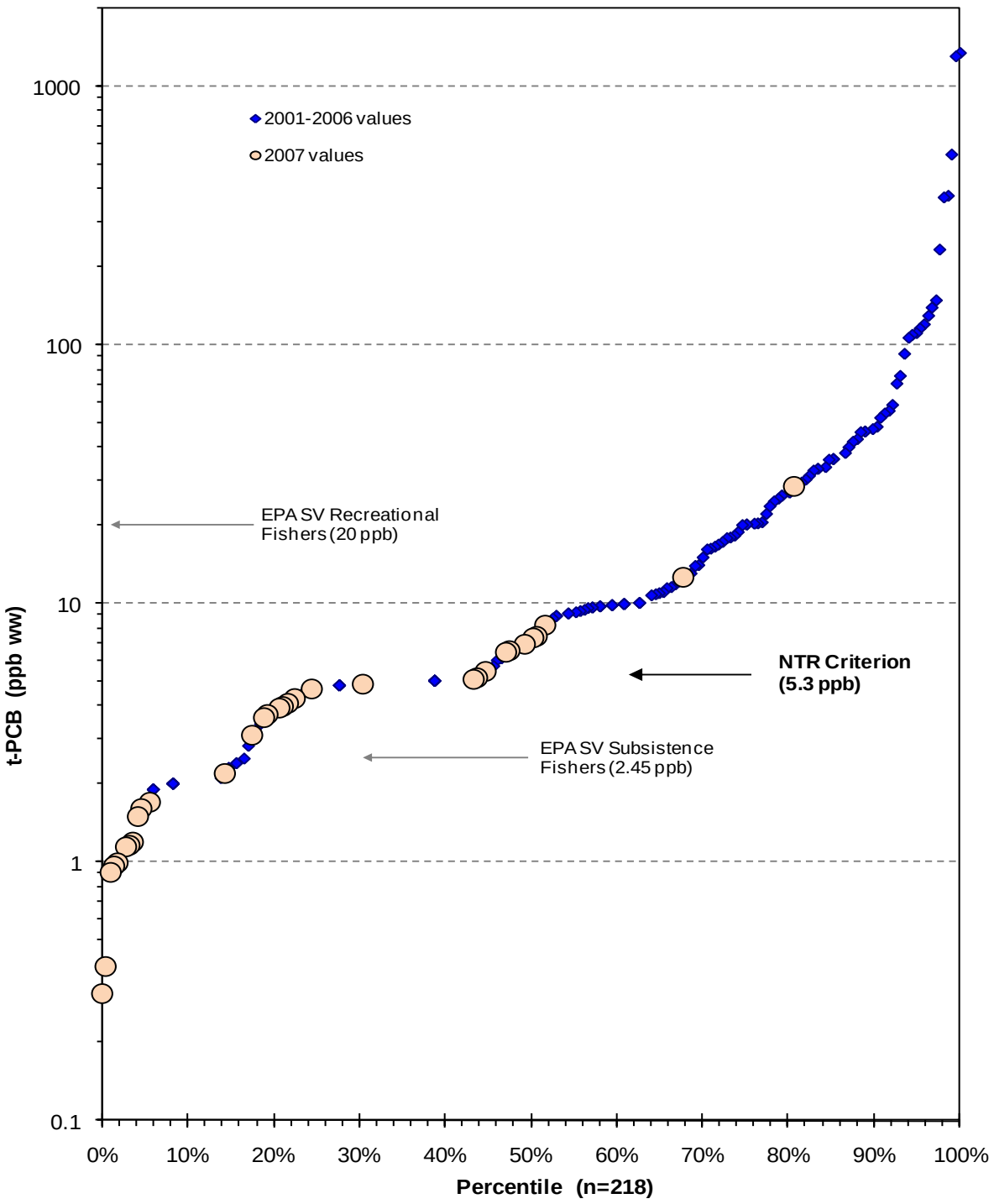

Figure 3. Distribution of Total PCBs in Edible Fish Tissue, WSTMP 2001-2007.

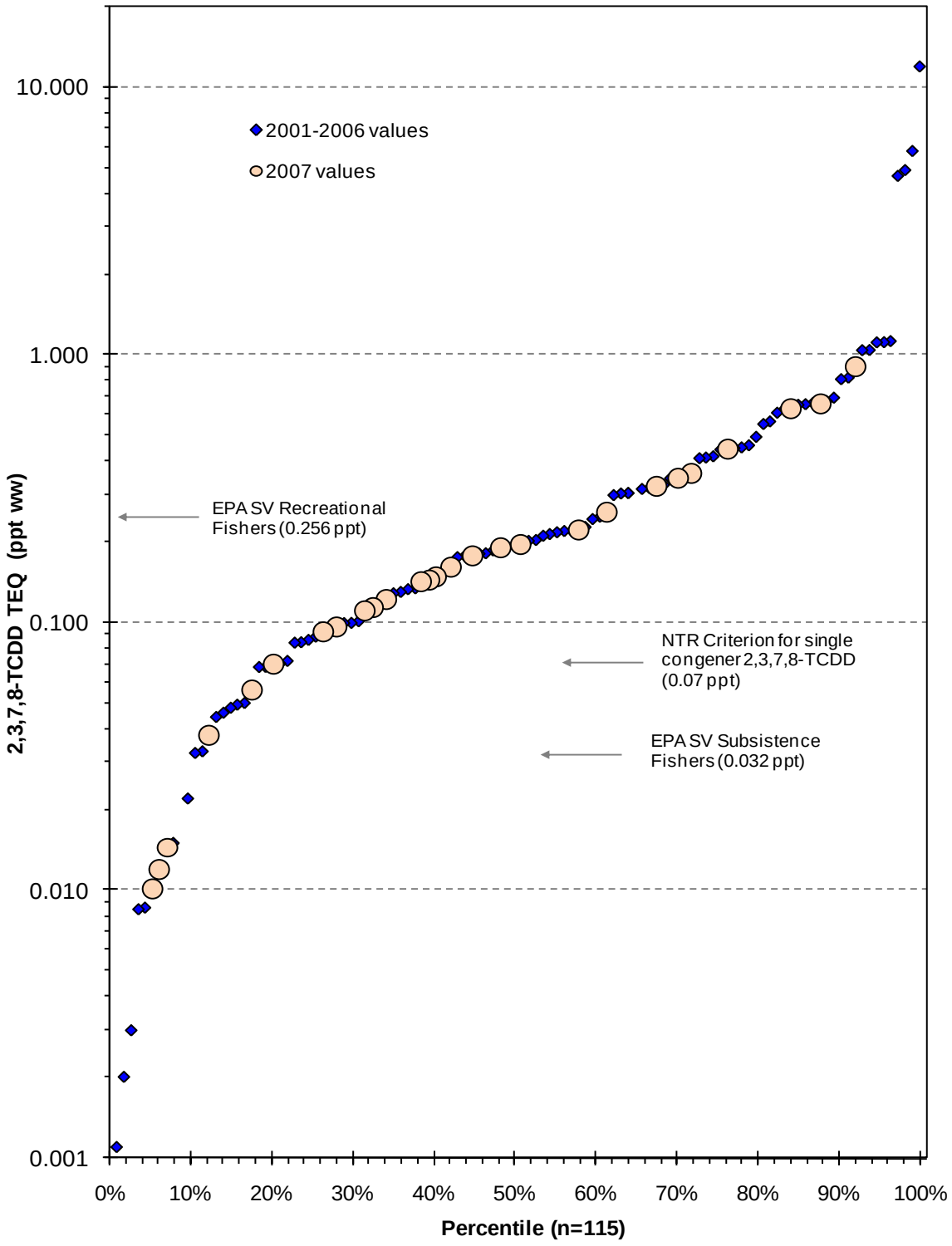

Figure 4. Distribution of 2,3,7,8-TCDD TEQ in Edible Fish Tissue, WSTMP 2001-2007.

Total chlordane was detected in only two samples: Sullivan Lake brown trout (1.3 ug/kg) and Samish Lake northern pikeminnow (1.1 ug/kg). Neither sample exceeded the NTR criterion of 8.3 ug/kg. However, technical grade chlordane was found at low levels (4.7-7.9 ug/kg) in three samples: Samish Lake northern pikeminnow and peamouth, and Sullivan Lake brown trout.

Regarding residues in fish tissue, total chlordane and technical grade chlordane can be considered synonymous based on descriptions by the Agency for Toxic Substances and Disease Registry (ASTDR, 1994) and EPA's Substance Registry System (EPA, 2008).

While technical chlordane is a complex mixture of over 100 individual chemicals, EPA (2000) recommends summing the concentrations of its major components and metabolites to yield a concentration called "total chlordane". The major components used in this summing are cis- and trans-chlordane, cis- and trans-nonachlor, and oxychlordane. These components have been target analytes and more consistently determined in fish tissue studies in Washington while technical grade chlordane has not. Ecology employs the total chlordane summing procedure to determine whether water quality standards are met (Ecology, 2006).

The only detection of hexachlorobenzene was in the cutthroat trout sample from Big Lake. The concentration of 8.3 ug/kg exceeded the NTR criterion of 6.7 ug/kg.

Dieldrin was found in two samples from the Samish River: cutthroat trout (0.46 ug/kg) and mountain whitefish (0.61 ug/kg). Both of these results were below the NTR criterion of 0.65 ug/kg.

Pentachloroanisole, a breakdown product of pentachlorophenol, was found in Samish Lake cutthroat trout (2.8 ug/kg) and peamouth (2.6 ug/kg). There are no regulatory criteria for Pentachloroanisole.

PBDE Flame Retardants

PBDEs were detected in 97% of fish tissue samples at low levels: all samples had less than 5 ug/kg total PBDEs. The highest levels of total PBDEs were in cutthroat trout from Samish Lake (4.3 ug/kg) and brown trout from Sullivan Lake (3.8 ug/kg). The remaining values were less than or equal to 3.5 ug/kg which is in the range of the median value of 2.8 ug/kg found during a survey of PBDEs in Washington (Johnson et al., 2006). The 2007 results were also in the lower 65% of all results for the WSTMP (Figure 5). About 80% of all WSTMP samples had PBDE levels below 10 ug/kg.

Comparisons to Historical Data

Only two sites sampled in 2007 had been studied in the past: Samish Lake and Lake Ozette. Two species from Samish Lake and one species from Lake Ozette can be compared.

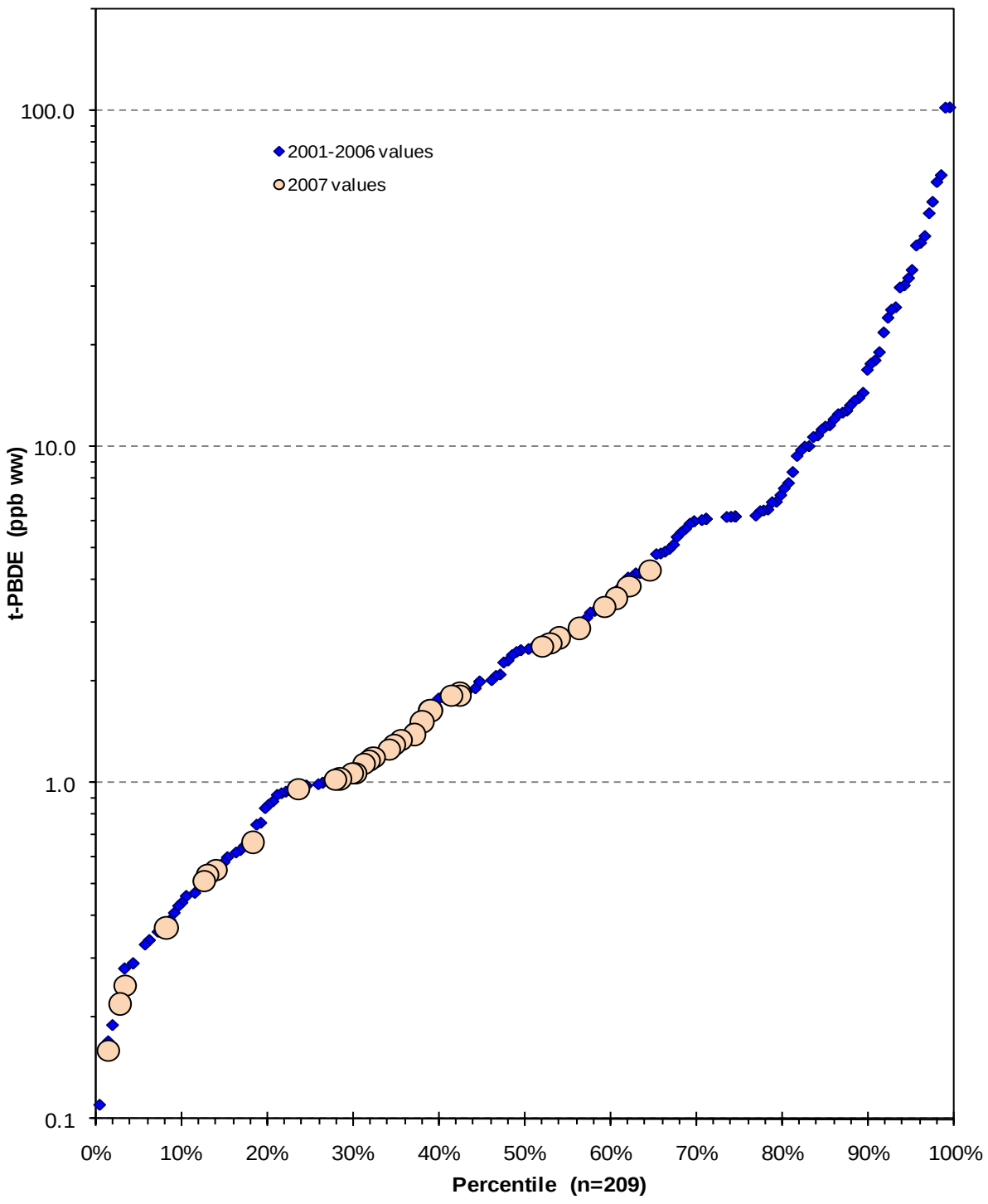

Figure 5. Distribution of Total PBDEs in Edible Fish Tissue, WSTMP 2001-2007.

Fish from Samish Lake were included in three studies: a statewide survey of 10 lakes in 1989 (Johnson and Norton, 1990); a statewide survey of mercury in fish (Fischnaller et al., 2003); and as part of the 2001 WSTMP (Seiders, 2003). Results from cutthroat trout samples from the 2001 and 2007 surveys are compared below. Changes in mercury levels in largemouth bass over time are discussed by Furl and Meredith (2008) as part of a statewide mercury trend monitoring effort. For Samish Lake, an insignificant difference (1%) was found in mercury levels between bass collected in 2003 and 2008.

Lake Ozette was initially sampled during the 2004 WSTMP (Seiders et al., 2007). While the 2007 sampling was part of a study to determine levels of PCBs and PCDD/Fs at "background" sites across the state (Johnson et al., 2007), the WSTMP analyzed one sample of northern pikeminnow for the same suite of contaminants that were analyzed in 2004. This additional analysis of a high trophic-level species should improve confidence in the data for this site within the Olympic National Park.

Differences in contaminant levels in samples can be influenced by many characteristics of the fish sampled, such as size, age, and lipid content. The greater the similarity among these factors, the stronger any comparison will be. Sample collection, preparation, and analytical methods were similar for all samples which also improves the comparability of results.

Tables 4 and 5 show that fish size, age, and lipids were similar between samples for each site. Samples were collected at nearly the same time during the season which helps negate any influence of seasonality that may affect contaminant levels. Levels of most contaminants were similar between years. Differences in levels are generally within the variability seen among field and laboratory duplicate samples. Yet fish from Lake Ozette showed larger differences in mercury and PCDD/Fs levels.

Mercury levels in both Lake Ozette samples were among the highest seen in Washington. The 2007 sample result (1600 ppb) is more than twice that of the 2004 result (724 ppb). This difference is likely due in part to the 2007 fish being about 20% older than those from 2004. Other reasons for the difference could be sampling variability and a real increase in mercury accumulation in Lake Ozette fish. In 2008, Lake Ozette was added to Ecology's effort to examine trends in mercury levels in fish, primarily largemouth bass (Furl and Meredith, 2008). Future sampling under the trends monitoring effort will provide more information about changes in mercury levels at Lake Ozette.

The 2,3,7,8-TCDD TEQ result for the 2004 sample is nearly 20 times higher than that for the 2007 sample. This difference is most likely due to changes in analytical detection limits and reporting practices between years rather than differences in the environment. For example, results for individual congeners that were near detection limits and reported as estimates may not be very accurate. Even so, such values were included in calculating the 2,3,7,8-TCDD TEQ.

Table 4. Comparison of Historical to Recent Fish Tissue Data from Samish Lake.

Parameter	2001 Sample	2007 Sample
Collection Date	9/11/01	9/4/07
Mean Total Length (mm)	291.0	271.6
Mean Weight (g)	213.0	179.6
Mean Age (years)	2.4	2.0
Lipids (%)	2.1	1.9
Total PCB aroclors (ug/kg)	13.1	8.2
Total PBDE (ug/kg)	2.9	3.7 A
T-DDT (ug/kg)	5.0	2.9
Total Chlordane (ug/kg)	2.0	0.98 U
Pentachloroanisole	0.58	2.8 J
MEL Sample ID	02088428	07494507
No. fish/composite	10	5

A Only the same congeners that were analyzed in 2001 were used to calculate this value.
J The analyte was positively identified. The associated numerical result is an estimate.
U The analyte was not detected at or above the reported result.

Table 5. Comparison of Historical to Recent Fish Tissue Data from Lake Ozette.

Parameter	2004 Sample	2007 Sample
Collection Date	10/6/04	9/12/07
Mean Total Length (mm)	371.3	377.2
Mean Weight (g)	463.5	433.2
Mean Age (years)	7.2	9.0
Lipids (%)	0.91	0.81
Total PCB aroclors (ug/kg)	5.0 U	1.7 J
Total PCB congeners (ug/kg)	0.91	1.4 J
T-DDT (ug/kg)	0.57	1.4
2378 TCDD TEQ (ng/kg)	0.195	0.010 J
2378 TCDD (ng/kg)	0.03 UJ	0.033 UJ
Mercury (ug/kg; EPA 245.6)	724	1600
MEL Sample ID	05084304	07494503
No. fish/composite	10	5

J = The analyte was positively identified. The associated numerical result is an estimate.
U = The analyte was not detected at or above the reported result.
UJ = The analyte was not detected at or above the reported estimated result.

Water Quality Standards Exceeded

Six of the 16 sites had fish tissue that did not meet one or more NTR criteria. Total PCBs and 2,3,7,8-TCDD accounted for 81% of these exceedances. The other exceedances were due to hexachlorobenzene and mercury. Table 6 shows the 11 cases from six sites recommended for Category 5 classification, *Does Not Meet Criteria*, in Ecology's 303(d) assessment method (Ecology, 2006).

A total of 12 sites had fish where 2,3,7,8-TCDD TEQ levels exceeded the NTR criterion for the single congener 2,3,7,8-TCDD (0.07 ppt). Ecology recently changed how dioxin/furan data are used for the 303(d) assessment method. Prior to Ecology documenting the assessment method (Ecology 2006), TEQ values were used in classifying waters as Category 5, which is the 303(d) list. Currently, when TEQ values exceed the NTR criterion for the single congener 2,3,7, 8-TCDD, the site is classified as Category 2. So, 12 cases are recommended for Category 2 classification, *Waters of Concern* (Table 6, last column on right).

Twenty-six sample analyses for aldrin, dieldrin, heptachlor epoxide, and toxaphene could not be compared to NTR criteria because the analyte was not detected at reporting limits that were greater than the respective criteria. These cases are recommended for a category 3 classification, *Lack of Sufficient Data*. The remaining results (n=822) that met NTR criteria are recommended for Category 1 classification, *Meets Tested Criteria*.

Table 6. Recommended 303(d) Listings for Fish Tissue Sample Results, WSTMP 2007.

Recommended Category for 303(d) Assessment -->			5				2
Site Name	Species Exceeding NTR Criteria	Sum of Recommended Category 5 Listings	Total PCBs	2,3,7,8-TCDD	Hexachloro-benzene	Mercury	2,3,7,8-TCDD TEQ
Baker Lake	RBT, CTT						x
Big Lake	CTT, LMB	3	x	x	x		x
Campbell Lake	LMB, CTT	2	x	x			x
Cushman Lake	KOK						x
Deer Lake	LMB, RBT						x
Kettle River	RBT						x
Ozette Lake	NPM	1				x	
Samish Lake	CTT, NPM, LMB, PEA	2	x	x			x
Samish River	CTT, MWF	1	x				x
Sanpoil River	RBT						x
Sauk River	MWF						x
Spada Lake	CTT						x
Sullivan Lake	BNT, CTT, MWF, RBT	2	x	x			x
Count of Recommended Category 5 Listings:		11	5	4	1	1	
Percent of Recommended Category 5 Listings:			45%	36%	9%	9%	
Count of Recommended Category 2 Listings:							12

Species Codes: CTT = Cutthroat trout, KOK = Kokanee salmon, LMB = Largemouth bass, NPM = Northern pikeminnow, PEA = Peamouth, RBT = Rainbow trout, BNT = Brown trout, MWF = Mountain whitefish.

Site Scoring and Ranking

In order to compare results across many species and sites, a scoring and ranking method was used. The scoring method used results for key contaminants that had high frequencies of detection and/or exceeded their respective benchmark values (described below). The sample and site scores give an overall picture of how far contaminant levels in fish are above benchmark values.

This scoring and ranking was applied only to sites sampled by the WSTMP from 2001 through 2007. Scoring and ranking results from other fish tissue studies conducted in Washington to gain a broader perspective is beyond the scope of this project's reporting effort.

Scoring

Contaminant scores were developed for each sample, then for each site. For samples, levels of contaminants in each sample were divided by a benchmark value which produced a ratio of the contaminant concentration in the sample to the benchmark value. These ratios show whether individual contaminants are higher or lower than the benchmark values and by how much. The ratios for each contaminant were then summed to give a sample contaminant score. Finally, site contaminant scores were derived by averaging the sample contaminant scores from each site.

Table 7 shows the benchmark values used and the contaminant scores generated for two samples from one site. The benchmark values used were the NTR criteria or other value as described in the table's footnotes. Where results were qualified as non-detects, the reporting limit was used.

Table 7. Example Calculation of Contaminant Scores for Samples and Sites Using the Campbell Lake Site near Anacortes, WSTMP 2007.

Contaminant [1]	Benchmark Value [2]	Sample Result Value				Benchmark Exceedance Factor	
		CTT		LMB		CTT	LMB
Total PCB Aroclors	5.3	3.6	J	7.4	J	0.7	1.4
Total DDT [3]	32	1.2		2.4		0.0	0.1
Total PBDE [4]	31.0	1.25		2.55	J	0.0	0.1
Total Chlordane	8.3	0.87	U	0.86	U	0.1	0.1
2,3,7,8-TCDD TEQ [5]	0.07	0.325	J	0.365	J	4.6	5.2
Mercury	825	44		603		0.1	0.7
Dieldrin	0.65	0.7	U	0.34	U	1.1	0.5
Sample Contaminant Score:						6.6	8.1
Site Contaminant Score: [6]						7.4	

1. Species Codes: CTT- Cutthroat trout, LMB - Largemouth bass.
2. Values in parts per billion wet weight (ug/kg ww) unless otherwise noted.
3. Benchmark values are NTR criteria unless noted otherwise.
4. Benchmark value is the NTR criterion for both 4,4'-DDE and 4,4'-DDT, the compounds which usually contribute the most to the total DDT value
5. There are no NTR criteria for PBDEs. The benchmark value is the 90th percentile from a statewide study of PBDEs (Johnson et al., 2006).
6. Benchmark value is the NTR criterion for the single congener 2,3,7,8-TCDD. The TEQ value is used for contaminant scoring purposes because it represents all dioxins and furan congeners. Values in parts per trillion (ng/kg ww).
7. The site contaminant score is the mean of the sample contaminant scores from that site.

U = The analyte was not detected at or above the reported result.
J = The analyte was positively identified. The associated numerical result is an estimate.

For site contaminant scoring, sample results for some areas were consolidated to represent one site. For example, sample results from Lake Washington were associated with three areas (north, south, and entire lake) so samples from these areas were combined to represent Lake Washington as a single site. Similarly, samples from four areas along the Spokane River between river miles 64 and 85 were combined to represent the Spokane River as a single site. Other consolidations were for sites on the Wenatchee and Palouse Rivers.

Overall, the 2007 sample contaminant scores were in the lower range of all scores from the 2001 through 2007 samples. The lowest contaminant scores for 2007 were for Cushman Lake rainbow trout (1.0) and Big Lake yellow perch (1.0). These samples did not exceed any benchmark values. The highest contaminant scores were for Samish Lake northern pikeminnow (17.1) and Sullivan Lake brown trout (17.8) where benchmark values were exceeded for three of the seven key contaminants.

The median score for all 2007 samples was 3.5. As in previous years, PCBs and 2,3,7,8-TCDD TEQ contributed most to these scores. For example, the Samish Lake northern pikeminnow sample had a 2,3,7,8-TCDD TEQ level which exceeded the benchmark value of 0.07 ng/kg by a factor of 13, accounting for about 75% of that sample's contaminant score of 17.1. The PCB level in this same sample accounted for nearly 14% of the contaminant score.

Ranking

Site contaminant scores were ranked from high to low to show the relative amount of contamination in fish from sampled sites. Figure 6 shows site contaminant scores for the 2001-2007 results with the 2007 sites identified. Site contaminant scores ranged from 1.8 (Aldwell Lake) to 7.4 (Campbell Lake) with the median score being 3.7. Thirteen of the 16 sites had at least one sample that exceeded NTR criteria as described earlier and shown in Table 6.

Overall, the 2007 site contaminant scores were in the lower half of the ranking for all 2004-2006 sites except for Campbell, Sullivan, Samish, and Big Lakes. These four sites ranked in the 55th to 63rd percentile of all sites sampled from 2001-2007. The species from these four sites that had higher levels of contamination included cutthroat trout, largemouth bass, brown trout, and northern pikeminnow. These four sites were near urbanized areas or had older fish that were sampled.

The site ranking presented here was done using PCDD/F data in scoring, although only about half of the samples were analyzed for PCDD/Fs. Sites were also scored without using PCDD/F data to see how much scores would change. The scores for 90% of all sites changed by no more than 5 points when PCDD/F data were excluded which is a minor effect on overall scores. While the effect on ranking was more pronounced, the general pattern of ranking for the majority of sites changed little.

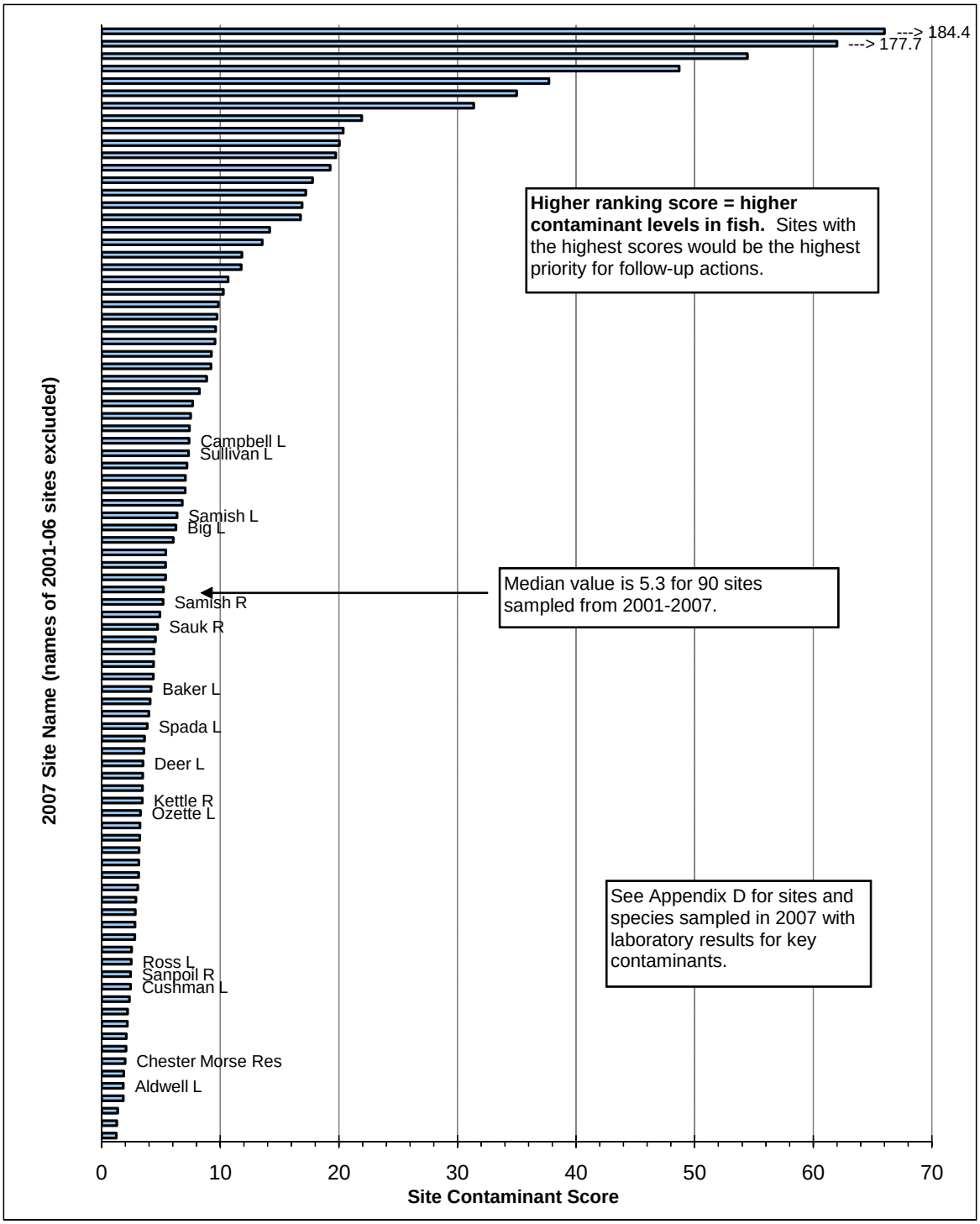

Figure 6. Site Ranking for Fish Tissue Results, WSTMP 2001-2007.

Conclusions and Recommendations

Conclusions

During 2007, PCBs, dioxin/furans, chlorinated pesticides, PBDE flame retardants, and mercury were frequently detected in 35 samples of fish from 16 lakes and rivers across Washington State.

A total of 10 of the 35 samples, from six of the 16 lakes, did not meet Washington State water quality standards for contaminants in fish tissue. Total PCBs and 2,3,7,8-TCDD accounted for most of these exceedances. Other contaminants exceeding water quality standards were mercury and hexachlorobenzene.

Overall, the 2007 site contaminant scores ranked in the lower half of all sites sampled between 2001 and 2007 for the WSTMP except for Campbell, Sullivan, Samish, and Big Lakes. These four sites ranked in the 55th to 63rd percentile of all sites sampled from 2001-2007. These four sites were near urbanized areas or had older and larger fish that were sampled.

Levels of mercury and 2,3,7,8-TCDD TEQ in the 2007 samples has a wide spread of values which was representative of all sample results from 2001-2007. Northern pikeminnow from Lake Ozette had the highest level of mercury found at WSTMP sites since 2001. Levels of PCBs and PBDEs in the 2007 samples were in the low to median range of all WSTMP samples since 2001.

Bull trout from Ross Lake were sampled in 2007, representing the first known case of this species being analyzed for contaminants in Washington. Contaminant levels in this bull trout sample were generally low except for mercury, which was among the highest level found in trout species collected thus far in Washington.

Recommendations

Because the WSTMP is a screening-level assessment only, the Washington State Department of Health, local health jurisdictions, and affected tribes should evaluate the need for more detailed assessment of risks to human health from the consumption of contaminated fish. The initial focus should be on the six sites where contaminant levels did not meet the NTR criteria (Category 5 sites in Table 6).

Ecology should determine what follow-up actions to take for the most contaminated sites identified in 2007: Campbell, Sullivan, Samish, and Big Lakes. Levels of PCBs and TCDD in fish from these sites were the main chemicals of concern.

Ecology should review the tissue data from the 13 lakes and rivers listed in Table 6 for placement of these sites in Categories 5 and 2 of Washington State's 303(d) assessment. Other results from this 2007 sampling effort should be reviewed and the remaining three lakes placed in Categories 1 and 3 of the 303(d) assessment.

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Appendices

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Appendix A. Site and Species Sampled: WSTMP 2007

Table A-1. Site and Species Sampled: WSTMP 2007.

Sample Site	County	WRIA	Species Sampled	Longitude	Latitude	WBID
Aldwell Lake	Clallam	18	BKT, RBT	-123.5730	48.0781	WA-18-9010
Baker Lake	Whatcom	4	CTT, RBT	-121.6555	48.7218	WA-04-9010
Big Lake	Skagit	3	CTT, LMB, YP	-122.2300	48.3792	WA-03-9020
Campbell Lake	Skagit	3	CTT, LMB	-122.6211	48.4390	WA-03-9040
Chester Morse Reservoir	King	8	RBT	-121.6979	47.3861	WA-08-9060
Cushman Lake	Mason	16	KOK, MWF, RBT, SS	-123.2240	47.4501	WA-16-9010
Deer Lake	Stevens	59	LMB, RBT	-117.5881	48.1116	WA-59-9040
Kettle River	Ferry	60	RBT	-118.5996	48.8884	WA-60-1020
Ozette Lake	Clallam	20	NPM	-124.6338	48.0967	WA-20-9040
Ross Lake	Whatcom	4	BLT, RBT, RSS	-121.0417	48.8333	WA-04-9180
Samish Lake	Whatcom	3	CTT, LMB, NPM, PEA, YP	-122.3861	48.6666	WA-03-9160
Samish River	Skagit	3	CTT, MWF	-122.2900	48.5571	WA-03-2010
Sanpoil River	Ferry	52	BKT, RBT	-118.7477	48.5442	WA-52-1010
Sauk River	Skagit	4	MWF	-121.3881	48.0987	WA-04-1080
Spada Lake	Snohomish	7	CTT	-121.6500	47.9700	WA-07-9710
Sullivan Lake	Pend Oreille	62	BNT, CTT, MWF, RBT	-117.2900	48.8000	WA-62-9190

WRIA = Water Resource Inventory Area.
WBID = Ecology's Water Body Identification Number (WBID).
Latitude and longitude coordinates datum is NAD 83 HARN.
Species Codes: BLT = Bull trout, BNT = Brown trout, BKT = Brook trout, CTT = Cutthroat trout, KOK = Kokanee salmon, LMB = Largemouth bass, MWF = Mountain whitefish, NPM = Northern pikeminnow, PEA = Peamouth, RBT = Rainbow trout, RSS = Redside shiner (whole fish), SS = Salish sucker, YP = Yellow perch

Appendix B. Data Quality Assessment

Data quality was assessed by reviewing laboratory case narratives, analytical results, and field replicate data. Case narratives were written by Manchester Laboratory (MEL) analytical staff. The narratives described the condition of samples upon receipt, analytical quality control (QC) procedures, and data qualifications. Quality control (QC) procedures included analysis of method blanks, calibration and control standards, matrix spikes, matrix spike duplicates, surrogate recoveries, and laboratory and field duplicates.

Lab duplicate samples were created at the analytical lab by splitting the tissue sample that was sent to them and analyzing each split. Field duplicate samples consisted of two samples that were created from different, yet similar-sized, fish of the same species collected from the same site at the same time. Individual fish were assigned to the two composite samples randomly.

Overall, the 2007 data met most quality control (QC) criteria defined by MEL and the Quality Assurance Project Plan. Initial analyses for PCB aroclors did not meet reporting limits, so samples were re-analyzed and met the desired reporting limits. No other data were rejected or re-analyzed. Some data were qualified due to challenges encountered in analyses. Estimates of precision appear typical for samples of fish tissue. All results are usable for this project as qualified. Table B1 summarizes results from quality control (QC) and quality assurance procedures while data quality for selected parameters is discussed below.

Standard Reference Materials (SRM) were analyzed to help evaluate analytical accuracy. The SRM 1946 (Lake Superior Fish Tissue) from the National Institute of Standards and Technology was analyzed for mercury, chlorinated pesticides, and PCB Aroclors. The SRM "Carp-2" (carp from Saginaw Bay, Lake Huron) obtained from the National Research Council of Canada was analyzed for dioxin/furan analysis and PCB congeners. Discussion of SRM results are included below.

Mercury, Chlorinated Pesticides, PCB Aroclors, PBDEs, and Lipids

Results of two SRM analyses for mercury were 7% and 12%, which are outside the 95% confidence interval (CI) of 2.1%. Results of SRM analyses for 16 chlorinated pesticides had 22 results (71%) outside the SRM's approximate 95% CI. These 22 results ranged from 2% - 276% outside the CI. The remaining 9 results (29%) were within the desired CI. Overall, results suggest that analytical accuracy was moderate to poor for chlorinated pesticides while accuracy for mercury was moderate.

Several target analytes were detected in two sets of lab and field duplicate samples. Estimates of precision based on the small number of results met requirements of the lab and the QA Project Plan, so analytical and sampling precision was deemed adequate.

Estimates of precision for lipids analyses were mixed. Two sets of lab duplicates by MEL had very good precision with relative percent differences (RPDs) of 1% and 4%. Three sets of lab duplicates by the contract lab Pace Analytical, Inc. were poor with RPDs of 68% to 148%. Inter-

laboratory analyses of 28 samples yielded poor to moderate precision in most cases, with RPDs ranging from 5% to 130%. Differences in analytical methods and the extraction solvents used by the different labs likely contribute to poor inter-laboratory precision.

PCB Congeners

Fourteen results for seven PCB congeners were within the SRM's approximate 95% CI of the certified or reference values. These results suggest good analytical accuracy at concentrations in the SRM. Concentrations of the PCB congener in the SRM are one to two orders of magnitude greater than concentrations found in the 2007 fish tissue samples.

Precision as determined through two lab and one field duplicate analyses was moderate to good. Interestingly, where field and lab duplicate analyses were done on the same samples, the field duplicate had better precision than the lab duplicate.

Dioxins and Furans

Sample analysis experienced difficulties that resulted in heavily qualified data with reporting limits being higher than desired. Technical issues with the initial and second extractions led to the use of results from the two different extractions. Some results were also affected by interfering substances or target analytes being found in blanks. Detections that were above the Limit of Detection (LOD) yet below the Estimated Quantitation Limit (EQL) were qualified as estimates at request of the project manager: 56% of results fell within this range while 43% of results were qualified as not detected. Less than 2% of results had no qualifiers attached.

Precision as determined through lab and field duplicate analyses was generally poor due to so many result values reported between the EQL and LOD. Table B1 summarizes other QA/QC characteristics of this data set.

Fifteen results for nine dioxins/furans had seven results that were slightly outside the SRM's approximate 95% CI. The remaining eight results were within the desired CI. Three results were qualified as not-detected yet two of the reporting limits for these were outside the 95% CI of the SRM. Overall, results suggest moderate to good analytical accuracy for dioxin/furans at the concentrations in the SRM. This SRM has concentrations that are one or more orders of magnitude greater than concentrations typically found in the 2007 samples. An SRM with lower concentrations would be more useful in evaluating analytical accuracy at levels typically found in fish tissue samples from Washington.

Table B1. Summary of Quality Assurance/Quality Control Specifications and Data Review Findings, WSTMP 2007.

Parameter	Analytical Method	Holding Time	Calibrations	Blanks	Reporting Limits [a]	Lab Dup (RPD)	Field Dup (RSD)	LCS (% recovery)	Surrogates (% recovery)	MS/MSD (% recovery)	Overall Decision
Mercury											
Finding	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	NA	Acceptable	Acceptable
QAPP or PSN specification	EPA 245.6 (CVAA) [b]	6 months [c]	NS	NS	17 ug/kg	NS	0%-14%	NS	NA	NS	-
LAB specification	EPA 245.6 (CVAA)	NS	See Method	g	17 ug/kg	0%-20%	NS	85%-115%	NA	75%-125%; RPD limits 0%-20%	-
Chlorinated pesticides											
Finding	Acceptable	Acceptable	Acceptable [n]	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable [p]	Acceptable	Acceptable [r]	Acceptable
QAPP or PSN specification	EPA 8081 (GC/ECD); MEL SOP*	1 year	NS	NS	most 0.5-2.0 ug/kg	NS	0%-28%	NS	NS	NS	-
LAB specification	SW 8081 & 8082 (GC/ECD)	1 year	See Method	g	ae	0%-40% [o]	NS	50%-150%	50%-150%	50%-150%; RPD limits 0%-40%	-
PBDEs											
Finding	Acceptable	Acceptable	Acceptable	Acceptable [h]	Acceptable [i]	Acceptable [k]	Acceptable [L]	Acceptable	Acceptable [v]	Acceptable	Acceptable
QAPP or PSN specification	EPA 8270 (SIM); MEL SOP*	1 year	NS	NS	0.5-1.0 ug/kg [f]	NS	0%-28%	NS	NS	NS	-
LAB specification	EPA 8270 (SIM); SOP 730104	1 year [d]	See Method	h	0.10-2.6 ug/kg; PBDE 209 2.6-28 ug/kg	0%-40%	NS	50%-150%	50%-150%	50%-150%; RPD limits 0%-40% [e]	-
PCB Aroclors											
Finding	Acceptable	Acceptable	Acceptable [m]	Acceptable	Acceptable [t]	Acceptable	Acceptable	Acceptable	Acceptable [u]	Acceptable	Acceptable
QAPP or PSN	EPA 8082 (GC/ECD); MEL SOP*	1 year	NS	NS	1.0 ug/kg	NS	0%-28%	NS	NS	NS	-
LAB specification	SW 8082 (GC/ECD)	1 year	See Method	g	0.92-15 ug/kg	0%-40%	NS	50%-150%	50%-150%	50%-150%; RPD limits 0%-40%	-

Parameter	Analytical Method	Holding Time	Calibrations	Blanks	Reporting Limits [a]	Lab Dup (RPD)	Field Dup (RSD)	LCS (% recovery)	Surrogates (% recovery)	MS/MSD (% recovery)	Overall Decision
PCB Congener											
Finding	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable [af]	Acceptable [ag]	Acceptable	NA	NA	Acceptable
QAPP or PSN specification	EPA 1668A (HiRes GC/MS)	NS	NS	NS	0.02-0.08 ug/kg	NS	NS	NS	NA	NA	-
LAB specification	EPA 1668A (HiRes GC/MS)	1 year	See Method	w	0.05-1.2 ug/kg	NS	NS	z, ab, ac	NA	NA	-
PCDD/Fs (17 congeners)											
Finding	Acceptable	Acceptable	Acceptable	Acceptable	Not Achieved	Acceptable [aa]	Acceptable [aa]	Acceptable [x,y,z]	NA	NA	Acceptable
QAPP or PSN	EPA 1613B (HiRes GC/MS)	1 year	NS	NS	0.05-0.30 ng/kg	NS	0%-28%	NS	NA	NA	-
LAB specification	EPA 1613B (HiRes GC/MS)	NS	See Method	w	EQL 1 -10 ng/kg	NS	NS	See Method	NA	NA	-
Lipids											
Finding	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable [s]	NS	NA	NA	Acceptable
QAPP or PSN specification	MEL SOP 730009	1 year	NS	NS	0.1%	NS	0%-14%	NS	NA	NA	-
LAB specification	MEL SOP 730009	NS	See Method	g	0.01%	0%-20%	NS	NS	NA	NA	-

Notes:

Abbreviations: NS - Not Specified, NA - Not Applicable, QAPP - Quality Assurance Project Plan, RPD - Relative Percent Difference, RSD - Relative Standard Deviation, MS/MSD - Matrix Spike and MS Duplicate.

Data Qualifiers: J - estimated value, NJ - target analyte tentatively identified at estimated value, E - estimate because value outside calibration range, U - not detected at reported result or estimated ("UJ") result.

PSN = Pre Sample Notification. This is an annual correspondence to MEL, prior to sample delivery, updating and describing analytical needs such as methods, reporting limits, and sample processing.

* - MEL modifications to analytical methods are documented in their Standard Operating Procedures.

a - The value given in the "Lab" row is the Reporting Limit achieved by the lab.

b - EPA method 245.5 was used for WSTMP samples from 2001-2003. EPA Method 245.6 has been used once 2004.
c - Holding time of six months was established for WSTMP fish tissue in 2002, after determining that 28-day holding time for tissue was unnecessary.
d - Case narrative: All samples remained frozen until thawed. All samples were analyzed within the required 40 days from extraction.
e - 1 of 26 matrix spike recoveries was above acceptance limits, PBDE 209.
f - Reporting limit for all congeners except PBDE 209 which is 1-6 ug/kg.
g - Case narrative: No analytically significant levels of analyte were detected in the method blanks associated with these samples.
h - No target compounds were detected in method blanks, with the exception of PBDE 209.
i - PBDE 209 in twelve of thirty nine samples had reporting limits of 8-28 ug/kg due to blank contamination.
k - All RPD limits within range except PBDE 49 in one sample which had RPD of 49%.
L - 5 of 6 within QAPP RSD limits. PBDE 49 in one sample had an RSD of 54%.
m - All PCB aroclors were recovered within acceptance limits of 85%-115%, with the exception of PCB aroclor 1016.
n - The following analytes did not meet acceptable independent calibration verifications (ICV) and/or continuing calibration verification (CCV) standards. These samples have been qualified as estimated reporting limits "UJ", or estimated detection limits "J" in some samples. Toxaphene, Hexachlorobenzene, Endosulfan Sulfate, Methoxychlor, Endrin Aldehyde, and Endosulfan II.
o - All RPDs were within acceptable limits except sample 07494518 technical chlordane with RPD of 51%, these results were qualified as "J".
p - Recoveries all within acceptable limits. Because of interference from other analytes, the recovery of DDMU was not calculated, "NC".
r - All matrix spike recoveries were within acceptable limits except chlorpyrifos and endrin aldehyde. Due to interference from analytes DDMU was not calculated "NC".
s - RSDs achieved were 30-33%. High RSDs likely due to differences in fish used for field duplicate samples. Lab dup RSDs were very good, less than or equal to 3%.
t - Reporting limits not met with initial analysis. Samples were reanalyzed and RLs were met.
u - All surrogate recoveries were within acceptable limits, except 8 of the 39 samples which were qualified "J" due to high recoveries (153%-166%) - Aroclor 1254 & 1260.
v - All surrogate recoveries were within acceptable limits except one sample which had a low recovery (30%). All results for this sample were qualified as estimates.
w - Few target analytes detected in blanks resulting in some qualifications of data
x - QC limits for Internal Standard recoveries not met in some cases leading to re-analyses of some samples and qualification of some data.
y - On-going Precision and Recovery (OPR) and LCS within limits with few exceptions resulting in qualification of some data and possible bias.
z - Ion Abundance Ratios and Retention Time Criteria were met with few exceptions resulting in qualification of some data.
aa - RPDs achieved for lab dups were 14%-171%. RSDs achieved for field dups were 25-130%. Results were heavily qualified due to being below range of calibration; poor precision is reasonable.
ab - OPR recoveries within QC limits of 50-100%. Labeled compound recoveries within QC limits of 30-140%.
ac - Internal Standard recoveries within QC limits of 25-150% except several above 150% which were qualified "J" as estimates.
ad - Values for "Lab" reflect the reporting limits that were actually achieved.
ae - Most analytes 0.34-3.4 ug/kg; Chlordane (technical) 3.4-7.8 ug/kg ; Hexachlorobenzene 3.4-4.6 ug/kg; Toxaphene 3.7-20 ug/kg.
af - RPDs achieved were 3%-117%.
ag - RSDs achieved were 0%-59%.

Appendix C. Data Evaluation by Ecology and DOH

Several state and federal agencies collect and evaluate fish tissue data in Washington State. These include the Washington State Departments of Ecology, Health (DOH), and Fish and Wildlife; the U.S. Environmental Protection Agency; and the U.S. Geological Survey. Tissue data are evaluated differently by these agencies because their mandates and roles are varied. These multiple evaluations often lead to confusion and misunderstanding among agencies and the public on how fish tissue data are used and interpreted. Adding to potential confusion are the numerous criteria or screening values derived to provide guidance for determining the risks of consuming contaminated fish and protecting public health.

Most fish tissue contaminant data from Washington fish, regardless of who conducted the study, make their way to DOH for evaluation regarding the safety of consuming fish. Appendix E has information about health benefits of eating fish and potential risks from consuming contaminated fish. The following is an overview of how Ecology and DOH evaluate fish tissue data to meet different needs.

For the WSTMP and many other Ecology studies, fish tissue data are evaluated primarily to determine if (1) Washington State water quality standards are being met, and (2) potential risks to human health from consuming contaminated fish warrant further study and/or development of a fish consumption advisory. Ecology's role is to determine whether water quality standards are met and to begin the process to correct problems where standards are not met. DOH and local health departments are responsible for developing fish consumption advisories in Washington. There is some overlap in these evaluations because the water quality standards that fish tissue data are compared to were developed for the protection of human health.

Washington State Water Quality Standards

Washington's water quality standards criteria for toxic contaminants were issued to the state in EPA's 1992 National Toxics Rule (NTR) (40CFR131.36). The human health-based NTR criteria are designed to minimize the risk of effects occurring to humans from chronic (lifetime) exposure to substances through the ingestion of drinking water and consumption of fish obtained from surface waters. *The NTR criteria, if met, will generally ensure that public health concerns do not arise, and that fish advisories are not needed.*

The NTR criteria are thresholds that, when exceeded, may lead to regulatory action. When water quality criteria are not met (exceeded), the federal Clean Water Act requires that the waterbody be put on a list and that a water cleanup plan be developed for the pollutant causing the problem. This list is known as the 303(d) list, and the water cleanup plan results from a Total Maximum Daily Load (TMDL) study and public involvement process. Ecology uses the TMDL program to control sources of the particular pollutant in order to bring the waterbody back into compliance with the water quality standards.

Risk Management Decisions

While DOH supports Ecology's use of the NTR criteria for identifying problems and controlling pollutant sources so that water quality will meet standards, DOH does not use the NTR criteria to establish fish consumption advisories (McBride, 2006). DOH uses an approach similar to that in EPA's *Guidance for Assessing Chemical Contaminant Data for use in Fish Advisories Vol. 1-4* for assessing mercury, PCBs, and other contaminants (EPA, 2000). These guidance documents provide a framework from which states can evaluate fish tissue data to develop fish consumption advisories. The framework is based on sound science and established procedures in risk assessment, risk management, and risk communication. Neither the NTR criteria, nor the screening values found in the EPA guidance documents above, incorporate the varied risk management decisions essential to developing fish consumption advisories.

- **Risk Assessment** involves calculating allowable meal limits based on known fish contaminant concentrations. These calculations are conducted for both non-cancer and cancer endpoints using the appropriate Reference Dose (RfD) or Cancer Slope Factor (CSF), if available. These initial calculations are the starting point for evaluating contaminant data to determine whether a fish advisory is warranted. Additionally, known or estimated fish consumption rates help determine the potential magnitude of exposure and highlight the sensitive groups or populations that may exist due to elevated consumption rates.

- **Risk Management** includes (but is not limited to) consideration of contaminant background concentrations, reduction in contaminant concentrations through preparation and cooking techniques, known health benefits from fish consumption, contaminant concentrations or health risks associated with replacement foods, and cultural importance of fish. Other considerations are the possible health endpoints associated with a contaminant, the strength or weaknesses of the supporting toxicological or sampling data, and whether effects are transient or irreversible.

- **Risk Communication** is the outreach component of the fish advisory. The interpretation of the data from the risk assessment and risk management components drives how and when the fish advisory recommendations are issued to the public, dependent on whether the message is targeted toward a sensitive group or a population or the general public. DOH's dual objective is (1) how best to provide guidance to the public to increase fish consumption of fish low in contaminants to gain the benefits of eating fish, while (2) steering the public away from fish that have high levels of health-damaging contaminants.

Appendix D. Summary of Results, WSTMP 2007

Table D1. Summary of Fish Tissue Sample Results, WSTMP 2007.

Site	Species Code	MEL Sample ID	Date collect	Total PCB aroclors (ug/kg)		Total PCB congeners (ug/kg)		Total PBDE (ug/kg)		Total DDT (ug/kg)		Total Chlordane (ug/kg)		Dieldrin (ug/kg)		2378 TCDD TEQ (ng/kg)		2378 TCDD (ng/kg)		Mercury 245.6 (ug/kg)		Lipids (%)		Mean Total Length (mm)		Mean Weight (g)		Mean Age (years)	
Aldwell Lake	BKT	07494543	10/10/07	4.7	J	na		0.96		0.93	U	0.93	U	0.37	U	na		na		181		0.58		319.6		331.0		3.0	
	RBT	07494544/4532	10/10/07	3.95	J,m	1.98	J	0.67	m	0.97	U,m	0.97	U,m	0.39	U,m	0.012	J	0.02	UJ	101.5	m	1.14	m	306.2	m	272.8	m	2.6	m
Baker Lake	CTT	07494512	10/9/07	0.98	U	1.16	J	0.55	J	0.95	U	0.95	U	0.38	U	0.092	J	0.031	UJ	100		1.26		235.4		121.0		2.2	
	RBT	07494511	10/9/07	0.98	U	0.91	J	0.37	J	0.96	U	0.96	U	0.38	U	0.350	J	0.063	NJ	41		1.48		215.0		103.0		1.0	
Big Lake, near Mt. Vernon	CTT	07494527	9/6/07	7	J	6.04	J	1.39		3.5		0.91	U	0.37	U	0.665	J	0.099	J	130		1.64		317.0		292.0		3.0	
	LMB	07494528	9/6/07	3.1		3.27	J	1.07		0.93	U	0.93	U	0.37	U	0.261	J	0.06	J	754		0.44		449.2		1542.6		10.4	
	YP	07494529	9/6/07	0.99	U	na		0.22		0.97	U	0.97	U	0.39	U	na		na		83		0.26		190.4		103.2		1.2	
Campbell Lake, near Anacortes	CTT	07494530	9/5/07	3.6	J	3.14	J	1.25		1.2		0.87	U	0.7	U	0.325	J	0.065	NJ	44		4.41		342.4		469.6		2.0	
	LMB	07494531	9/5/07	7.4	J	7.69	J	2.55	J	2.4		0.86	U	0.34	U	0.365	J	0.08	J	603		1.7		515.6		2744.6		15.8	
Chester Morse Reservoir	RBT	07494545	11/5/07	1.2	J	1.36	J	0.53	J	0.97	U	0.97	U	0.39	U	0.070	J	0.024	UJ	407		1.12		411.6		602.8		3.6	
Cushman Lake	KOK	07494515	10/4/07	2	U	1.14	J	3.54		0.98	U	0.98	U	0.98	U	0.143	J	0.016	NJ	130		1.21		253.8		146.4		3.0	
	MWF	07494516	9/27/07	1.6	J	1.30	J	1.64		0.85	U	0.85	U	0.34	U	0.056	J	0.014	NJ	86		2.31		276.0		180.8		6.0	
	RBT	07494517	9/27/07	0.99	U	na		1.30		0.87	U	0.87	U	0.35	U	na		na		100		1.75		282.0		203.5		1.8	
Deer Lake, 20 miles SE of Chewelah	LMB	07494501	9/18/07	5.2		2.62	J	1.07		2.4		0.97	U	0.39	U	0.111	J	0.024	NJ	443		0.59		421.8		1159.6		7.6	
	RBT	07494502	9/18/07	4		3.79	J	1.14		3.1		0.95	U	0.38	U	0.097	J	0.037	NJ	60		0.8		363.0		472.4		na	
Kettle River, at Curlew	RBT	07494526	10/10/07	0.99	U	0.31	J	1.81		2.5		0.99	U	0.4	U	0.163	J	0.028	UJ	43		1.23		282.8		193.2		2.0	
Ozette Lake	NPM	07494503	9/12/07	1.7	J	1.38	J	0.51	J	1.4		0.96	U	0.38	U	0.010	J	0.033	UJ	1600		0.81		377.2		433.2		9.0	
Ross Lake	BLT	07494540	7/19/07	5.1	J	3.01	J	1.19	J	3.1		0.88	U	0.71	U	0.038	J	0.037	UJ	216		4.24		504.4		1184.4		5.0	
	RBT	07494541	7/19/07	1.4	U	0.40	J	0.16	J	0.96	U	0.96	U	0.77	U	0.014	J	0.041	UJ	63		3.6		328.0		339.4		2.8	
	RSS	07494542	7/19/07	3.1	J	na		2.70	U	1.8		0.94	U	0.75	U	na		na		160		4.6		108.6		10.8		na	
Samish Lake	CTT	07494507	9/4/07	8.2		5.80	J	4.27		2.9		0.98	U	0.39	U	0.446	J	0.12	NJ	68		1.88		271.6		179.6		2.0	
	LMB	07494500	9/4/07	4.3	J	2.79	J	1.03	J	1.5		0.98	U	0.39	U	0.115	J	0.036	NJ	497		0.41		414.8		1166.6		5.8	
	NPM	07494508/4518	9/4/07	12.6	J,m	13.48	J,m	2.60	m	5.20	m	1.10	m	0.39	U,m	0.911	J,m	0.195	J,m	575	m	1.17	m	395.4	m	543.5	m	7.5	m
	PEA	07494509	9/4/07	6.6		na		2.70		3.9		0.94	U	0.38	U	na		na		429		2.4		284.4		220.6		8.4	
	YP	07494510	9/4/07	0.97	U	na		0.25	J	0.88	U	0.88	U	0.35	U	na		na		226		0.18		225.4		131.0		3.4	
Samish River, near 5 miles north of Burlington	CTT	07494533	10/3/07	2.2	J	1.71	J	1.02		1.9		0.86	U	0.46		0.196	J	0.032	NJ	160		1.35		269.4		210.0		2.6	
	MWF	07494534	10/3/07	7.5	J	5.17	J	2.87		4.8		0.87	U	0.61		0.222	J	0.038	UJ	140		2.05		265.2		186.8		3.6	
Sanpoil River, near 10 miles south of Republic	BKT	07494535	10/11/07	1.5		na		1.16		2		0.95	U	0.38	U	na		na		234		0.95		246.6		193.6		2.4	
	RBT	07494536	10/11/07	1.6	J	1.71	J	3.34		2.5		0.99	U	0.39	U	0.149	J	0.053	UJ	140		2.13		270.4		242.6		2.4	
Sauk River, near confluence of N&S Forks	MWF	07494514	10/4/07	3.7	J	1.97	J	1.65	J	2.1		0.96	U	0.77	U	0.178	J	0.06	NJ	53		3.81		255.0		172.5		2.5	
Spada Lake	CTT	07494537	10/17/07	4.1	J	2.38	J	1.52	J	0.99	U	0.99	U	0.4	U	0.145	J	0.045	UJ	150		0.39		291.0		173.2		3.4	
Sullivan Lake	BNT	07494519	9/18/07	28.4	J	19.12	J	3.84	J	24.2		1.3	J	1.4	U	0.635	J	0.1	NJ	120		9.03		575.4		2521.0		4.8	
	CTT	07494521	9/17/07	6.5	J	3.53	J	1.34	J	0.92		0.92	U	0.74	U	0.123	J	0.017	NJ	41		3.57		299.6		267.4		2.4	
	MWF	07494522	9/17/07	4.9	J	3.37	J	1.81	J	3.2		0.93	U	0.37	U	0.191	J	0.041	NJ	54		2.91		264.8		163.6		2.6	
	RBT	07494524	9/17/07	5.5	J	na		1.85	J	4.9		0.99	U	0.79	U	na		na		46		3.3		319.5		307.8		2.2	

See next page for qualifier codes and species codes.

Qualifier Codes

J	The analyte was positively identified. The associated numerical result is an estimate.
NJ	The analyte was tentatively identified and the associated numerical value represents an approximate concentration.
U	The analyte was not detected at or above the reported value.
UJ	The analyte was not detected at or above the reported estimated result.
m	Mean value from analyses of field duplicates where two results are available. Where both values were non-detect, the highest value was usually used. Where one duplicate was qualified as a non-detect (U, UJ), the reported value was used in determining the mean value. For some duplicate pairs, analysis for PCDD/Fs and PCB congeners was done on only one of the samples; these results are not qualified with an "m".

Species Codes

BKT	Brook trout
BLT	Bull trout
BNT	Brown trout
CTT	Cutthroat trout,
KOK	Kokanee salmon
LMB	Largemouth bass
MWF	Mountain whitefish
NPM	Northern pikeminnow
PEA	Peamouth
RBT	Rainbow trout
RSS	Redside shiner (whole fish)
YP	Yellow perch.

Appendix E. Health Information about Fish

Fish is good food. Trying to balance the health benefits of fish with concerns about contaminant levels can be challenging, yet information is available to help consumers make healthy choices. Contaminants are found in most foods, and choosing fish wisely can be an excellent health choice. The key is to make smart decisions and choose fish that are low in mercury, PCBs, and other contaminants.

The American Heart Association recommends eating fish twice a week because fish are a great source of protein, vitamins, and nutrients. Fish are loaded with omega-3 fatty acids, which provide protection from heart disease and are great "brain food" for adults and children.

A valuable source of information about eating fish is the Washington State Department of Health (DOH) website:

www.doh.wa.gov/ehp/oehas/fish/default.htm

- Advice for women and children who eat fish.
- Waterbody-specific fish consumption advisories in Washington.
- How contaminants (mercury, PCBs, PBDEs, DDTs) get into fish.
- How you can help reduce contaminants.

www.doh.wa.gov/ehp/oehas/fish/fishchart.htm

- Healthy fish eating guide.
- Checklist to reduce contaminant exposure including the proper way to fillet and prepare fish meals.
- Health benefits of fish/recipes.

www.doh.wa.gov/ehp/oehas/fish/advisoriesmap.htm

- Fish and shellfish consumption advisories.

The U.S. Environmental Protection Agency (EPA) and the Food and Drug Administration (FDA) also provide information on health benefits of fish:

www.epa.gov/waterscience/fish/

- What you need to know about mercury - 10 frequently asked questions.

www.cfsan.fda.gov/seafood1.html

- Seafood information and resources.

Appendix F. Glossary, Acronyms, and Abbreviations

303(d) list: Section 303(d) of the federal Clean Water Act requires Washington State to periodically prepare a list of all surface waters in the state for which designated uses of the water – such as for drinking, recreation, aquatic habitat, and industrial use – are impaired by pollutants. These are water quality limited estuaries, lakes, and streams that fall short of state surface water quality standards, and are not expected to improve within the next two years.

Total Maximum Daily Load (TMDL): A distribution of a substance in a waterbody designed to protect it from exceeding water quality standards. A TMDL is equal to the sum of all of the following: (1) individual wasteload allocations for point sources, (2) the load allocations for nonpoint sources, (3) the contribution of natural sources, and (4) a Margin of Safety to allow for uncertainty in the wasteload determination. A reserve for future growth is also generally provided.

DDMU	1-chloro-2,2-bis(p-chlorophenyl)ethane
DDD	dichloro-diphenyl-dichloroethane
DDE	dichloro-diphenyl-trichloroethylene
DDT	dichloro-diphenyl-trichloroethane
DOH	Washington State Department of Health
Ecology	Washington State Department of Ecology
EIM	Environmental Information Management
EPA	Environmental Protection Agency
MEL	Manchester Environmental Laboratory
ng/kg	nanograms per kilogram, or parts per trillion (ppt)
NTR	National Toxics Rule
mg/kg	milligrams per kilogram, or parts per million (ppm)
PBDE	polybrominated diphenyl ethers
PBT	persistent, bioaccumulative, and toxic substance
PCB	polychlorinated biphenyls
PCDD/Fs	polychlorinated dibenzo-p-dioxins and -furans
SOP	Standard operating procedures
SRM	Standard reference materials
SV	Screening values
TCDD	tetrachlorodibenzo-p-dioxin
TEF	Toxicity Equivalent Factor
TEQ	Toxic Equivalent
ug/kg	micrograms per kilogram, or parts per billion (ppb)
WAC	Washington Administrative Code
WDFW	Washington Department of Fish and Wildlife
WSTMP	Washington State Toxics Monitoring Program
ww	wet weight

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

APPENDIX E.3-5
SULLIVAN LAKE ELEVATION MANAGEMENT SCENARIOS REPORT

WORKING DRAFT

SULLIVAN LAKE ELEVATION MANAGEMENT SCENARIOS

Prepared for:

Sullivan Lake Hydroelectric Project Mediation Team

and

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

Prepared by:

EES Consulting
1155 N. State Street, Suite 700
Bellingham, Washington 98225
(360)734-5915 phone, (360)734-5918 fax

June 22, 2009

SULLIVAN LAKE ELEVATION MANAGEMENT SCENARIOS

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.

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 the low concentrations of total phosphorus and cholorphyll 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).

There is a dam at the outlet of Sullivan Lake, built in 1931, which is owned and operated by the Pend Oreille Public Utility District (District). Under current operations, Sullivan Lake is drawn down approximately 20 feet each fall from its full pool elevation, beginning October 1. During settlement negotiation meetings regarding operations of Sullivan Lake, there was concern expressed that this drawdown might further deplete nutrients and/or productivity in Sullivan Lake. The analysis presented in this report summarizes the results of simulating several different management alternatives for regulating lake levels.

2.0 LAKE LEVEL SIMULATION

EES Consulting examined historical water surface elevations of Sullivan Lake from 1999-2008, and applied these observations to five different scenarios of lake level management as postulated by the Mediation Team. Lake elevation observations were not available on a daily basis, but only on a somewhat periodic basis, with several days to a week between observations (980 observations over the ten-year period). Between observation dates, lake levels were assumed to follow a linear response. The scenarios examined and assumptions for each are described below.

- Base case: Actual measurements as recorded.

- Scenario 1: Maintain winter lake elevation five feet higher than historical records (to approximate elevation of 2570 ft. AMSL). Keep spillway at 2588 ft. elevation. Spring ramp-up and fall drawdown occur at the same rate as historical records.

- Scenario 2: Maintain winter lake elevation five feet higher than historical records (approximately 2570 ft. AMSL). Raise dam one foot (i.e., make spillway elevation 2589 ft.). Spring ramp-up and fall drawdown occur at the same rate as historical records.

- Scenario 3: Maintain winter lake elevation five feet higher than historical records (approximately 2570 ft. AMSL). Keep spillway at 2588 ft. elevation. From July 1 through August 9 (40 days), reduce lake elevation 0.0575 feet (0.69 inches) per day. Spring ramp-up and fall drawdown occur at the same rate as historical records.

- Scenario 4: Maintain winter lake elevation five feet higher than historical records (approximately 2570 ft. AMSL). Raise dam one foot (i.e., make spillway elevation 2589 ft.). From July 1 through August 9 (40 days), reduce lake elevation 0.0575 feet (0.69 inches) per day. Spring ramp-up and fall drawdown occur at the same rate as historical records.

- Scenario 5: Maintain winter lake elevation five feet higher than historical records (approximately 2570 ft. AMSL), and maintain until May 1 (i.e., allow outflow from lake to equal inflow until May 1). Keep spillway at 2588 ft. elevation. Spring ramp-up after May 1 and fall drawdown occur at the same rate as historical records.

The conditions of each scenario are summarized in Table 1. In all scenarios, if the lake filled during the summer, lake level was assumed to remain slightly above the spillway elevation (about 0.5 feet) until historical records indicated that the lake level began to come down. After that date, simulated levels were lowered at the same rate as indicated by the historical records.

Table 1. Management Conditions for Sullivan Lake Elevation Simulations						
	Base case	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5**
Winter lake level (approximate elevation AMSL)	2565 ft.	2570 ft.	2570 ft.	2570 ft.	2570 ft.	2570 ft.
Spillway elevation	2588 ft.	2588 ft.	2589 ft.	2588 ft.	2589 ft.	2588 ft.
Drawdown 7/1 - 8/9	none	none	none	-2.3 ft.	-2.3 ft.	none
Hold winter elevation until 5/1	no	no	no	no	no	yes

3.0 RESULTS

Figures 1-6 illustrate lake levels for 1999-2008 for the base case and five management scenarios described above. Key facts characterizing each scenario are summarized in Table 2.

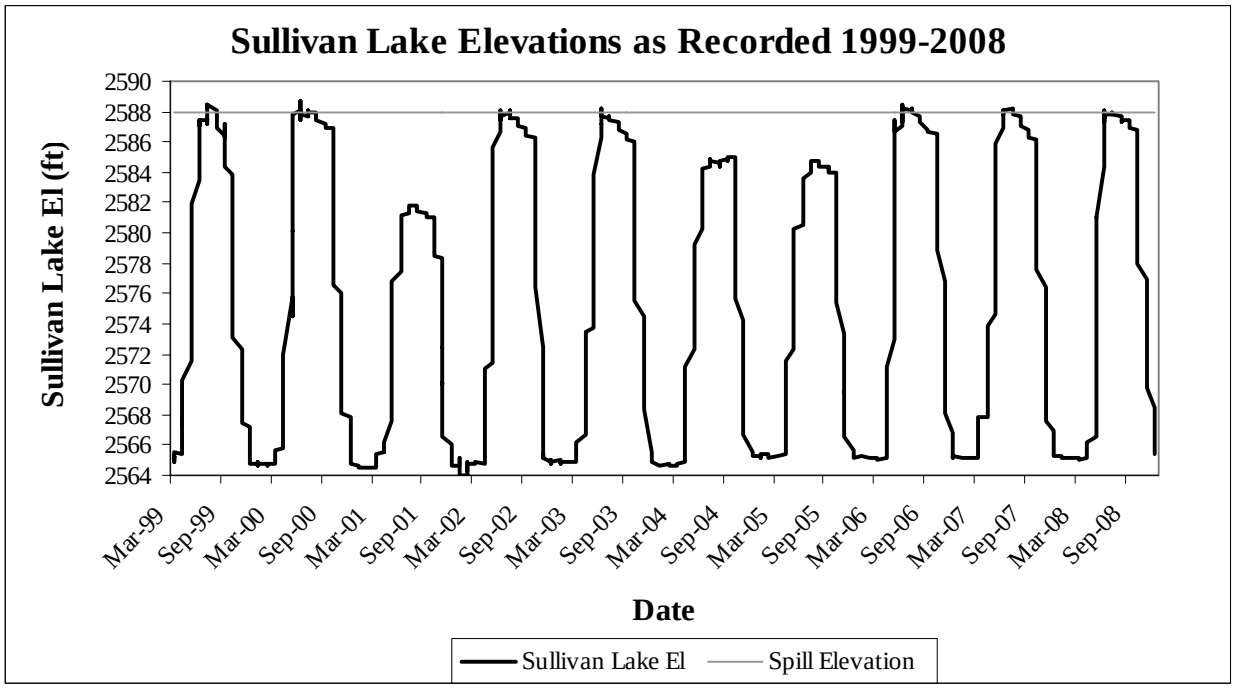

Figure 1. Sullivan Lake Elevations as Measured 1999-2008 (Base Case).

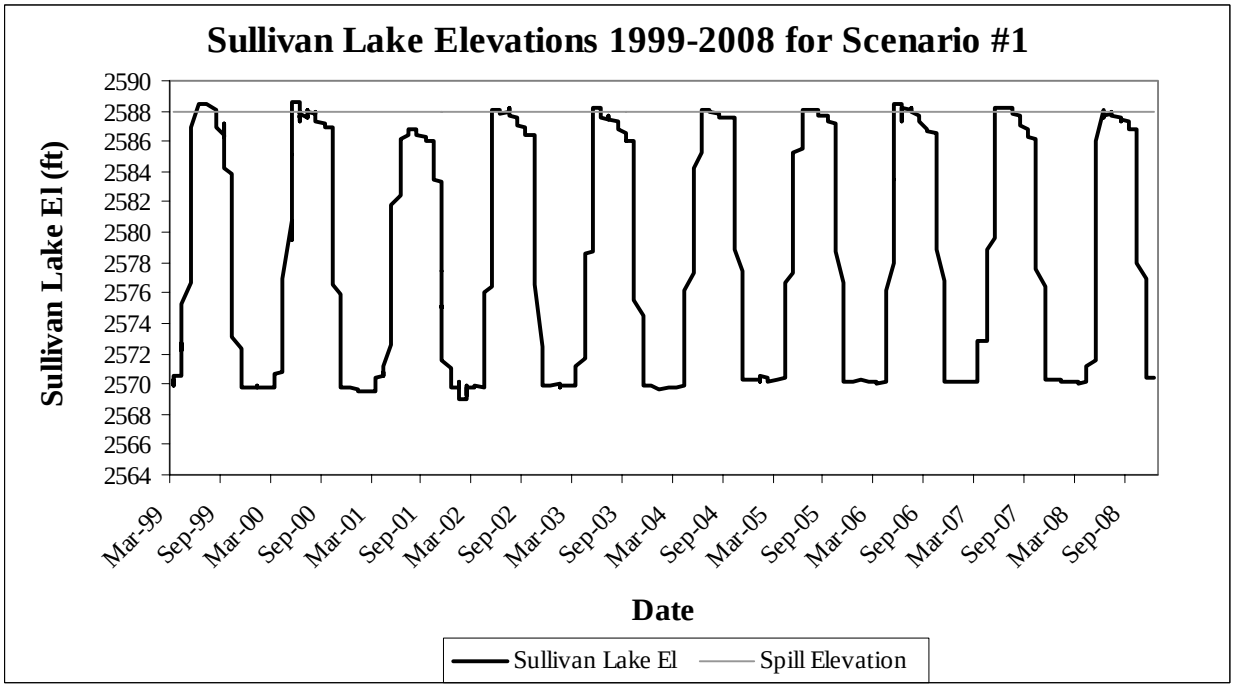

Figure 2. Sullivan Lake Elevations for Scenario 1 1999-2008.

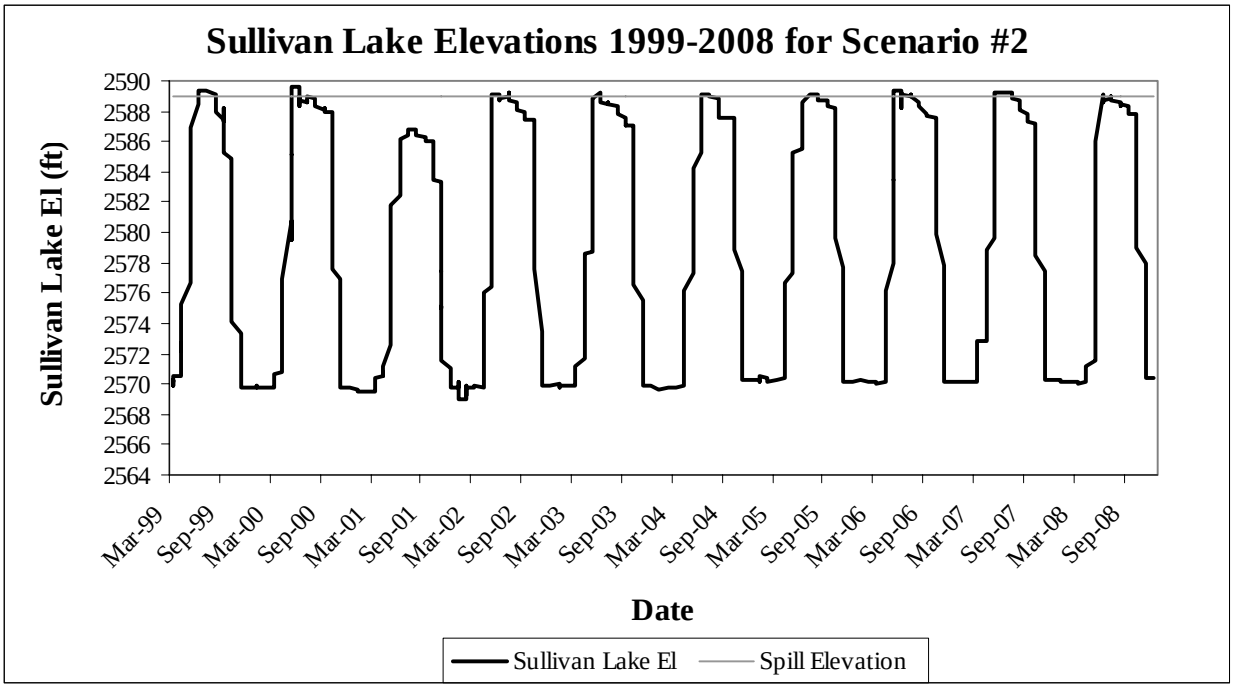

Figure 3. Sullivan Lake Elevations for Scenario 2 1999-2008

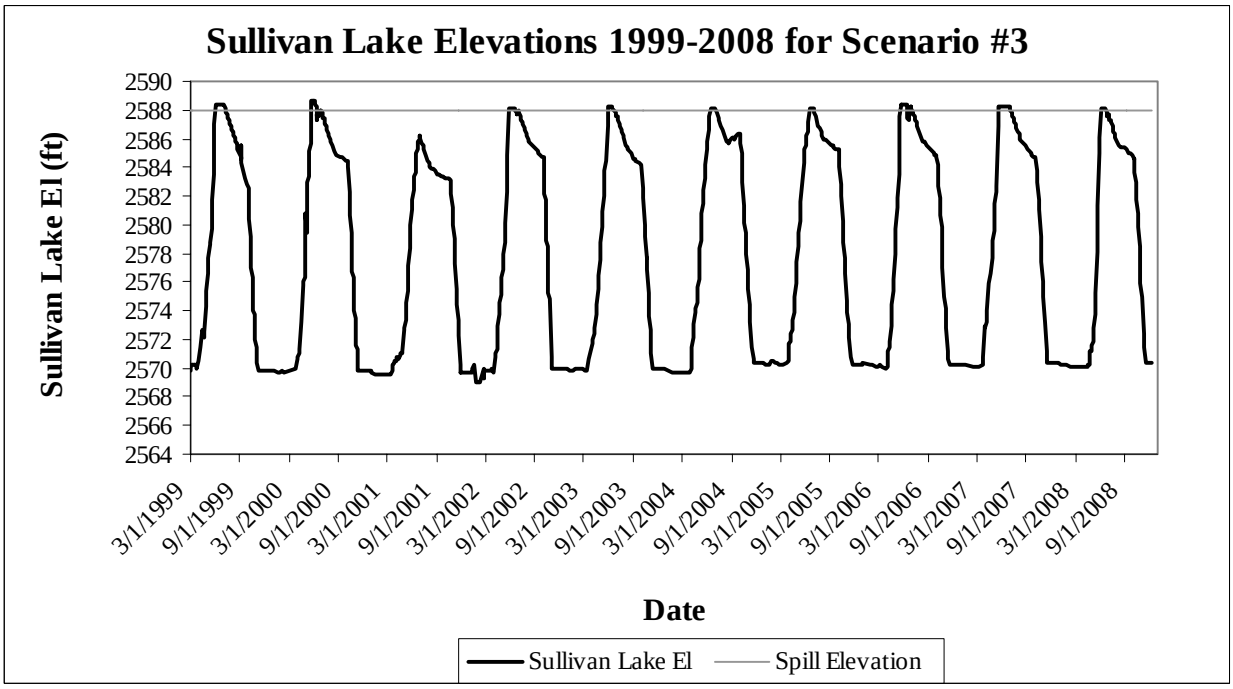

Figure 4. Sullivan Lake Elevations for Scenario 3 1999-2008.

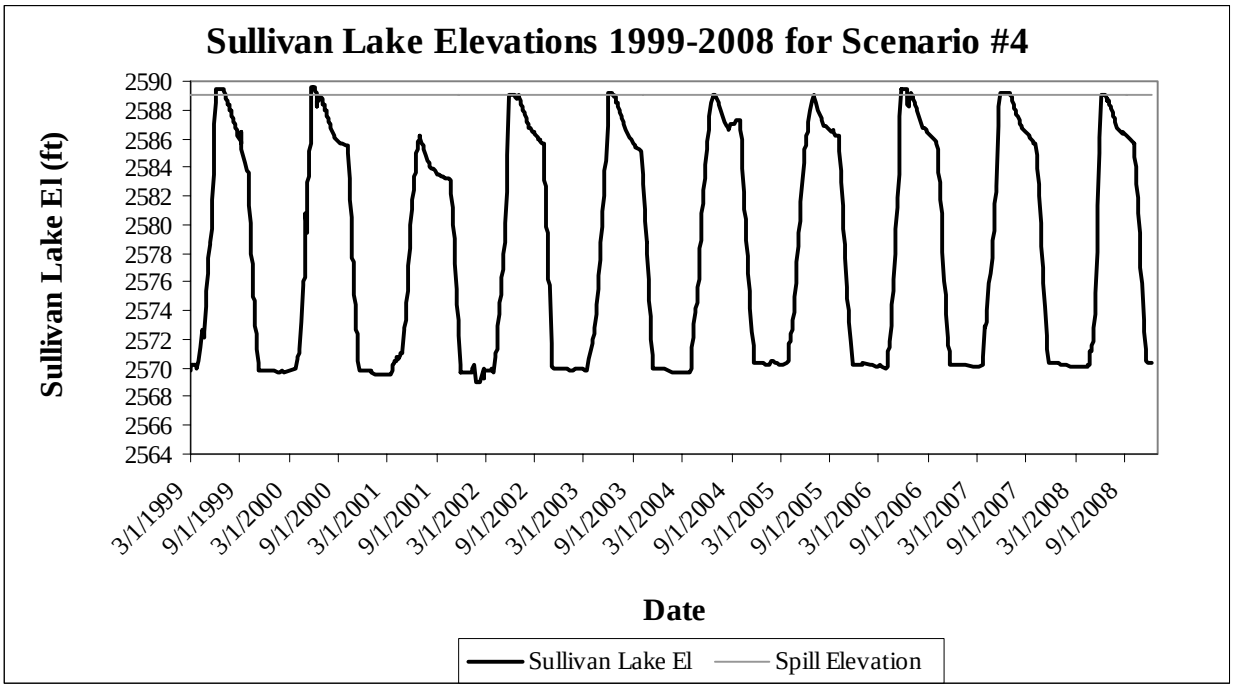

Figure 5. Sullivan Lake Elevations for Scenario 4 1999-2008.

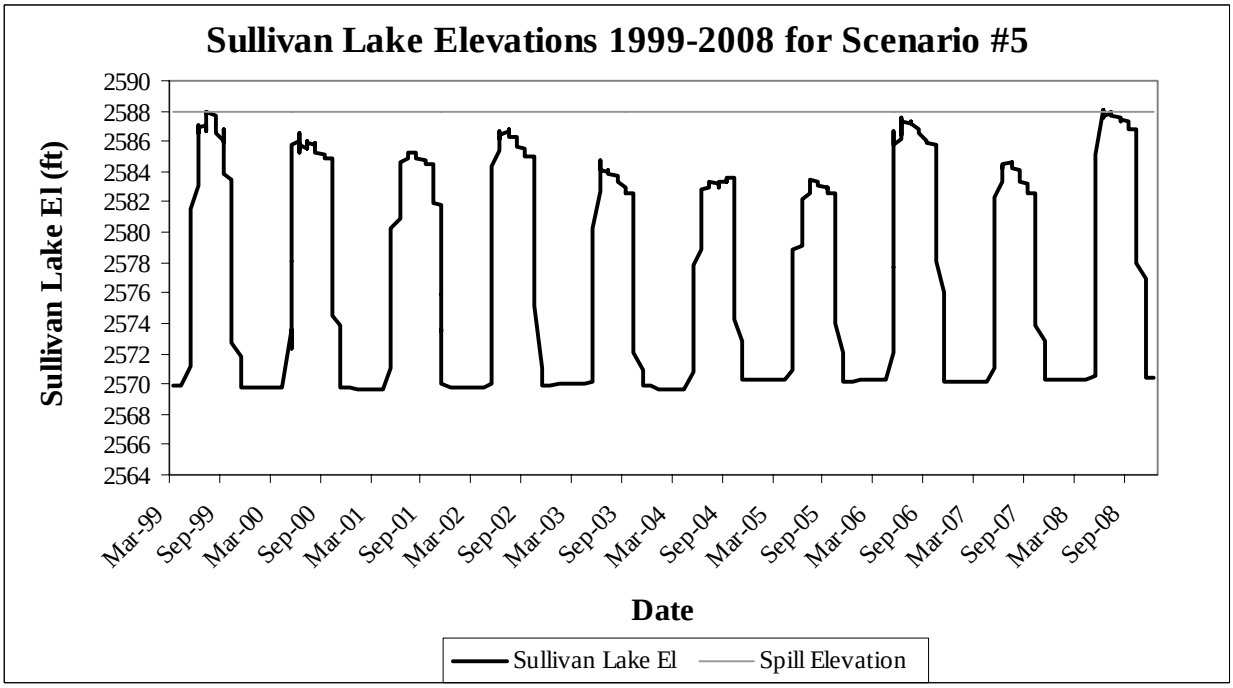

Figure 6. Sullivan Lake Elevations for Scenario 5 1999-2008.

Table 2. Summary of Results of Sullivan Lake Management Scenarios

	Base case	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5**
# years filled	7	9	9	9	9	1
Average date first filled (range)	6/20 (6/1-7/13)	6/1 (5/21-6/20)	6/4 (5/22-7/1)	6/1 (5/21-6/20)	6/4 (5/22-7/1)	6/4
Average number of days remains filled (range)	16 (1-37)	33 (16-64)	30 (15-60)	22 (1-42)	19 (1-38)	10
# years not filled	3	1	1	1	1	9
Average date of maximum elevation in years not filled (range)	8/18 (7/21-9/27)	8/7	8/7	6/30	6/30	7/11 (6/12-8/7)
Average maximum elevation in years not filled (range)	2583.88 (2581.76-2585.06)	2586.76	2586.76	2586.21	2586.21	2585.52 (2583.39-2587.99)
Average elevation on August 9 after summer drawdown (range)	2586.42 (2581.73-2587.99)	2587.57 (2586.73-2587.96)	2588.47 (2586.73-2588.96)	2585.58 (2583.97-2586.16)	2586.48 (2583.97-2587.16)	2585.30 (2583.20-2587.57)

4.0 DISCUSSION

Scenarios 1 and 2 result in reservoir filling more often than the base case, because the higher elevation maintained over the winter allows more rapid approach to spillway elevation in the spring. The reservoir also remains filled for a longer period of time compared to the base case, because it fills earlier in the year. Even in the one year when the lake does not fill, maximum elevation approaches near full (within 1-2 feet of the spillway). There is little difference between Scenario 1 and Scenario 2 in terms of when the lake is filled and for how long; however, Scenario 2 would result in additional storage due to the one foot higher spillway.

Scenarios 3 and 4 result in reservoir filling in the same years as Scenarios 1 and 2 (nine out of ten years), with the dates of first fill also the same as Scenarios 1 and 2, respectively. However, the lake remains filled a shorter period of time compared to Scenarios 1 and 2, since the summer drawdown begins July 1. Compared to the base case, Scenarios 3 and 4 result in a slightly longer period of spill, but the lake elevations on August 9 (at the end of the summer drawdown) for Scenarios 3 and 4 are within a foot of the base case on the same date. There is little difference between Scenario 3 and Scenario 4 in terms of when the lake is filled and for how long; however, Scenario 4 would result in additional storage due to the one foot higher spillway.

Scenario 5 results in reservoir filling in only one year out of ten. This is due to the fact that much of the spring runoff is allowed to pass through the dam prior to May 1, leaving insufficient runoff after that date to fill the lake in most years.

Finally, three cautions are appropriate when considering these results:

1. Dates and spill periods are estimates based on historic information that was collected every few days, and therefore the resulting estimates may be off by a few days.
2. The averages are based on a period of record of the last ten years, and are therefore indicative of this time period only. Streamflows may vary in the future, which could warrant different lake level management actions.
3. This analysis is conducted assuming the current instream flow requirement of 10 cfs for Outlet Creek on a year-round basis. This instream flow may change, based on further investigation by WDFW during the summer of 2009.

5.0 REFERENCES

Horne, A. J., and C. R. Goldman. 1994. Limnology. 2nd Edition. McGraw-Hill, Inc., New York, NY.

WDOE (Washington Department of Ecology). 1997. Lake Water Quality Monitoring web site. www.ecy.wa.gov/programs/eap/fw_lakes/lksulpe1.html

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

APPENDIX E.3-6
OUTLET CREEK FLOW STUDY MEMO, JULY 17, 2009

July 17, 2009

TO: Doug Robison
Brad Caldwell
John Blum

From: Hal Beecher

SUBJECT: Outlet Creek flows released from Sullivan Lake on July 15, 2009

Dave Sullivan (Pend Oreille PUD) managed flow releases during Wednesday, July 15, while John Blum (EES Consulting), Brad Caldwell (Ecology), and I measured depths and widths at three selected transects. These transects appeared representative of Outlet Creek, with emphasis on the most flow sensitive areas. The downstream transect was about 15-20 feet downstream from the USGS gage and we checked the staff gage at the beginning of each set of measurements, then estimated flow based on the rating table that Dave had obtained from USGS. (From earlier review of the gage records on the internet I agree with Dave's conclusion that the gage is quite stable.) We photographed each transect at each flow.

Measurements are summarized in Table 1. Table 2 shows flows that provide thresholds for favorable depths ($\geq$ 1 ft) or rate of change in wetted width. The depths selected are above the minimum (> 0.5 ft) for adult resident salmonids for either rearing or spawning and would provide adequate passage. The threshold for wetted width is to avoid conditions that could lead to stranding if flows were decreased rapidly from the flow of interest (for example, the braided riffle transect is 67.2 feet wide at 263 cfs, but only 43.2 feet wide at 13 cfs, and a sudden decrease of flow from 263 cfs to 13 cfs could strand fish.

In an earlier memo, I suggested flows of 25 cfs from August through March, followed by 90 cfs in April, 275 cfs in May, 225 cfs in June, and 65 cfs in July to roughly mimic the Sullivan Creek natural hydrograph. However, if the retention of lake level in summer and steady release of flow in fall is the objective, then a fall release of a flow close to 69 cfs should be considered. This flow looked like a reasonably good habitat flow (my subjective impression) that is consistent with Table 2. However, at this time I do not know all the constraints on such a flow. I would like to see such a flow continued throughout the fall and winter, as I understand the onset of flow release is to be October. A summer release of 25 cfs would be desirable, but I understand it may not be consistent with the goal of maintaining lake elevation.

We observed a number of log structures along the banks of Outlet Creek. Those structures appeared effective in providing deep water (> 2 ft) even at the lowest measured flow (13 cfs).

Table 1. Summary of depth and width measurements at 13, 18, 29, 69, 101, 181, and 263 cfs in Outlet Creek.

flow as measured at USGS gage (cfs)	13	18	29	69	101	181	263
stage as measured at USGS gage (ft)	9.16	9.24	9.38	9.72	9.91	10.31	10.65
increment of depth (ft)		0.08	0.14	0.34	0.19	0.4	0.34
transect about 15' DS of gage							
wetted width (ft)	33.6	33.6	35.7	40.1	42.4	43	44.9
max depth (ft)	0.9	1	1.1	1.5	1.7	2	2.5
mean of sampled depths (ft)	0.559091	0.629091	0.754545	1.05	1.277273	1.713636	2.040909
increment of max depth (ft)		0.1	0.1	0.4	0.2	0.3	0.5
cumulative increment of max depth (ft)		0.1	0.2	0.6	0.8	1.1	1.6
wide glide transect							
wetted width (ft)	47.7	48.2	49.3	50.6	51	52.5	53
max depth (ft)	0.65	0.7	0.9	1.2	1.4	1.9	2.3
mean of sampled depths (ft)	0.446875	0.528125	0.68125	0.96875	1.146875	1.590625	1.990625
increment of max depth (ft)		0.05	0.2	0.3	0.2	0.5	0.4
cumulative increment of max depth (ft)		0.05	0.25	0.55	0.75	1.25	1.65
braided riffle transect							
wetted width (ft)	43.2	44	55.2	47.7	49.4	53.1	67.2
max depth (ft)	0.65	0.65	0.8	1.2	1.45	2.05	2.6
mean of sampled depths (ft)	0.267647	0.335294	0.441765	0.808824	1.088235	1.65	2.179412
increment of max depth (ft)		0	0.15	0.4	0.25	0.6	0.55
cumulative increment of max depth (ft)		0	0.15	0.55	0.8	1.4	1.95

Table 2. Critical flows for depths and widths by transect.

	Maximum depth $\geq$ 1 ft	Mean depth $\geq$ 1 ft	Threshold of rapid width change
Gage transect	18 cfs	69 cfs	180 cfs
Wide glide	69 cfs	101 cfs	NA
Braided riffle	69 cfs	101 cfs	180 cfs