Lake Tapps (Pierce County) Monitoring

Final Data Report

January 2006

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Lake Tapps (Pierce County) Monitoring

Final Data Report

by
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Table of Contents

List of Figures and Tables

Page

Figures

Tables

Abstract

Lake Tapps is located in Pierce County, Washington, near the town of Bonney Lake. Basic water quality data have been collected during several earlier studies on Lake Tapps. However, except for Secchi depths collected during the Department of Ecology's 1997-2000 Lake Monitoring Program, earlier studies were limited, with samples collected only one or two times a year at a maximum of two locations.

The purpose of this July 2004 – June 2005 monitoring was to document current conditions at four lake stations and at three tributary stations over the course of a year. Results are compiled, evaluated for quality, and summarized in this report.

The nutrient concentration evaluation classifies Lake Tapps as oligotrophic[1]; however, other indicators, such as chlorophyll concentrations and hypolimnetic oxygen depletion, were more typical of mesotrophic[2] lakes.

[1] Nutrient poor
[2] Moderately productive in terms of aquatic animal and plant life

Acknowledgements

The following people contributed to this project:

- Heather Kibby and John Collins at Pierce County Water Resources Program, and Nancy Rapin of the Muckleshoot Indian Tribe, shared their sampling data with us. We used the data to check our own analyses. Ms. Rapin also reviewed the original sampling plan.
- Mike Loftus, of R2 Resource Consultants for Puget Sound Energy, reviewed this report.
- Staff with the Washington State Department of Ecology:
  - Bill Ward and Bruce Cochran helped collect samples.
  - Greg Zentner proposed the project, acquired and managed the funding, and handled interagency activities.
  - Rob Plotnikoff, Maggie Bell-McKinnon, Jim Carroll, Greg Zentner, and Clair Yoder reviewed the report.
  - Many people at Manchester Environmental Laboratory worked hard to manage the samples and produce quality results.
  - Joan LeTourneau and Gayla Lord prepared the final document.

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Introduction

Lake Tapps is located in Pierce County, Washington, near the town of Bonney Lake. The lake was created in 1911 when an impoundment on the White River diverted some of the river to the southwest, where a second impoundment for power generation joined together four smaller lakes (Figure 1). At the time of the original diversion and impoundment, the region around the lake was sparsely populated, and hydroelectric power generation was the sole use of the lake. Today, the lake shoreline is developed with residential homes. The lake is used intensively for recreation, and Ecology is processing applications for water rights for future municipal use.

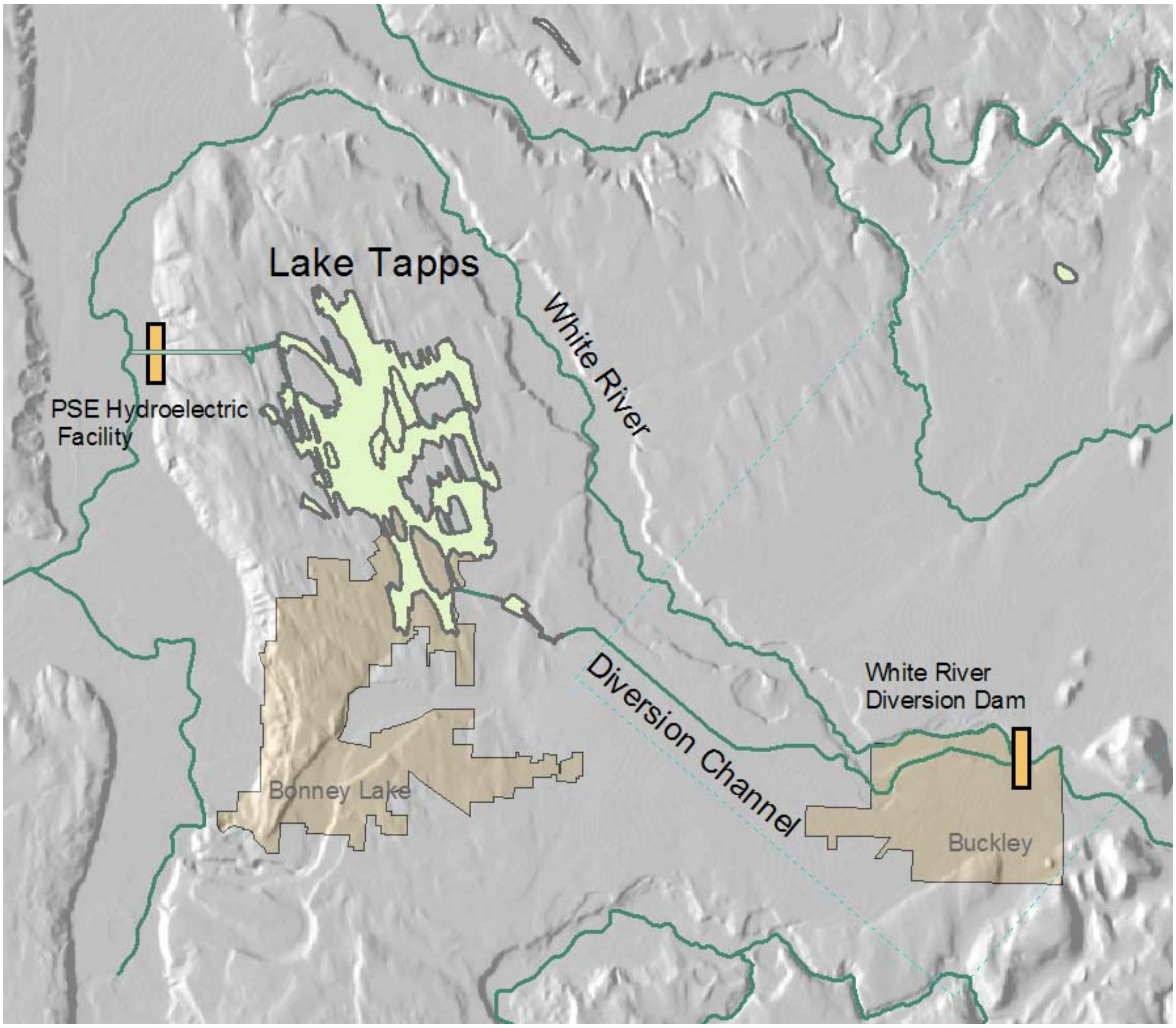

Figure 1. Map of Lake Tapps and the surrounding region.

Lake Tapps has a maximum depth of 27 meters and a mean depth of 7.6 meters[3]. Its surface area is 10.9 square kilometers, which, with a shoreline length of 67.6 kilometers, yields a very high shoreline development index of 5.8. The shoreline development index is the ratio of the lake's shoreline length to that of a circle with the same area. On average, lakes with higher indexes are more susceptible to eutrophication, reflecting the relatively greater length of developable shoreline (Wetzel, 1975).

Lake Tapps is listed in Category 4C on the Washington State Department of Ecology's (Ecology's) 2004 303(d) list as being impaired by a non-pollutant (Eurasian milfoil; listing #4693). Category 4C is for impairment by causes that cannot be addressed through a Total Maximum Daily Load (TMDL) study. This project is not intended to address that listing, but the data collected here may guide future studies based on that indicator of impairment.

Basic water quality data have been collected by several earlier studies. Samples were collected in 1974 (Dion et al., 1976) and in 1981 (Sumioka and Dion, 1985). Ecology's Lake Monitoring Program sampled Lake Tapps from 1997 through 2000. Except for Secchi depths collected during the Lake Monitoring Program, these studies characterized water quality on one or two dates at one or two locations.

Results from these studies may not be comparable to the current study because of differences in the flow regime through Lake Tapps. Hydropower operations ceased in January 2004, and the lake is now operated for recreation, with much lower flow through the lake.

This July 2004 – June 2005 monitoring project, which was proposed by Ecology's Southwest Regional Office, is intended to document current conditions in Lake Tapps. Objectives are as follows:

- Determine vertical profiles for temperature, pH, conductivity, and dissolved oxygen at up to four open-water stations during the course of a year.
- Determine nutrient concentrations (epilimnion and hypolimnion composites) and other constituents (epilimnion composites only) at up to four open-water stations during the course of a year.
- Determine nutrient concentrations at the major inflow, the head of the diversion channel, and at the outflow during the course of a year.
- Compile, evaluate, and document results.
- Classify Lake Tapps by trophic state based on data collected during this project.

Detailed analysis and comparison to other on-going monitoring studies is not within the scope of this project.

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[3] In English units, roughly, the maximum depth is 90 feet; the mean depth is 25 feet; the surface area is 4.2 square miles (2700 acres); and the length of shoreline around the lake is 42 miles. The shoreline development index is 5.8 regardless of whether one uses English units or S.I. (System International) units.

Sampling Design

Samples were collected from four open-water stations: the central lake, and each of the three eastern basins (Table 1 and Figure 2). Stations were chosen based on a review of lake bathymetry, shoreline maps, and aerial photos. The lake consists of a main basin to the west, through which most of the water may flow directly from the inlet to the outlet, and three side-basins that are northeast, east, and southeast of the main basin.

Table 1. Sample stations.

Station	MEL [a] Identifier	Lake Code [b]	Lat.	Long.	Narrative
#1	6030	TAPPI111E	47.2228	122.1750	~90 ft deep spot in center of main lake.
#4 [c]	6032	TAPPI141E	47.2348	122.1591	~50 ft deep spot in northeastern basin.
#5	6034	TAPPI151E	47.2243	122.1579	~40 ft deep spot in eastern center basin.
#6	6036	TAPPI161E	47.2066	122.1518	~20 ft deep spot in southeastern basin. Epilimnion composite.
#7, Inlet	6038	TAPPI171	47.1968	122.1392	Lake Inlet, from 218th Street Bridge.
#8, Diversion	6039	TAPPI181	47.1717	122.0192	Channel Inlet (at diversion), end of River Road.
#9, Outlet	6040	TAPPI191	47.2383	122.2237	Lake Outlet, from East Valley Highway Bridge.

[a] Manchester Environmental Laboratory

[b] The lake code follows the convention used in Ecology's 1989-2000 Lake Monitoring Program: The lake is identified by the first three letters of the lake name, the first two letters of the county, and a digit for cases where these five letters are not unique. The station number follows, then a digit indicating a primary sample (1), duplicate (2), or split (3), followed by a depth indicator (e.g., "E" indicates an epilimnion composite sample).

[c] Station numbers 2 and 3 were sampled by Ecology's Lake Monitoring Program at different locations than stations monitored in this study. The numbers are not being re-used to avoid confusion.

Figure 2. Morphometric map of Lake Tapps showing lake sampling locations.

Lake inlet samples were obtained from the diversion channel at the 218th Street Bridge just before the channel enters the lake. The channel inlet was sampled, just below the diversion from the White River at the end of River Road in Buckley. The lake outlet, also known as the tailrace discharge, was sampled from the East Valley Highway Bridge.

In addition, a data logger was deployed from 0900 August 9 through 1730 August 11, 2004. The instrument was deployed at a depth of about one meter from a private dock in the shallow embayment north-northeast of station 5 (latitude 48.2266, longitude 122.1626). The logger was set to record temperature, pH, oxygen, and conductivity hourly.

Constituents sampled are shown in Table 2. Methods, procedures, and quality control (QC) requirements are given in the Quality Assurance Project Plan (Hallock, 2004). Table 3 lists the sampling schedule.

Table 2. Constituents sampled.

Constituents	Lake Samples		Tributaries
	Epilimnion	Hypolimnion	
Profile (temperature, oxygen, pH, and conductivity)	X	X	[a]
Nutrients (total phosphorus, soluble reactive phosphorus, total nitrogen, nitrate plus nitrite nitrogen, and ammonia)	X	X	X
Turbidity	X		X
Chlorophyll, total suspended solids, total volatile suspended solids	X		

[a] Sub-surface temperature, pH, and conductivity were measured at tributary stations on most dates.

Table 3. Sampling schedule.

Date	Lake Stations	Tributary Stations
Jul 7, 2004	X	X
Aug 11, 2004	X	X
Sep 15, 2004 [a]		X
Sep 16, 2004 [a]	X	
Oct 6, 2004	X	X
Nov 8, 2004		X
Dec 6, 2004		X
Jan 19, 2005	X	X
Feb 8, 2005		X
Mar 8, 2005	X	X
Apr 5, 2005		X
May 10, 2005	X	X
Jun 7, 2005	X	X

[a] Due to mechanical problems, lake stations were sampled one day after tributary stations in September.

Results

This report is primarily intended to present the results of monthly water quality monitoring on Lake Tapps and its inlet and outlet. These results are compiled in Appendix A (sample notes), Appendix B (profiles), and Appendix C (discrete results). Results are evaluated against quality control requirements in the *Quality Control Analysis* section of this report.

This section presents a basic summary of the data.

Diel Fluctuations

The diel fluctuations in temperature, pH, and oxygen were low (Figure 3), as might be expected in conditions with low algal and aquatic macrophyte productivity. These data were collected on only one occasion and at only one site, and will not be representative of the entire lake. However, open water fluctuations were likely less than the fluctuations from the shallow embayment reported here because the ratio of overlying water volume to sediment area is so much greater in deep water locations.

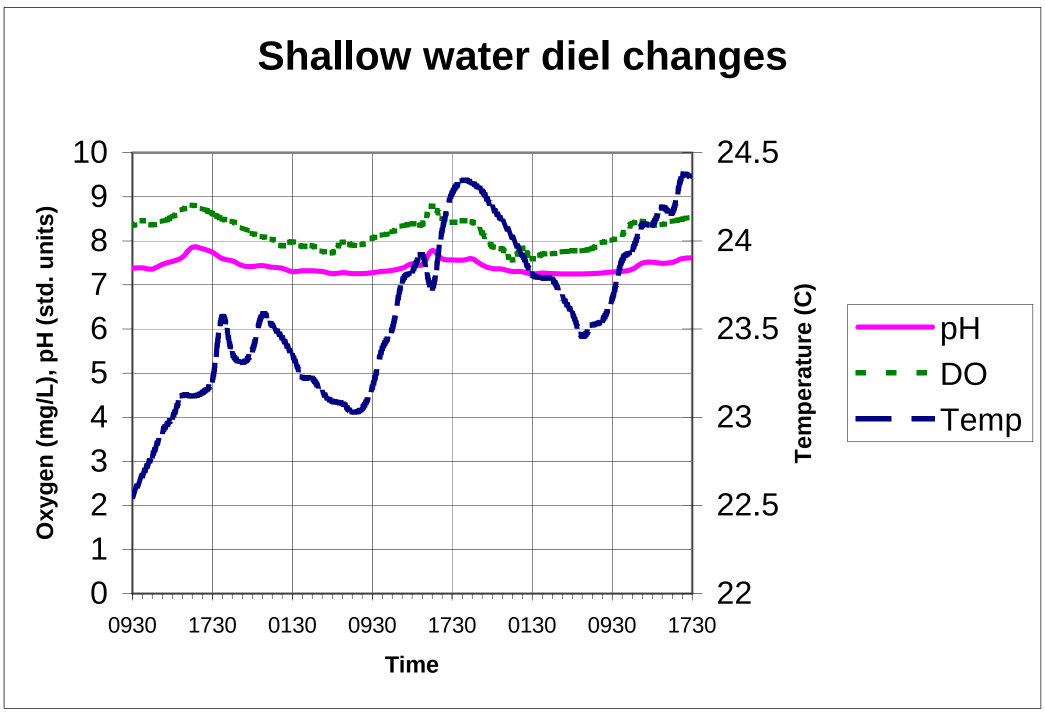


Figure 3. Near-surface diel oxygen (estimates), pH, and temperature collected on August 8-10, 2004.

Lake Profiles

Water temperature measurements were warmest in August and coldest in January; the lake was stratified with a clearly defined epilimnion during all monitored months except January and March (Figure 4, top). Oxygen profiles indicate hypolimnetic concentrations below 8 mg/L during all sampled months except January, March, and May, with near-bottom concentrations approaching 0 mg/L in August and September (Figure 4, bottom).

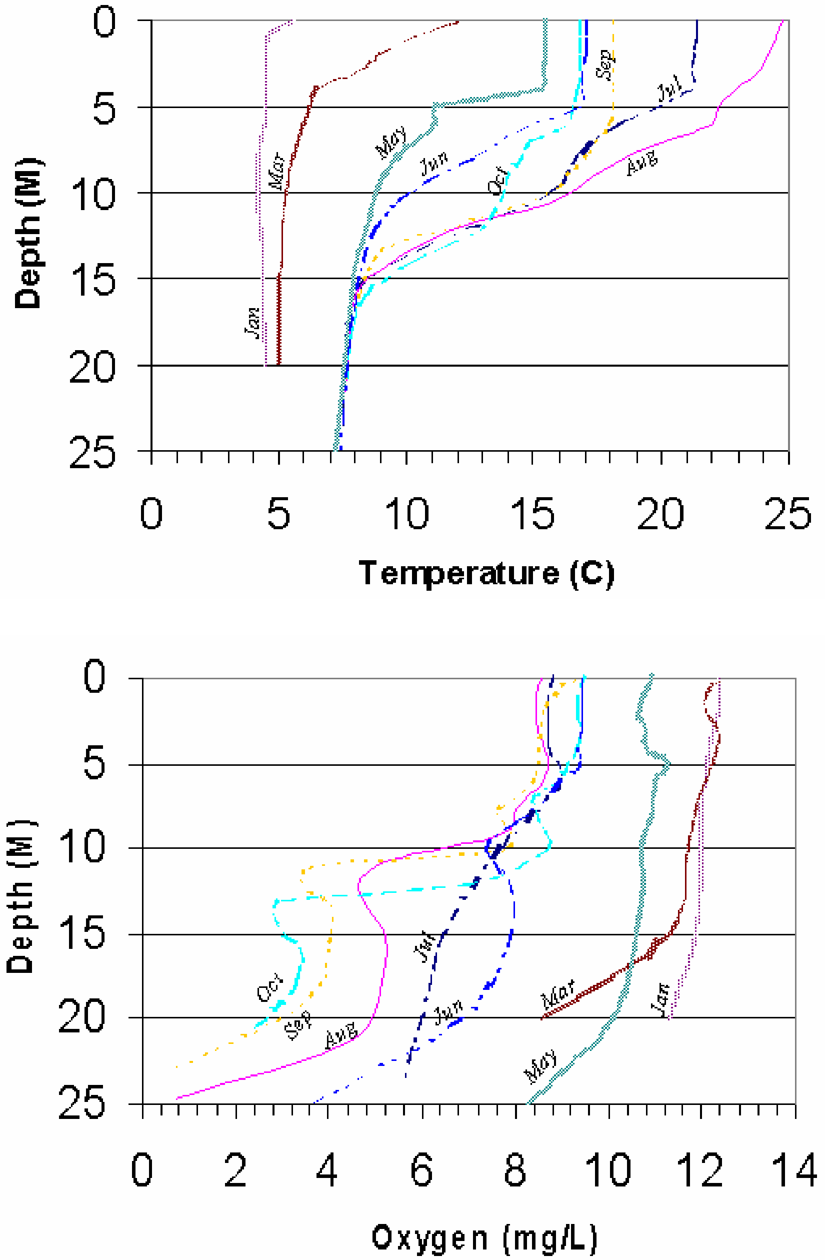


Figure 4. Temperature (top) and oxygen (bottom) profiles from Lake Tapps station 1 (the deep basin).

The small mid-water column dip in oxygen concentration during those two months and in October may be a result of the decomposition of organic matter accumulated at the density gradient caused by the thermocline (metalimnion). In this case, however, the inlet from the White River contributes an interflow at about this depth that complicates the explanation.

September oxygen profiles from all four lake stations are shown in Figure 5. The hypolimnion at stations 4 and 5 was anoxic. This anoxia is attributable in part to the narrowness of the hypolimnetic zone (1 to 5 m): the amount of oxygen available at these stations to be consumed by decomposition was small relative to the open lake station with its far deeper hypolimnion. Although the substrate at all stations was fine, gray, glacial silt, there was apparently enough organic matter present for decomposer activity to cause anoxia, at least near the bottom.

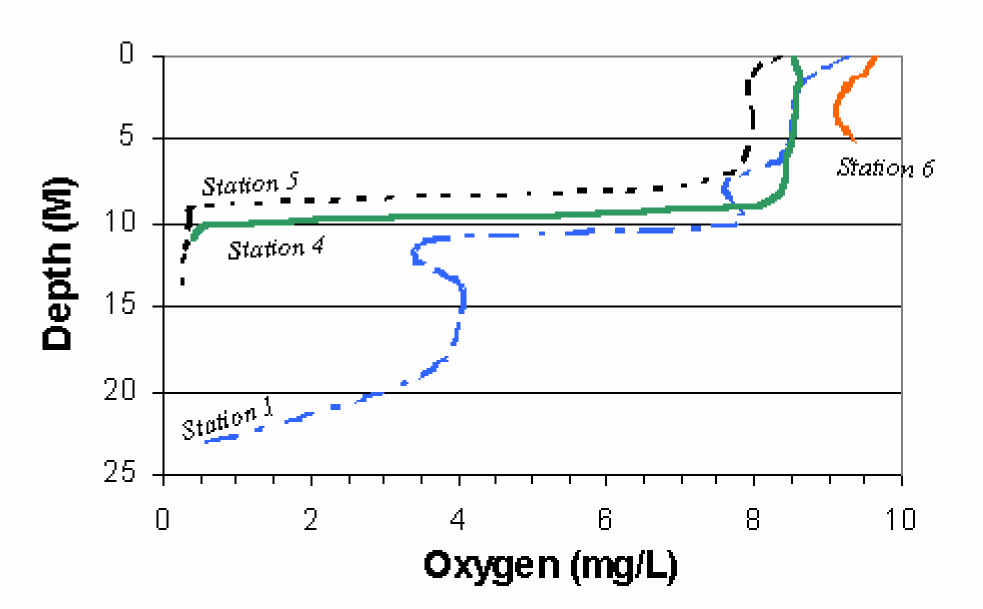


Figure 5. September 16, 2006 oxygen profiles from Lake Tapps monitoring stations.

Lake Discrete Results

The average chlorophyll *a* concentration for Lake Tapps was 3.0 µg/L (Table 4). This concentration is in the mesotrophic range (2.6 – 6.4 µg/L; Carlson, 1977). Concentrations in July through October 2004 were mostly in the oligotrophic range, while later results were mostly in the mesotrophic range (Figure 6).

Table 4. Average results at lake stations.

Constituent	Chlorophyll (µg/L)	Total Phosphorus (µg/L)	TN:TP* (mg N/mg P)
Station 1			
Epilimnion	2.8	6	24
Hypolimnion	NA	11	33
Station 4			
Epilimnion	2.9	4	25
Hypolimnion	NA	6	27
Station 5			
Epilimnion	2.9	4	25
Hypolimnion	NA	10	24
Station 6			
Epilimnion	3.2	5	23
Hypolimnion	NA	7	21
Epilimnetic Average	3.0	5	23

*TN:TP = Total Nitrogen: Total Phosphorus

Total phosphorus (TP) concentrations in the epilimnion averaged 5 µg/L, well within the typical oligotrophic range (<10 µg/L). Individual results rarely exceeded that criterion (Figure 7) except at station 1 during winter draw-down. High nutrient concentrations entering the lake had greater influence on water quality during the winter months when lake levels were low and the lake was not stratified.

TP concentrations in the epilimnion of isolated embayments were always low. Poor circulation, shallow depths, and high residential development leave these embayments at a relatively greater risk of eutrophication. The low phosphorus concentrations at these locations are a good sign that eutrophication problems do not currently exist. On the other hand, TP, total nitrogen (TN), and ammonia were higher in hypolimnion samples, especially at station 5 which is located in the east-central basin. Ammonia in the hypolimnion of station 5 was nearly 10 times epilimnion concentrations, indicating decomposition of organic matter (hypolimnion TN and TP were 2.5 times epilimnion concentrations at station 5).

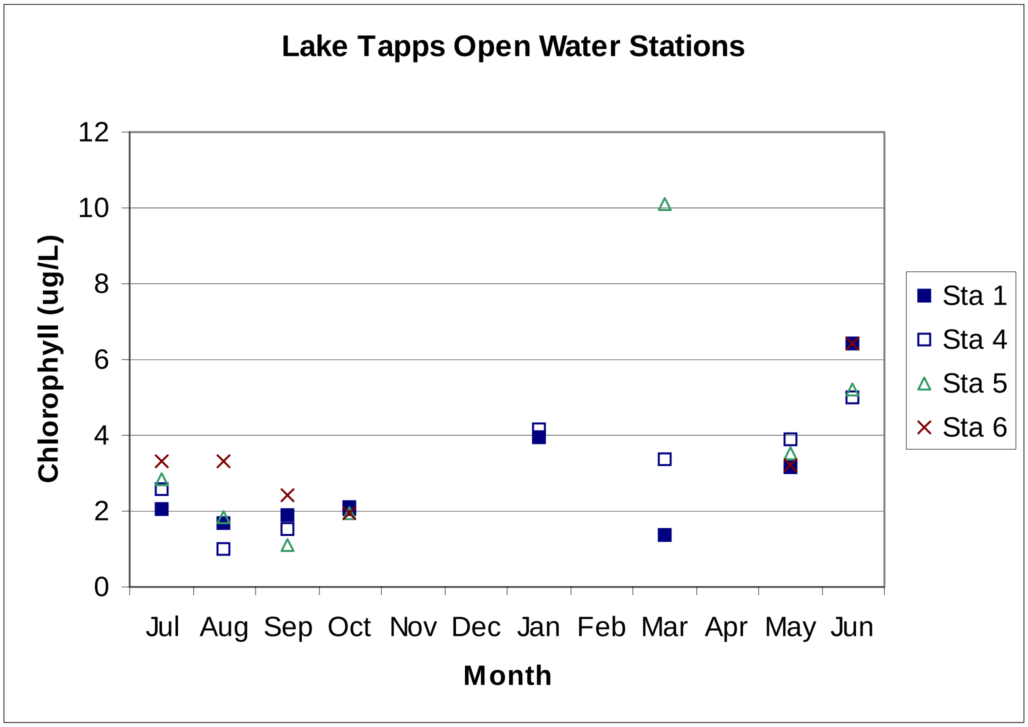


Figure 6. Chlorophyll *a* concentrations at lake stations from July 2004 to June 2005.

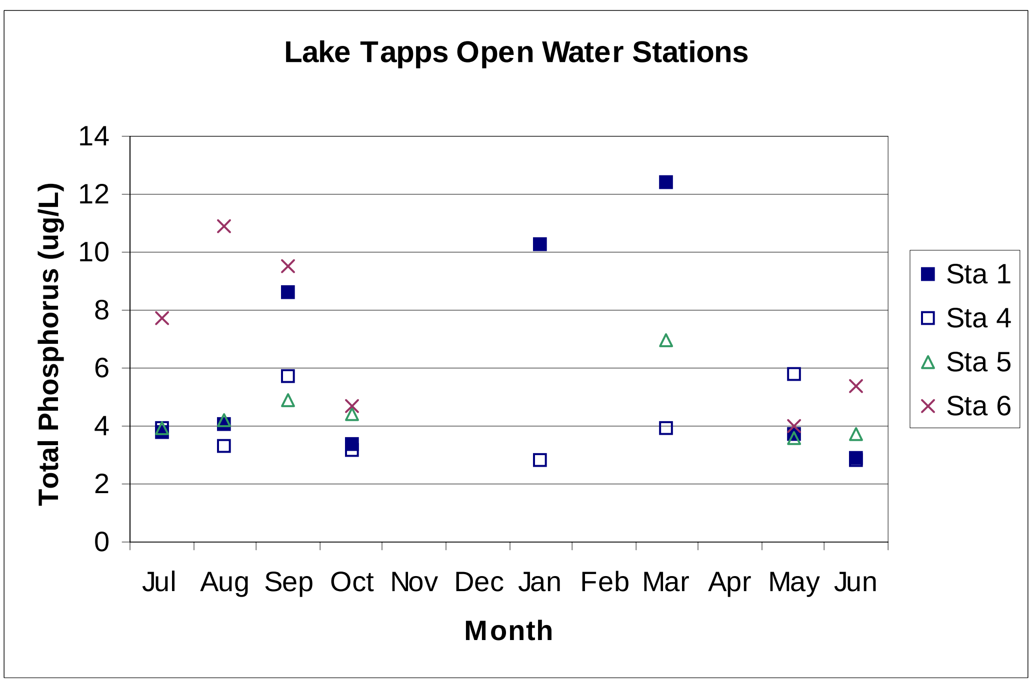


Figure 7. Total phosphorus concentrations at lake stations from July 2004 to June 2005.

Soluble reactive phosphorus (SRP) did not increase much in the hypolimnion even when oxygen concentrations were low, based on composite grab samples. Average overall epilimnion and hypolimnion SRP concentrations were both 3 µg/L. TP concentrations were slightly higher in hypolimnion composites (average 9 µg/L vs. 5 µg/L TP in the epilimnion), probably due at least in part to interflow from the White River diversion. (In preliminary Pierce County data collected at discrete depths rather than composited, phosphorus concentrations were significantly higher in the 10 m sample.)

The average epilimnetic TN:TP ratios at all lake stations indicated that phosphorus was the limiting nutrient.

Lake Tapps is oligotrophic based on nutrient chemistry data, though there was some indication of mesotrophy (Table 5). Secchi depth Trophic State Indices (TSI), which were slightly mesotrophic, can probably be discounted since they were likely influenced by the suspended glacial flour that gives Lake Tapps its remarkable color.

Table 5. Average Carlson's Trophic State Indexes (TSIs) at lake stations.
TSIs <= 40 are indicative of oligotrophy.

Station	TSI (Chlorophyll)	TSI (Total Phosphorus)	TSI (Secchi Depth)
1	40	28	44
4	40	23	41
5	40	23	41
6	41	27	44

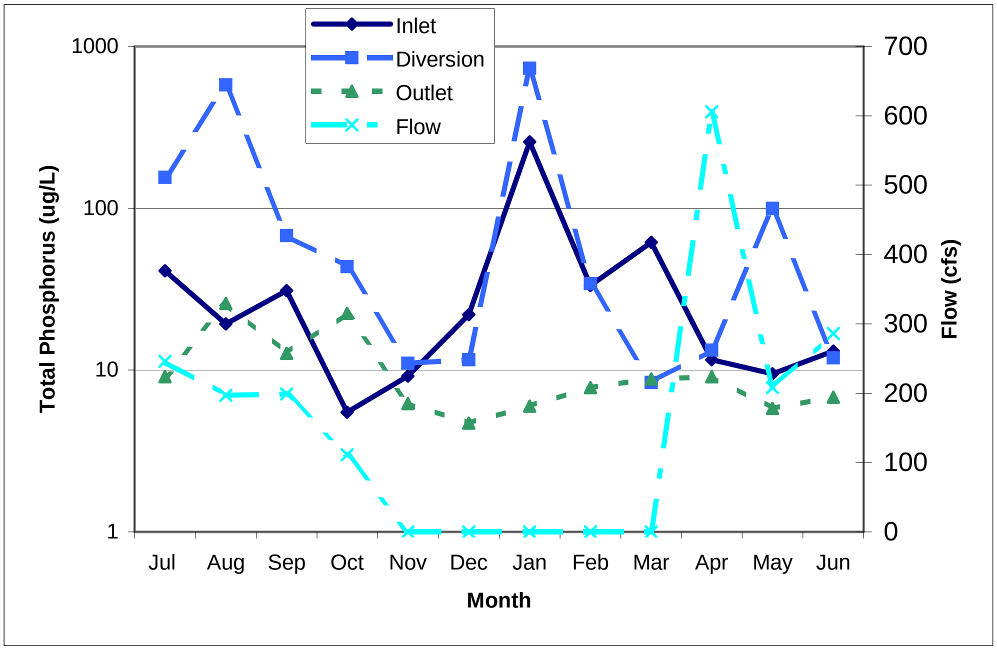
Chlorophyll concentrations, however, indicated that the lake quality was between oligotrophic and mesotrophic. Nutrient and chlorophyll trophic state indicators will not always agree. However, the 12 TSI unit difference at the main lake station (station 1) is within the frequency distribution reported by Carlson (1991) in National Eutrophication Survey data. Furthermore, Carlson (1991) pointed out that under low light conditions, chlorophyll may increase relative to biomass. Hence the chlorophyll TSI may (falsely) indicate a higher biomass than would be expected from the phosphorus TSI under relatively turbid conditions like those in Lake Tapps.

Other indications of mesotrophy include hypolimnetic oxygen depletion (Figure 4) and extensive filamentous algae growth observed near Lake Tapps North Park. These blooms occurred during mid-winter drawdown (Field Notes, Appendix A). Workers at the park also reported that extensive filamentous algae growth occurred periodically on the boat launch. Future limnological researchers of Lake Tapps should consider including a periphyton component.

Tributary Results

The influence and interactions of tributary nutrients were complex, and this study was not designed to determine loading; however, a few points can be made from the completed monitoring work:

- At the White River diversion (station 8), TP concentrations were periodically extremely high (>500 µg/L; Figure 8 and Table 6).
- TP concentrations were usually lower at the lake inlet (station 7) than at the diversion (mean concentrations were 43 and 147 µg/L, respectively). The only times this was not true was when flow was low (Figure 8, top). This reduction between the diversion and the inlet is probably due largely to settling of sediment and associated TP in the diversion channel settling ponds.
- SRP concentrations were also lower at the inlet than at the diversion, though the reduction in the diversion channel was not nearly as great as for TP (mean concentrations were 11 and 16 µg/L, respectively; Figure 8, bottom). This reduction may be due to biological uptake in the diversion channel or settling of the SRP fraction.
- The unusually high TP and SRP concentrations at the inlet in January 2005 could be related to a combination of the unusually low lake levels and a runoff event (Appendix A) allowing entrainment of exposed sediment into the water near the sampling site.
- Theoretically, high enough diversion flows could exceed efficient settling of phosphorus, allowing high nutrient concentrations to enter the lake. This was not observed during this study, however, where the only flow greater than 300 cfs had a low associated TP concentration (Table 6).
- Lake outlet (station 9) TP concentrations were lower than lake inlet concentrations (mean concentrations were 10 and 43 µg/L, respectively), indicating the lake was a net sink for phosphorus.
- TP concentrations were strongly correlated with turbidity at both stations (Table 7).
- TP concentrations at the lake inlet and diversion stations were not strongly correlated with flow at the diversion station nor was turbidity correlated with flow. Normally in rivers and streams, a correlation is expected between flow and both TP and turbidity; however, water quality in the channel was a function of water quality in the White River, while flow was controlled and independent of flow in the river.
- The settling basins appear to significantly reduce TP concentrations entering Lake Tapps when diversion rates and turbidity levels are both at moderate to high levels (Table 6).



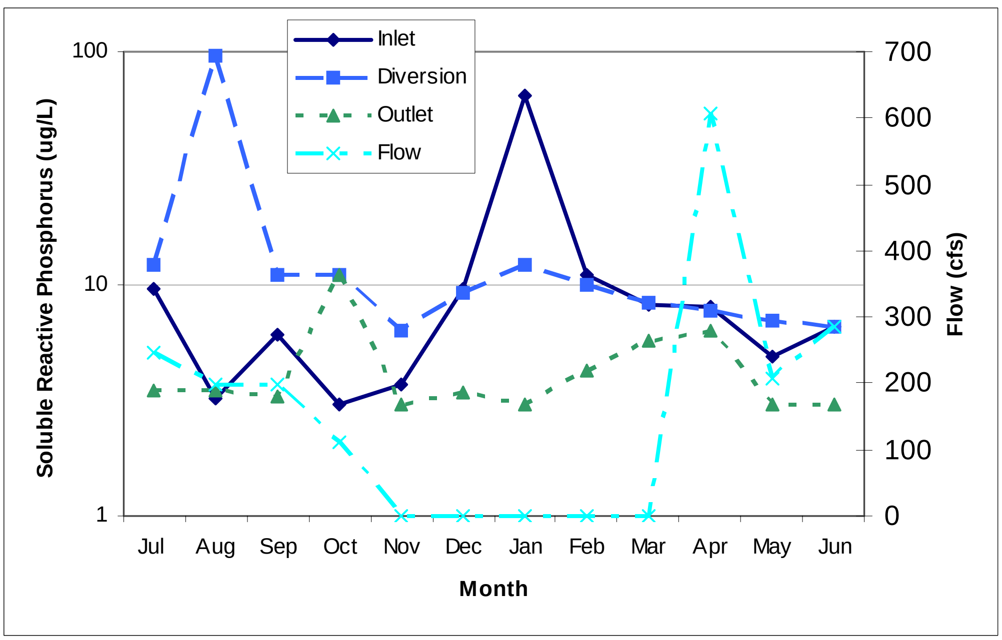


Figure 8. Total phosphorus (top) and soluble reactive phosphorus (bottom) at Lake Tapps inlet and outlet stations. Flow at the diversion is also shown.

Table 6. Percent reduction in total phosphorus (TP), soluble reactive phosphorus (SRP), and turbidity sorted by increasing turbidity at the diversion. The diversion-weighted average weights the average by the concentration at the diversion.

Flow at Diversion (cfs)	Reduction in TP	Reduction in SRP	Reduction in Turbidity	TP at Diversion (µg/L)	SRP at Diversion (µg/L)	Turbidity at Diversion (NTU)
0	-633%	1%	-658%	8.4	8.3	1.2
606	13%	-4%	-45%	13.3	7.6	2.2
0	-90%	-4%	-89%	11.6	9.1	2.4
0	16%	41%	-37%	11.0	6.3	3.4
0	3%	-10%	-134%	34.3	10.0	4.0
286	-10%	-2%	-29%	11.9	6.5	5.0
111	87%	73%	72%	43.5	11.0	23.2
199	54%	45%	-10%	67.7	11.0	32.4
208	91%	29%	92%	100	6.9	42.3
246	73%	21%	70%	155	12.0	147
197	97%	97%	97%	578	96.7	702
0	65%	-436%	94%	734	12.0	1406
Diversion-weighted Average	77%	32%	96%	147	16	198

Table 7. Pearson correlation coefficients between several tributary stream characteristics. Statistically significant correlations ($p<0.10$) are shown in bold. The top number is the correlation coefficient (r); the bottom number is the probability of significance (p). N=12.

	Log TP at Diversion	Log Flow at Diversion	Percent TP Reduction	Log Turbidity at Inlet	Log Turbidity at Diversion
Log TP at Inlet	0.43 (0.16)	-0.46 (0.13)	-0.28 (0.38)	**0.76** **(0.004)**	0.409 (0.19)
Log TP at Diversion	....	0.2 (0.53)	**0.52** **(0.08)**	**0.74** **(0.005)**	**0.98** **(<0.001)**
Log Flow at Diversion	....	....	0.46 (0.13)	-0.026 (0.94)	0.24 (0.46)
Percent TP Reduction	....	....	....	0.15 (0.63)	**0.53** **(0.07)**
Log Turbidity at Inlet	....	....	....	....	**0.76** **(0.004)**

Quality Control Analysis

The performance of the Hydrolab® model Datasonde 4a profiling instrument resulted in few or no problems for conductivity and temperature measurements. All conductivity calibration checks met previously specified criteria (Appendix D; Hallock, 2004). The profiling instrument was not checked for temperature calibration prior to each sampling event because the temperature probe is inherently more stable than other measurements. Periodic checks for temperature made during the course of the sampling season were within criteria.

The pH probe failed on one occasion, and those data have not been reported. Results were slightly outside criteria on one other occasion; those results were coded as estimates ("J").

Oxygen calibration checks failed on four occasions. Results from three of those sampling events were coded as estimates (one set of results was not coded because the criterion was only slightly exceeded and check standard results were good). The quality control (QC) criterion was more stringent than that specified in many studies; all oxygen calibration checks would have passed with a criterion of ±0.4 mg/L. Also, post-calibrations were consistently low; calibration by Winkler titrations rather than saturated air calibration may have improved performance.

Results from sequentially collected profiles were within QC criteria. The 95th percent confidence intervals on the average difference between the original results and the QC results included 0 for all constituents (Table 8).

Turbidimeter calibration checks were always well within instrument criteria for the secondary "gelex" standard.

Table 8. Differences between original profile results and duplicate results for the same depth.

Constituent	Maximum Difference	Average Difference	Number of pairs	Standard Deviation	Lower 95th Percent Confidence Interval	Upper 95th Percent Confidence Interval	QC Criterion (Hallock, 2004)
Conductivity (µS/cm)	1	0.086957	23	0.733178	-0.23011	0.404026	± 10 µs/cm
Oxygen (mg/L)	0.54	0.027391	23	0.232872	-0.07332	0.128099	± 0.2 mg/L
PH (std. units)	0.4	0.036087	23	0.120368	-0.01597	0.088141	± 0.15 std units
Temperature (°C)	0.9	0.047826	23	0.233296	-0.05306	0.148717	± 0.2 °C

Laboratory samples were processed according to procedures specified in Manchester Environmental Laboratory User's Manual and QC guidance (Ecology 2005 and Ecology 2001, respectively). Lab QC requirements were met in all but three cases:

- One soluble reactive phosphorus matrix spike was less than the required limit. Since all other associated QC data were acceptable, no action was taken.
- One chlorophyll duplicate exceeded the acceptance range. This sample was coded as an estimate ("J").
- One turbidity sample had to be diluted to bring it into the range of the meter. This sample was also coded as an estimate.

QC evaluations of discrete samples used the pooled standard deviation of sequentially collected samples, converted to a relative standard deviation by dividing by the mean of all results and expressed as a percent (%RSDp). The Quality Assurance Project Plan (Hallock, 2004) establishes criteria based on split samples. Comparing sequential samples (i.e., the QC sample was collected immediately after the primary sample) is more stringent than comparing split samples because sequential samples include environmental and sampling variability in addition to variability due to field processing and lab analyses.

All sequentially sampled duplicates met split sample QC criteria except ammonia, phosphorus, and turbidity (Table 9). For ammonia and turbidity, the split-sample %RSDp were 5.4 and 3.1 percent, respectively, and did not exceed applicable criteria. There were insufficient split samples from this study to evaluate phosphorus against criteria; however, recent split-sample results from the stream monitoring program yielded a %RSDp of 2.8 percent, within criteria.

Table 9. Quality control results for discrete or composited samples collected sequentially. Results exceeding the QC precision criterion for split samples (Table 3 in Hallock, 2004) are shown in bold.

Constituent	No. of sequential sample pairs	Average Result	%RSDp or Difference [a]	QC Precision Criterion
Nitrogen, ammonia (mg/L)	7	0.011	**16.9%**	10%
Chlorophyll a (µg/L)	5	3.66	15.5%	20%
Nitrogen, nitrate-nitrite (mg/L)	7	0.042	0.9%	10%
Secchi depth (ft)	7	12.0	0.1 m	±0.5m
Solids, total suspended (mg/L)	5	2.5	12.6%	20%
Solids, total volatile (mg/L)	5	1.4	0.0%	20%
Phosphorus, soluble reactive (µg/L)	7	3.8	7.3%	10%
Nitrogen, total (mg/L)	7	0.12	8.6%	10%
Phosphorus, total (µg/L)	7	5.9	**18.9%**	10%
Turbidity (NTU)	7	3.4	**12.4%**	10%

[a] %RSDp is the pooled relative standard deviation (pooled standard deviation divided by the mean of all samples) expressed as a percent. For Secchi depth, the test value is the mean difference between duplicates.

All blank results were less than reporting limits.

Conclusions

Conclusions from this July 2004 – June 2005 study are as follows:

- Hypolimnetic oxygen concentration approached 0 mg/L during some months near the bottom of the lake.
- With some exceptions, chlorophyll concentrations indicated an oligo-mesotrophic lake condition.
- Phosphorus concentrations were almost always in the oligotrophic range.
- Epilimnion phosphorus concentrations were always low in the main embayments, indicating that eutrophication was not currently a problem. On the other hand, hypolimnetic anoxia and subsequent elevated concentrations of phosphorus, nitrogen, and ammonia in the hypolimnion (particularly at station 5) are indicators of mesotrophic conditions.
- Abundant filamentous algae growth near Lake Tapps North Park was observed during winter drawdown. Future studies of Lake Tapps should consider including a periphyton component.
- Water diverted from the White River had very high phosphorus concentrations at times, though significant settling (and possible biological uptake) occurred in the diversion channel prior to entering the lake.
- Total phosphorus concentrations at the diversion and the inlet were highly correlated with turbidity, but not with the diversion flow rates.
- The settling basins appear to significantly reduce total phosphorus loads to Lake Tapps when diversion rates and turbidity levels are both at moderate to high levels.

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Appendix A. Sample Notes

Date	Time	Field Notes	Epilimnion Composite Depths (M)	Hypolimnion Composite Depths (M)
Station 1 (Main Lake)				
Jul 7, 2004	1415	No depth sensor. Married h-lab to secchi for depths. 10M sample cloudy but 20M sample clear. Bottom at 24.2M on Kemmerer. Wind quickening from SE; some drift during sampling.	01-02-04	10-20-00
Aug 11, 2004	1500	Choppy due to boat traffic: Secchi hard to read. Took QC sample from epilimnion. 10M sample hazy; other samples clear. Bottom at 25.3 M. Other boats were touring, PWC, Tubing.	01-03-05	10-15-23
Sep 16, 2004	1300	Watercraft a PWC. Boat mechanical problems yesterday so couldn't sample lake on same day as tribs. Fairly windy at times; a dark rainy day. 15M sample cloudy, 20M sample clear. No odor.	02-04-06	15-20-00
Oct 6, 2004	1446	Slight haze in 15 M sample. No H2S in any samples.	00-03-06	10-15-20
Jan 19, 2005	1245	Warm (~60°F) breeze. Eagle. Lake level down so boat had to be carried to access lake. Stumps protruding 5 ft (some 1ft below surface). Breeze picked up slightly causing drift towards end of sampling.	05-10-15	None
Mar 8, 2005	1315	Lake maybe a foot higher than last month. Thick beds of filamentous algae at channel leaving state park launch. Sunny, warm (~60F). Tiny algae colonies visible and fairly thick against background of Secchi disk.	05-10-15	None
May 10, 2005	1310	Lake is back up to full volume. Bottom at 25.3M.	01-02-03	15-00-00
Jun 7, 2005	1355	1 boat in transit. A few large daphnia in 20M samples. 1 or 2 in 15M. Bottom @ 25.3M.	01-03-05	15-20-00
Station 4 (Northeast basin, across from Lake Tapps North Park)				
Jul 7, 2004	1525	No depth readings. Getting depths by estimation or by marrying Hlab to Secchi. pH may be suspect (it gave erroneously low readings at later stations). Cloudier; bottom on Kemmerer was 15.0M. Fine clean gray sediment.	01-02-04	10-12-00
Aug 11, 2004	1618	Trees on bottom at this site can snag the anchor. Other boats were sailing, PWC, touring, and tubing.	01-02-03	10-12-00
Sep 16, 2004	1350	No odor in hypo sample.	02-05-08	10-00-00
Oct 6, 2004	1535	Sample from 12m hazy and strong H2S odor. No H2S in 10m sample.	00-03-06	10-12-00
Jan 19, 2005	1400	Tied to 1 of a forest of stumps. Didn't try to access #6. #5 MAY have been accessible, but did not sample. NE basin (#4) is completely isolated from main lake except for a narrow man-made channel.	01-02-04	None
Mar 8, 2005	1545	D.O. check collected at 1M. Not fixed for ~1.75 hours, however, until return to lab. No Hlab QC (see 3/9 QC at Erie).	01-02-03	None
May 10, 2005	1350	Bottom at 15.2M.	01-02-03	10-00-00
Jun 7, 2005	1435	Jetski, canoe. No daphnia in deep sample. Bottom at 9.3 M.	01-02-04	08-00-00
Station 5 (East central basin, south of Golf Course)				
Jul 7, 2004	1625	No depth sensor. This sample date, getting depths by estimation or by marrying Hlab to Secchi. pH may be suspect (it gave erroneously low readings at later stations).	01-02-04	08-10-00
Aug 11, 2004	1658	H2S odor at 10M; strong at 14M. Other boats touring, tubing, and PWC.	01-02-04	10-14-00

Date	Time	Field Notes	Epilimnion Composite Depths (M)	Hypolimnion Composite Depths (M)
Sep 16, 2004	1500	H2S in 10 and 12 M samples, but not as strong at 12M as last month	02-04-06	08-10-12
Oct 6, 2004	1610	Took oxygen sample at 1.5 meters for QC. Strong H2S in 12m sample but not in 8 or 10m samples.	01-03-05	08-10-12
Mar 8, 2005	1430	Water a hazy brown. Several geese seen on way to station. InSitu probe hit bottom at 8.4M. Bottom 8.27 on Hlab	01-03-05	None
May 10, 2005	1230	1 paddle boat, 3 kids swimming from the shore. Bottom at 13.9M.	01-02-03	10-00-00
Jun 7, 2005	1308	Boat in transit. A few big daphnia in 14 M sample. Bottom at 14.8 M.	01-02-04	10-14-00
Station 6 (Southeast basin, east of inlet)				
Jul 7, 2004	1330	No depth sensor. Married h-lab to secchi for depths. pH quit working later, so all pHs may be suspect—though pre-calibration was good. Not stratified so no hypo samples	01-02-04	None
Aug 11, 2004	1420	Color green-white. Whiter that last month. Not stratified. Other boats: PWC, tubing.	00-01-02	None
Sep 16, 2004	1230	Boats touring and PWC. Bottom at 4.9 M.	01-02-04	None
Oct 6, 2004	1415	Not as turbid as previously. Weather has been cooler lately perhaps reducing glacial melt. No hypo sample.	01-02-04	None
May 10, 2005	1150	2 boats in transit, 1 skier. Water level up to full. Bottom at 5.4M.	01-02-00	04-00-00
Jun 7, 2005	1215	Water hazy. Bottom at 5.5M	01-02-03	05-00-00
Station 7 (Lake inlet, from 218th Street Bridge)				
Jul 7, 2004	1120	Nutrient and turbidity samples only. Bridge construction: sampled from bank, downstream (lat: 47 11 48, long: 122 08 18). Water milky but much less brown that at diversion.		
Aug 11, 2004	1100	White-colored. Flows about where they were last month or perhaps a little lower. Bridge still under construction; sampled downstream where last month's sample was taken.		
Sep 15, 2004	1030	Very turbid (white). Little flow.		
Oct 6, 2004	1205	Little flow. Greenish and less white that previous months.		
Nov 8, 2004	1200	Very little flow. Greenish.		
Dec 6, 2004	1305	Hard rain last night; no rain today. About 8 feet below normal summer level. No flow noticeable.		
Jan 19, 2005	1030	Water level very low but with definite flow. Not too turbid but sickly yellowish color. Lots of dumping from bridge (e.g., a transmission). Heavy rains on Monday, lighter rains yesterday.		
Feb 8, 2005	1040	Same appearance as last month.		
Mar 8, 2005	1030	Like last month or even lower. Nearly stagnant; very slight flow. Yellowish.		
Apr 5, 2005	1135	About 5 ft higher than last month. Clear, greenish hue.		
May 10, 2005	1030	Water level up to about normal. Green, no apparent flow.		
Jun 7, 2005	1030	Typical water level and flow. Thermistor not working; temps from pH probe.		

Appendix A. Sample Notes (cont.)

Date	Time	Field Notes	Flow (cfs) [a]
Station 8 (Diversion, end of River Road)			
Jul 7, 2004	1035	Nutrient and turbidity samples only. Very turbid: milky-brown like weak coffee and cream. Took QC (sequential duplicate) of nutrients and turbidity.	245
Aug 11, 2004	1030	White and reddish-brown colored. Flows about where they were last month or perhaps a little lower.	197
Sep 15, 2004	0950	Still very turbid (white-brown) but clearer and without reddish tinge it had last month.	199
Oct 6, 2004	1135	Flow like previous month. White to light brown (watery coffee with a little cream).	111
Nov 8, 2004	1135	Water level is ~1’5" below previous and much clearer	0
Dec 6, 2004	1155	Hard rain last night; no rain today. About 5" lower than last month and very clear. Silty bottom visible.	0
Jan 19, 2005	0945	Level may be lower. Barely got bucket to submerge. Very brown, however.	0
Feb 8, 2005	1005	A few inches higher (10-12?) than last month. Not too turbid.	0
Mar 8, 2005	1000	Very low and clear. Like last month. Diversion dam is damaged so lake may take longer to fill this year until it can be repaired.	0
Apr 5, 2005	1050	High, fast, and clear.	606
May 10, 2005	1000	Water level up but ~1 foot below high water mark on wall. Very brown and turbid.	208
Jun 7, 2005	1000	Typical flow. Greenish, not too turbid.	286
Station 9 (Outlet, from East Valley Highway Bridge)			
Jul 7, 2004	0945	Nutrient and turbidity samples only. Even at outlet, water is a little milky.	
Aug 11, 2004	0940	White-colored. Flows about where they were last month or perhaps a little lower.	
Sep 15, 2004	0905	Looks same as last month in color and volume. One chinook (?) hanging out below bridge.	
Oct 6, 2004	1055	Very little flow (almost dry)	
Nov 8, 2004	1040	Flows back to normal compared to last month. Fairly clear.	
Dec 6, 2004	1100	Hard rain last night; no rain today. Flow is typical but clearer than usual. Drain just below bridge has a whitish discharge (188NTUs).	
Jan 19, 2005	0905	Same appearance as last month. Drain discharging turbid plume (99.8NTU) visible for a long way along the RB.	
Feb 8, 2005	0925	May be slightly lower than last mo. Only a little turbid discharge from drain.	
Mar 8, 2005	0900	Very low flow. Very slight flow from one culvert.	
Apr 5, 2005	1010	Water level low; clear--like past few months.	
May 10, 2005	0920	Flows up, windows rattling in powerhouse. Highly turbid discharge from culverts again.	
Jun 7, 2005	0920	Typical flow; rattling powerhouse windows. Clear. No discharge from culverts.	

[a] Flows are interpolated from hourly flows provided by Puget Sound Energy.

Appendix B. Profile Results (Including subsurface tributary measurements)

Date	Depth (M)	Conductivity (µS/cm)		Oxygen (mg/L)		pH (Std. Units)		Temperature (°C)	
Station 1 (Main Lake)									
Jul 07, 2004	0	50		8.78				21.4	
Jul 07, 2004	1	50		8.7				21.4	
Jul 07, 2004	2	49		8.7				21.3	
Jul 07, 2004	3	49		8.7				21.2	
Jul 07, 2004	4	50		8.7				21.2	
Jul 07, 2004	6	45		9				18.3	
Jul 07, 2004	8	42		8.4				16.7	
Jul 07, 2004	10	43		7.7				15.7	
Jul 07, 2004	15	50		6.5				8.5	
Jul 07, 2004	20	51		6				7.6	
Jul 07, 2004	23.7	52		5.6				7.5	
Aug 11, 2004	0	54		8.53		8.2		24.7	
Aug 11, 2004	0.9	54		8.45		8		24.5	
Aug 11, 2004	1.8	54		8.46		7.9		24.2	
Aug 11, 2004	3	54		8.51		7.9		23.8	
Aug 11, 2004	4.6	53		8.69		7.9		22.4	
Aug 11, 2004	6.1	53		8.61		7.8		21.8	
Aug 11, 2004	7.6	51		8		7.6		19.1	
Aug 11, 2004	9.1	51		7.77		7.5		17.3	
Aug 11, 2004	10.7	48		5.31		7.3		15.5	
Aug 11, 2004	12.2	51		4.61		7.1		11.8	
Aug 11, 2004	15.2	52		5.23		7.1		8.3	
Aug 11, 2004	18.3	53		5.13		7		7.8	
Aug 11, 2004	21.3	55		4.54		6.9		7.6	
Aug 11, 2004	24.7	64		0.7		6.8		7.3	
Sep 16, 2004	0	58		9.27		7.7		18.1	
Sep 16, 2004	1	59		8.84	J	7.7		18.1	
Sep 16, 2004	2	59		8.6	J	7.7		18.1	
Sep 16, 2004	4	59		8.5	J	7.6		18.1	
Sep 16, 2004	6	59		8.39	J	7.6		18	
Sep 16, 2004	8	60		7.6	J	7.5		17	
Sep 16, 2004	10	59		7.8	J	7.4		15.6	
Sep 16, 2004	11	58		3.7	J	7.1		13.7	
Sep 16, 2004	12	60		3.39	J	7		11.7	
Sep 16, 2004	13	60		3.86	J	6.9		9.6	
Sep 16, 2004	14	60		4.09	J	6.9		8.7	
Sep 16, 2004	16	62		4	J	6.8		8.1	
Sep 16, 2004	18	62		3.83	J	6.8		7.8	
Sep 16, 2004	20	64		2.98	J	6.8		7.6	
Sep 16, 2004	23	74		0.6	J	6.7		7.5	
Oct 06, 2004	0	58		9.5		7.5		16.8	
Oct 06, 2004	1	58		9.35		7.5		16.8	

Date	Depth (M)	Conductivity (µS/cm)		Oxygen (mg/L)		pH (Std. Units)		Temperature (°C)	
Oct 06, 2004	2	58		9.35		7.5		16.8	
Oct 06, 2004	4	58		9.35		7.5		16.7	
Oct 06, 2004	6	58		8.9		7.4		16.3	
Oct 06, 2004	7	59		8.4		7.2		14.9	
Oct 06, 2004	8	60		8.45		7.1		14.5	
Oct 06, 2004	9	61		8.6		7.1		14	
Oct 06, 2004	10	62		8.7		7.1		13.8	
Oct 06, 2004	12	59		7.1		6.9		13	
Oct 06, 2004	13	59		3		6.6		11.8	
Oct 06, 2004	14	59		2.8		6.5		10.3	
Oct 06, 2004	16	59		3.4		6.5		8.4	
Oct 06, 2004	18	60		3.3		6.4		7.9	
Oct 06, 2004	20	61		2.7		6.4		7.7	
Oct 06, 2004	21.1	62		2.2		6.4		7.7	
Jan 19, 2005	0	60		12.4		7.6		5.6	
Jan 19, 2005	1	60		12.4		7.5		4.6	
Jan 19, 2005	2	60		12.4		7.5		4.5	
Jan 19, 2005	4	60		12.2		7.5		4.5	
Jan 19, 2005	6	60		12.1		7.4		4.5	
Jan 19, 2005	8	62		12		7.4		4.2	
Jan 19, 2005	10	62		12		7.4		4.2	
Jan 19, 2005	15	64		11.9		7.3		4.4	
Jan 19, 2005	20.1	80		11.3		7		4.5	
Mar 08, 2005	0	66		12.43		8.8		12.1	
Mar 08, 2005	1	66		12.09		8.4		10.1	
Mar 08, 2005	2	65		12.08		8.2		8.9	
Mar 08, 2005	3	65		12.31		8		8.1	
Mar 08, 2005	4	64		12.31		7.9		6.6	
Mar 08, 2005	6	64		12.1		7.8		6	
Mar 08, 2005	8	65		11.83		7.7		5.5	
Mar 08, 2005	10	64		11.71		7.6		5.3	
Mar 08, 2005	15	66		11.3		7.5		5	
Mar 08, 2005	19.9	70		8.64		7.2		5	
May 10, 2005	0	58		10.96		8	J	15.5	
May 10, 2005	1	59		10.75		8	J	15.5	
May 10, 2005	2	58		10.64		8	J	15.5	
May 10, 2005	3	59		10.8		8	J	15.4	
May 10, 2005	4	59		10.8		7.9	J	15.3	
May 10, 2005	5	58		11.3		7.6	J	11.2	
May 10, 2005	6	58		11.01		7.3	J	11.2	
May 10, 2005	8	59		10.93		7.2	J	9.7	
May 10, 2005	10	59		10.73		7.2	J	8.8	
May 10, 2005	12	59		10.75		7.1	J	8.5	
May 10, 2005	15	59		10.62		7	J	8	
May 10, 2005	20	60		10.11		6.9	J	7.6	
May 10, 2005	25	61		8.3		6.8	J	7.3	
Jun 07, 2005	0	58		9.45	J	8.7		17	

Date	Depth (M)	Conductivity (µS/cm)		Oxygen (mg/L)		pH (Std. Units)		Temperature (°C)	
Jun 07, 2005	1	58		9.41	J	8.7		17	
Jun 07, 2005	2	58		9.43	J	8.7		17	
Jun 07, 2005	3	58		9.42	J	8.6		16.9	
Jun 07, 2005	4	58		9.34	J	8.6		16.9	
Jun 07, 2005	5	58		9.37	J	8.5		16.8	
Jun 07, 2005	6	57		9	J	7.8		14.9	
Jun 07, 2005	8	55		8.3	J	7.5		12.6	
Jun 07, 2005	10	58		7.36	J	7.2		10.1	
Jun 07, 2005	12	58		7.85	J	7.1		8.8	
Jun 07, 2005	15	58		7.9	J	7.1		8.1	
Jun 07, 2005	20	59		6.88	J	7		7.7	
Jun 07, 2005	25	64		3.66	J	6.9		7.4	
Station 4 (Northeast basin, across from Lake Tapps North Park)									
Jul 07, 2004	0	50		8.5				21.7	
Jul 07, 2004	1	50		8.3				21.7	
Jul 07, 2004	2	50		8.4				21.3	
Jul 07, 2004	4	50		8.4				21.2	
Jul 07, 2004	6	49		8.7				19.3	
Jul 07, 2004	7	50		7.8				16.2	
Jul 07, 2004	8	50		7.2				14.1	
Jul 07, 2004	10	50		3.8				9.8	
Jul 07, 2004	12	50		1.8				7.5	
Jul 07, 2004	14.5	51		0.7				7.3	
Aug 11, 2004	0	54		8.3		8.1		24.8	
Aug 11, 2004	1.5	54		8.26		7.9		24.6	
Aug 11, 2004	3	54		8.37		7.9		24	
Aug 11, 2004	4.6	53		8.56		7.9		22.9	
Aug 11, 2004	6.1	54		8.44		7.9		22.3	
Aug 11, 2004	7.6	53		7.41		7.6		19.5	
Aug 11, 2004	9.1	53		4.93		7.4		15.8	
Aug 11, 2004	10.7	53		1.53		7.1		12.2	
Aug 11, 2004	13.4	53		0.52		6.9		10.2	
Sep 16, 2004	0	58		8.55	J	7.6		18.6	
Sep 16, 2004	1	59		8.59	J	7.6		18.6	
Sep 16, 2004	2	58		8.56	J	7.6		18.5	
Sep 16, 2004	4	59		8.55	J	7.5		18.6	
Sep 16, 2004	6	59		8.43	J	7.5		18.4	
Sep 16, 2004	8	59		8.38	J	7.4		18.3	
Sep 16, 2004	9	59		7.88	J	7.4		18.2	
Sep 16, 2004	10	61		0.59	J	6.6		14.4	
Sep 16, 2004	10.9	61		0.4	J	6.6		12.5	
Oct 06, 2004	0	57		9.21		7.4		17.4	
Oct 06, 2004	1	57		9.05		7.4		17.4	
Oct 06, 2004	2	57		8.99		7.4		17.3	
Oct 06, 2004	4	57		8.6		7.3		17	
Oct 06, 2004	6	57		8.4		7.3		16.8	
Oct 06, 2004	8	57		8.2		7.2		16.6	

Date	Depth (M)	Conductivity (µS/cm)		Oxygen (mg/L)		pH (Std. Units)		Temperature (°C)	
Oct 06, 2004	10	57		7.75		7.1		16.4	
Oct 06, 2004	11	57		4.64		6.9		15.8	
Oct 06, 2004	12	61		0.7		6.4		12.9	
Oct 06, 2004	12.6	61		0.3		6.4		11.9	
Jan 19, 2005	0	56		12.7		7.5		5.8	
Jan 19, 2005	1	54		12.9		7.6		4.2	
Jan 19, 2005	2	55		13		7.5		4.1	
Jan 19, 2005	3	55		13		7.6		4	
Jan 19, 2005	4	55		12.8		7.6		4	
Jan 19, 2005	5	55		12.8		7.5		3.9	
Mar 08, 2005	0	59		11.68		8.6		12.9	
Mar 08, 2005	1	59		11.84		8.5		11.9	
Mar 08, 2005	2	59		12.18		8.5		10.2	
Mar 08, 2005	3	58		12.5		8.4		8.8	
Mar 08, 2005	4	57		12.92		8.4		7.6	
Mar 08, 2005	4.4	57		12.94		8.4		7.3	
May 10, 2005	0	59		10.76		8.1	J	16.1	
May 10, 2005	1	59		10.56		8.2	J	16	
May 10, 2005	2	59		10.54		8.1	J	15.8	
May 10, 2005	3	59		11.15		8.1	J	15.1	
May 10, 2005	4	59		11.44		7.9	J	14.2	
May 10, 2005	5	59		11		7.6	J	11.9	
May 10, 2005	6	59		10.55		7.4	J	10.8	
May 10, 2005	7	60		10.2		7.3	J	10.5	
May 10, 2005	8	60		9.85		7.2	J	10.2	
May 10, 2005	10	61		8.51		7	J	9.4	
May 10, 2005	12	62		7.99		6.9	J	8.6	
May 10, 2005	15	62		4.65		6.8	J	7.1	
Jun 07, 2005	0	58		9.32	J	8.5		17.2	
Jun 07, 2005	1	58		9.25	J	8.6		17.2	
Jun 07, 2005	2	58		9.22	J	8.6		17.1	
Jun 07, 2005	3	58		9.12	J	8.5		17	
Jun 07, 2005	4	57		9.12	J	8.4		17	
Jun 07, 2005	5	58		9.1	J	8.3		16.8	
Jun 07, 2005	6	58		10.14	J	8.3		14.8	
Jun 07, 2005	8	59		8.82	J	7.6		11.6	
Jun 07, 2005	9	59		6.94	J	7.3		11	
Station 5 (East central basin, south of Golf Course)									
Jul 07, 2004	0	50		8.6				21.5	
Jul 07, 2004	1	50		8.5				21.5	
Jul 07, 2004	2	50		8.4				21.5	
Jul 07, 2004	3	50		8.4				21.3	
Jul 07, 2004	4	50		8.4				21.7	
Jul 07, 2004	5	50		8.3				20.2	
Jul 07, 2004	6	48		6.6				16	
Jul 07, 2004	7	55		1.2				13	
Jul 07, 2004	8	60		0.5				11.1	

Date	Depth (M)	Conductivity (µS/cm)		Oxygen (mg/L)		pH (Std. Units)		Temperature (°C)	
Jul 07, 2004	10	68		0.4				8.7	
Jul 07, 2004	12	91		0.3				8.3	
Aug 11, 2004	0	54		8.41		8		24.8	
Aug 11, 2004	1.5	54		8.45		7.8		24.6	
Aug 11, 2004	3	54		8.68		7.9		23.1	
Aug 11, 2004	4.6	53		8.68		7.8		22.3	
Aug 11, 2004	6.1	53		8.43		7.7		21.4	
Aug 11, 2004	7.6	52		5.35		7.4		17.8	
Aug 11, 2004	9.1	65		0.72		7.1		14.3	
Aug 11, 2004	10.7	61		0.48		7		10.6	
Aug 11, 2004	12.2	69		0.35		7		9	
Aug 11, 2004	13.7	86		0.4		6.9		8.5	
Sep 16, 2004	0	59		8.38	J	7.4		18.6	
Sep 16, 2004	1	58		8.03	J	7.4		18.6	
Sep 16, 2004	2	60		7.91	J	7.4		18.6	
Sep 16, 2004	4	60		7.99	J	7.4		18.4	
Sep 16, 2004	6	60		7.88	J	7.4		18.4	
Sep 16, 2004	7	60		7.65	J	7.3		18.1	
Sep 16, 2004	8	61		6.73	J	7.2		17.5	
Sep 16, 2004	9	85		0.45	J	6.5		13.3	
Sep 16, 2004	10	77		0.38	J	6.5		11.7	
Sep 16, 2004	12	99		0.29	J	6.5		8.9	
Sep 16, 2004	13.6	115		0.28	J	6.5		8.6	
Oct 06, 2004	0	58		9.44		7.4		17	
Oct 06, 2004	1	58		9.35		7.4		17	
Oct 06, 2004	2	58		9.3		7.4		17	
Oct 06, 2004	4	58		9.15		7.4		17	
Oct 06, 2004	5	58		9		7.3		16.9	
Oct 06, 2004	6	58		7.15		7.1		15.6	
Oct 06, 2004	7	59		7.33		7		15.2	
Oct 06, 2004	8	59		7.2		6.9		14.5	
Oct 06, 2004	9	61		5		6.8		14.3	
Oct 06, 2004	10	68		0.53		6.5		13.4	
Oct 06, 2004	12	79		0.2		6.5		9.7	
Oct 06, 2004	14	110		0.2		6.6		8.7	
Oct 06, 2004	15	126		0.2		6.7		8.5	
Mar 08, 2005	0	69		12.31		8.9		12.8	
Mar 08, 2005	1	70		12.39		8.9		12.6	
Mar 08, 2005	2	69		12.76		8.6		9.5	
Mar 08, 2005	3	68		12.99		8.4		7.7	
Mar 08, 2005	4	68		12.4		8.1		6.8	
Mar 08, 2005	6	68		12.05		8		6.1	
Mar 08, 2005	8	69		11.31		7.8		5.7	
May 10, 2005	0	59		10.94		8	J	15.8	
May 10, 2005	1	59		10.65		8	J	15.8	
May 10, 2005	2	59		10.56		8	J	15.7	
May 10, 2005	3	59		10.57		7.9	J	15.5	

Date	Depth (M)	Conductivity (µS/cm)		Oxygen (mg/L)		pH (Std. Units)		Temperature (°C)	
May 10, 2005	4	58		10.94		7.5	J	12.8	
May 10, 2005	5	57		10.83		7.4	J	11.8	
May 10, 2005	6	58		10.38		7.3	J	10.4	
May 10, 2005	8	58		9.62		7.1	J	9.6	
May 10, 2005	10	59		8.57		6.9	J	8.8	
May 10, 2005	12	59		8.48		6.9	J	8.3	
May 10, 2005	13.5	60		7.34		6.8	J	8.2	
Jun 07, 2005	0	58		9.45	J	8.4		17.2	
Jun 07, 2005	1	58		9.45	J	8.4		17.2	
Jun 07, 2005	2	58		9.25	J	8.4		17.2	
Jun 07, 2005	3	58		9.27	J	8.3		17.2	
Jun 07, 2005	4	58		9.43	J	8.3		17.1	
Jun 07, 2005	5	57		9.28	J	7.9		16.3	
Jun 07, 2005	6	57		9.23	J	7.6		14.8	
Jun 07, 2005	8	59		6.24	J	7		11.5	
Jun 07, 2005	10	61		4.17	J	6.9		9.8	
Jun 07, 2005	12	62		3.91	J	6.9		8.7	
Jun 07, 2005	14	66		2.13	J	6.8		8.4	
Station 6 (Southeast basin, east of inlet)									
Jul 07, 2004	0	50		8.4				21.9	
Jul 07, 2004	1	50		8.2				21.9	
Jul 07, 2004	2	50		8.24				21.8	
Jul 07, 2004	3	49		7.93				21.6	
Jul 07, 2004	4	48		7.87				20.2	
Jul 07, 2004	5	49		6.9				19.1	
Aug 11, 2004	0	54		8.5		7.9		24.7	
Aug 11, 2004	1	54		8.46		7.8		24.6	
Aug 11, 2004	2	54		8.47		7.7		24.2	
Aug 11, 2004	2.6	54		8.5		7.7		23.6	
Sep 16, 2004	0	59		9.66	J	7.7		18.4	
Sep 16, 2004	1	59		9.49	J	7.7		18.3	
Sep 16, 2004	2	59		9.24	J	7.7		18.2	
Sep 16, 2004	3	59		9.1	J	7.6		18.2	
Sep 16, 2004	4	60		9.15	J	7.6		17.9	
Sep 16, 2004	4.9	59		9.35	J	7.6		17.2	
Oct 06, 2004	0	58		9.26		7.6		17.3	
Oct 06, 2004	1	58		9.16		7.6		17.3	
Oct 06, 2004	2	58		9.2		7.6		17	
Oct 06, 2004	3	58		9.05		7.5		16.8	
Oct 06, 2004	4	58		8.81		7.4		16.6	
Oct 06, 2004	5	61		5.3		7.1		16.2	
May 10, 2005	0	58		10.34		7.7	J	16.1	
May 10, 2005	1	59		10.39		7.7	J	16.1	
May 10, 2005	2	58		10.35		7.7	J	15.7	
May 10, 2005	3	57		10.83		7.5	J	12.5	
May 10, 2005	4	58		10.55		7.4	J	11.9	
May 10, 2005	5	58		9.75		7.3	J	10.9	

Date	Depth (M)	Conductivity (µS/cm)		Oxygen (mg/L)		pH (Std. Units)		Temperature (°C)	
Jun 07, 2005	0	57		9.71	J	8.4		17.3	
Jun 07, 2005	1	57		9.62	J	8.4		17.3	
Jun 07, 2005	2	57		9.55	J	8.3		17.2	
Jun 07, 2005	3	57		9.54	J	8.3		17.1	
Jun 07, 2005	4	56		9.63	J	8.1		16.2	
Jun 07, 2005	5	59		5.22	J	7.2		15.2	
Station 7 (Inlet, from 218th Street Bridge)									
Aug 11, 2004								17.7	
Sep 15, 2004		60				7.5		15.6	
Oct 06, 2004		61				7.7		16.6	
Nov 08, 2004		67				7.6		8.2	
Dec 06, 2004		95				7.2		5.1	
Jan 19, 2005		138				6.9		8.8	
Feb 08, 2005		77				7.3		5.1	
Mar 08, 2005		127				6.8		10.7	
Apr 05, 2005		62				7.4		5.9	
May 10, 2005		60				7.5		10	
Jun 07, 2005		61				7.4		10.6	
Station 8 (Inlet (at diversion), end of River Road)									
Aug 11, 2004								14.3	
Sep 15, 2004		57				7.6		10.3	
Oct 06, 2004		73				7.6		12.1	
Nov 08, 2004		66				7.6		6.1	
Dec 06, 2004		66				7.5		4.1	
Jan 19, 2005		44				7.2		6.8	
Feb 08, 2005		65				7.4		2.5	
Mar 08, 2005		76				7.5		7.5	
Apr 05, 2005		61				7.4		4.9	
May 10, 2005		50				7.3		8.3	
Jun 07, 2005		59				7.4		9.7	
Station 9 (Outlet, from East Valley Highway Bridge)									
Aug 11, 2004								17.3	
Sep 15, 2004		59				7.5		17.9	
Oct 06, 2004		74				7.4		14.2	
Nov 08, 2004		61				7.6		11.2	
Dec 06, 2004		66				7.5		8.3	
Jan 19, 2005		65				7.6		5.2	
Feb 08, 2005		64				7.4		6	
Mar 08, 2005		70				7.4		7.5	
Apr 05, 2005		68				7.6		8.7	
May 10, 2005		63				7.6		10.9	
Jun 07, 2005		62				7.1		13.3	

Appendix C. Discrete/Composite Results

Date	Strata	Ammonia Nitrogen (mg/L)		Chlorophyll a (µg/L)		Soluble Reactive Phosphorus (mg/L)		Nitrate-Nitrite (mg/L)		Secchi Depth (ft)		Suspended Solids (mg/L)		Volatile Solids (mg/L)		Total Nitrogen (mg/L)		Total Phosphorus (mg/L)		Turbidity (NTU)	
Station 1 (Main Lake)																					
Jul 07, 2004	E	0.01	U	2.07		0.003	U	0.01	U	9.8		2		0.6		0.065		0.0038		2.3	
Jul 07, 2004	H	0.01	U			0.0036		0.088								0.14		0.0161			
Aug 11, 2004	E	0.01	U	1.69		0.003	U	0.01	U	8.5		2		1	U	0.075		0.0041		2.9	
Aug 11, 2004	H	0.01	U			0.0033		0.13								0.193		0.0143			
Sep 16, 2004	E	0.01	U	1.89		0.003	U	0.01	U	5.0		2		1	U	0.06		0.0086		7.76	
Sep 16, 2004	H	0.013				0.003		0.151								0.16		0.0146			
Oct 06, 2004	E	0.01	U	2.08		0.0036		0.01	U	12.0		1	U	1	U	0.078		0.0034		3.13	
Oct 06, 2004	H	0.01	U			0.0044		0.123								0.18		0.0126			
Jan 19, 2005	E	0.024		3.97	J	0.0031		0.188		7.9		9		1	U	0.299		0.0103		9.63	
Mar 08, 2005	E	0.011		1.35		0.0035		0.211		12.7		2		1	U	0.324		0.0124		3.22	
May 10, 2005	E	0.015		3.14		0.003		0.06		19.5		2	U	2	U	0.19		0.0037		1.1	
May 10, 2005	H	0.022				0.003	U	0.177								0.301		0.0035			
Jun 07, 2005	E	0.01	U	6.4		0.003	U	0.01	U	12.3		3		1		0.047		0.0029		1.61	
Jun 07, 2005	H	0.01	U			0.003	U	0.227								0.265		0.0041			
Station 4 (Northeast basin, across from Lake Tapps North Park)																					
Jul 07, 2004	E	0.01	U	2.56		0.003	U	0.01	U	10.8		2		0.7		0.078		0.0039		2.1	
Jul 07, 2004	H	0.01	U			0.003		0.08								0.15		0.0055			
Aug 11, 2004	E	0.01	U	1.02		0.003	U	0.01	U	13.8		1		1	U	0.082		0.0033		1.5	
Aug 11, 2004	H	0.01	U			0.003	U	0.012								0.09		0.006			
Sep 16, 2004	E	0.01	U	1.51		0.003	U	0.01	U	6.5		4		1	U	0.071		0.0057		5.53	
Sep 16, 2004	H	0.01	U			0.003	U	0.01	U							0.07		0.0074			
Oct 06, 2004	E	0.01	U	2.04		0.003	U	0.01	U	11.1		2		1	U	0.073		0.0031		2.47	
Oct 06, 2004	H	0.027				0.0034		0.01	U							0.091		0.0086			
Jan 19, 2005	E	0.01	U	4.15		0.003	U	0.027		11.6		2		1	U	0.11		0.0028		2.9	
Mar 08, 2005	E	0.01	U	3.35		0.003	U	0.055		12.3		1		1	U	0.14		0.0039		2.24	
May 10, 2005	E	0.014		3.87		0.003	U	0.052		19.0		2	U	2	U	0.18		0.0058		1.41	
May 10, 2005	H	0.029				0.003	U	0.124								0.24		0.0035			
Jun 07, 2005	E	0.01	U	5		0.003	U	0.01	U	13.9		3		1		0.046		0.0028		1.46	
Jun 07, 2005	H	0.01	U			0.003	U	0.023								0.13		0.0044			
Station 5 (East central basin, south of Golf Course)																					
Jul 07, 2004	E	0.01	U	2.82		0.003	U	0.01	U	9.8		3		0.9		0.075		0.0039		2.21	
Jul 07, 2004	H	0.01	U			0.003	U	0.01	U							0.076		0.0079			
Aug 11, 2004	E	0.01	U	1.82		0.003	U	0.01	U	7.5		3		1	U	0.081		0.0042		3.07	
Aug 11, 2004	H	0.358				0.0035		0.01	U							0.506		0.0156			
Sep 16, 2004	E	0.01	U	1.08		0.003	U	0.01	U	7.5		2		1	U	0.072		0.0049		3.82	
Sep 16, 2004	H	0.011				0.003	U	0.01	U							0.17		0.007			

Date	Strata	Ammonia Nitrogen (mg/L)	Q	Chlorophyll a (µg/L)	Q	Soluble Reactive Phosphorus (mg/L)	Q	Nitrate-Nitrite (mg/L)	Q	Secchi Depth (ft)	Q	Suspended Solids (mg/L)	Q	Volatile Solids (mg/L)	Q	Total Nitrogen (mg/L)	Q	Total Phosphorus (mg/L)	Q	Turbidity (NTU)	Q
Oct 06, 2004	E	0.01	U	1.95		0.0033		0.01	U	12.6		1	U	1	U	0.075		0.0044		2.47	
Oct 06, 2004	H	0.094				0.0037		0.01	U							0.17		0.0127			
Mar 08, 2005	E	0.01	U	10.1		0.003	U	0.073		7.0		4		1		0.19		0.007		5.16	
May 10, 2005	E	0.012		3.51		0.003	U	0.049		16.7		2	U	2	U	0.17		0.0036		1.39	
May 10, 2005	H	0.029				0.003	U	0.15								0.24		0.0072			
Jun 07, 2005	E	0.01	U	5.2		0.003	U	0.01	U	11.3		3		1		0.12		0.0037		1.56	
Jun 07, 2005	H	0.112				0.003	U	0.114								0.307		0.0099			
Station 6 (Southeast basin, east of inlet)																					
Jul 07, 2004	E	0.01	U	3.29		0.003	U	0.01	U	5.2		5		0.9		0.082		0.0077		5.39	
Aug 11, 2004	E	0.01	U	3.29		0.003	U	0.01	U	2.6		5		1	U	0.074		0.0109		10.7	
Sep 16, 2004	E	0.01	U	2.41		0.003	U	0.01	U	3.5		8		1	U	0.1		0.0095		9.94	
Oct 06, 2004	E	0.01	U	1.94		0.003	U	0.01	U	7.9		3		1	U	0.075		0.0047		4.63	
May 10, 2005	E	0.01		3.21		0.003	U	0.02		10.7		2	U	2	U	0.14		0.004		2.65	
May 10, 2005	H	0.011				0.003	U	0.072								0.16		0.0056			
Jun 07, 2005	E	0.01	U	6.4		0.003	U	0.01	U	7.0		4		2		0.11		0.0054		2.75	
Jun 07, 2005	H	0.01	U			0.003	U	0.01	U							0.11		0.0081			
Station 7 (Lake Inlet, from 218th Street Bridge)																					
Jul 07, 2004		0.01	U			0.0095		0.021								0.043		0.0411		43.8	
Aug 11, 2004		0.01	U			0.0032		0.01	U							0.063		0.0193		22.9	
Sep 15, 2004		0.01	U			0.0061		0.01	U							0.053		0.031		35.8	
Oct 06, 2004		0.01	U			0.003	U	0.01	U							0.072		0.0055		6.55	
Nov 08, 2004		0.01	U			0.0037		0.055								0.15		0.0092		4.58	
Dec 06, 2004		0.027				0.0095		1.69								1.88		0.022		4.48	
Jan 19, 2005		0.292				0.0643		3.71								4.72		0.258		80.9	
Feb 08, 2005		0.038				0.011		0.506								0.689		0.0333		9.3	
Mar 08, 2005		0.209				0.0082		0.591								0.872		0.0616		9.48	
Apr 05, 2005		0.017				0.0079		0.184								0.285		0.0116		3.27	
May 10, 2005		0.01	U			0.0049		0.066								0.12		0.0095		3.59	
Jun 07, 2005		0.01	U			0.0066		0.038								0.077		0.0131		6.42	
Station 8 (Diversion, end of River Road)																					
Jul 07, 2004		0.01	U			0.012		0.028								0.049		0.155		147	
Aug 11, 2004		0.01	U			0.0967		0.022								0.062		0.578		702	
Sep 15, 2004		0.01	U			0.011		0.074								0.066		0.0677		32.4	
Oct 06, 2004		0.01	U			0.011		0.034								0.064		0.0435		23.2	
Nov 08, 2004		0.01	U			0.0063		0.104								0.14		0.011		3.35	
Dec 06, 2004		0.01	U			0.0091		0.205								0.244		0.0116		2.37	
Jan 19, 2005		0.01				0.012		0.347								0.376		0.734		1406	J
Feb 08, 2005		0.01	U			0.01		0.13								0.16		0.0343		3.97	
Mar 08, 2005		0.01	U			0.0083		0.057								0.095		0.0084		1.25	
Apr 05, 2005		0.017				0.0076		0.144								0.23		0.0133		2.25	
May 10, 2005		0.01	U			0.0069		0.078								0.13		0.1		42.3	

Date	Strata	Ammonia Nitrogen (mg/L)		Chlorophyll a (µg/L)		Soluble Reactive Phosphorus (mg/L)		Nitrate-Nitrite (mg/L)		Secchi Depth (ft)		Suspended Solids (mg/L)		Volatile Solids (mg/L)		Total Nitrogen (mg/L)		Total Phosphorus (mg/L)		Turbidity (NTU)	
Jun 07, 2005		0.01	U			0.0065		0.043								0.071		0.0119		4.96	
Station 9 (Outlet, from East Valley Highway Bridge)																					
Jul 07, 2004		0.01	U			0.0035		0.014								0.062		0.0091		9.3	
Aug 11, 2004		0.01	U			0.0035		0.011								0.057		0.0258		33.9	
Sep 15, 2004		0.01	U			0.0033		0.01	U							0.055		0.0127		16.4	
Oct 06, 2004		0.01	U			0.011		0.053								0.1		0.0224		17.8	
Nov 08, 2004		0.01	U			0.003	U	0.022								0.075		0.0062		4.74	
Dec 06, 2004		0.01	U			0.0034		0.04								0.11		0.0047		4.1	
Jan 19, 2005		0.01	U			0.003	U	0.122								0.2		0.006		3.91	
Feb 08, 2005		0.01	U			0.0042		0.16								0.254		0.0078		3.58	
Mar 08, 2005		0.01	U			0.0057		0.194								0.298		0.0088		2.65	
Apr 05, 2005		0.023				0.0063		0.181								0.307		0.0091		3.48	
May 10, 2005		0.02				0.003	U	0.13								0.23		0.0058		1.53	
Jun 07, 2005		0.01	U			0.003		0.093								0.19		0.0068		2.02	

Appendix D. Profiling Instrument Post-Calibration Results

Results rejected or qualified for failing quality control requirements (Hallock, 2004) are shown in bold. The difference between expected and reported results is given in parentheses (for pH, this is the maximum difference for either the 7 or the 9 buffer).

Calibration Date	pH (criteria ±0.15 std. units)	Oxygen (criteria ±0.20 mg/L)	Cond. (criteria ±10 µS)	Temp. (criteria ±0.20°C)	Remarks
8 Jul	**Fail (3.38)**	Pass (0.2)	Pass (1.4)		The pH meter failed (post calibration in 7.00 buffer was 3.62); results are not reported.
12 Aug	Pass (0.06)	**Fail (0.33)**	Pass (2.8)	Pass (0.0)	Calibration for 48-hour deployed meter. Code oxygen results as estimates (“J”).
12 Aug	Pass (-0.11)	Pass (-0.04)	Pass (1.1)		Calibration for profiling instrument
16 Sept	Pass (-0.04)	**Fail (0.35)**	Pass (2.2)		Saturated air at 8.80 mg/L oxygen read 8.45 mg/L. Code oxygen results as estimates (“J”).
6 Oct	Pass (0.01)	Pass (0.01)	Pass (0)		
20 Jan	Pass (0.10)	Pass (0.4%)	Pass (-1.7)		
8 Feb				Pass (0.2)	
8 Mar (oxygen), 10 Mar (pH, Cond)	Pass (0.12)	**Fail (0.22)**	Pass (-2.2)		Saturated air at 9.06 mg/L oxygen read 8.84 mg/L. However, this only slightly exceeded criteria, and check standards were acceptable. Results were not qualified.
12 May	**Fail (0.18)**	**Fail (0.33)**	Pass (1.4)		Post calibrations in 6.99 and 9.23 buffers were 6.83 and 9.05, respectively, both just outside the ±0.15 criterion. pH results have been coded as estimates (“J”). Saturated air at 9.50 mg/L oxygen read 9.17 mg/L; however, post-calibration was two days after sampling and the check standard was within criteria (Winkler: 10.47 mg/L; profiler: 10.56). Results were not qualified.
8 Jun (oxygen), 9 Jun (pH, Cond.)	Pass (0.04)	**Fail (0.32)**	Pass (1.0)		Saturated air at 10.51 mg/L oxygen read 10.19 mg/L; The check standard results were also outside criteria (Winkler: 9.78 mg/L; profiler: 9.25). Oxygen results, which may be about 0.3-0.4 mg/L too low, have been coded as estimates (“J”).
21 Jul				Pass (0.2)	