Capitol Lake – How It Functions and What Water Quality Issues It Faces

May 2000

for the State of Washington General Administration
by Thurston County Public Health Department,
Environmental Health Division

THURSTON COUNTY
WASHINGTON
SINCE 1852

History

The Deschutes River is a 57 mile long river that historically discharged into an estuary at the head of Budd Inlet. It resembled Mud Bay in Eld Inlet as it appears today --- shallow, deep sediments, nutrient rich water, and a mixture of salt and fresh waters. Its watershed is approximately 162 square miles and includes timber and agricultural lands and increasingly residential and urban land uses. Geologically, much of the land through which the river flows is comprised of unconsolidated glacial material, making it easily erodable and transportable by the river. Even in the headwaters area where bedrock dominates, soils developed from sedimentary rock are easily eroded and unstable in many areas. Percival Creek, a four-mile long creek with approximately 13 square miles of watershed, also discharged to the former Budd Inlet estuary.

In 1951 a dam was built at the Fifth Avenue bridge essentially blocking off the lower estuary to the free exchange of fresh and salt water during the ebb and flood cycles of the tides. The dam created a 320 acre fresh water impoundment from what had formerly been an estuarine environment. Although the newly created water body was named Capitol Lake, according to the lake definition in W.A.C. 173-201A, Capitol Lake is not a "lake". By definition, a lake must have a mean detention time of 15 days or longer. The mean detention time of water in Capitol lake can be less than one day depending on the winter flows in the river or up to 11 days during summer low flows. Capitol Lake is actually an impoundment of the river. As such, it retains many of the characteristics of the river and those of its former estuary:

- Similar water chemistry and pollutant concentrations
- Nutrient rich with high biological productivity
- Low energy gradient/high sediment deposition area
- Important wildlife habitat area

Human Influences

In addition to the major hydrologic alteration which created Capitol Lake, there are many other past and on-going human activities which directly influence the water quality and biological conditions of the lake:

- Shoreline alterations, such as filling for I-5, railroad, Deschutes Parkway and bulkheading for the bathing beaches and public parks;
- Landscaping which can contribute pollutants and promotes a high concentration of Canada geese;
- Introduction of non-native species, such as purple loosestrife, resident Canada geese, domestic waterfowl, and warm water fish species;

- Construction of the fish ladder at Tumwater Falls, creating anadromous fish runs where previously there had been none;
- Rearing and feeding of juvenile salmon in net pens in Percival Cove;
- Brewery discharges of high temperature waters and nutrients;
- Numerous direct discharges of stormwater from urban areas and major highways;
- Accidental spills of toxic chemicals and human sewage;
- Construction of the Black Lake Ditch which altered the natural drainage of Black Lake from south to north into Percival Cove; and
- Lake drawdown and saltwater flushing practice.

Human activities within the watershed also have a major influence on conditions in the lake because of its location at the most downstream point in the watershed. Activities, such as logging or land development and paving, which change the hydrology, will effect flows in the river and sediment transport. Agricultural practices, urban development, and other human activities which add pollutant loads to the river and will also adversely affect the lake.

Capitol Lake Conditions

During the winter when the flow in the Deschutes river is high, Capitol Lake is essentially an expansion of the Deschutes River. During a study conducted by Thurston County Health Department (March 1993), water quality conditions below the Falls and at the railroad trestle below the north and middle basins of the lake, were found to be very similar. Total suspended solids were found to decrease slightly between the two sites, implying that material was settling out of suspension as flow velocities decreased within the middle basin. Although there have been, and continue to be, river bank stabilization and riparian restoration projects along the Deschutes and Percival Creeks, the lake will always be a depositional area for sediments. The rates of deposition change constantly as they are influenced by weather and hydrologic conditions and human influences in the watershed. Aside from sedimentation, winter water quality conditions have little influence on summer-time conditions in the lake because the hydraulic detention time of the water is very short.

During the summer, flow in the river is low, detention time begins to approach that of a lake, and conditions common to eutrophic lakes appear. Production of filamentous and free floating algae and rooted aquatic plants increase, often to nuisance levels. Past studies (CH2M Hill, June 1978 and WSU, 1975) concluded that Capitol Lake is both nitrogen and phosphorus limited at various times throughout the growing season. However, phosphorus is usually the nutrient in shortest supply, and the most manageable nutrient to control. Summer-time inputs of nutrients have the greatest impact on algae production in Capitol Lake. Because almost all of the lake is less than 10 feet in depth, conditions are also ideal for rooted aquatic plants. However, the water column nutrient levels have less impact on rooted aquatic plant growth because they can utilize nutrients stored in the sediments.

In a 1984 report, Entranco Engineers concentrated on control of phosphorus to limit algae and plant productivity. They estimated that 70 percent of the annual total phosphorus load to Capitol Lake was carried by the river, 8 percent was contributed by Percival Creek, 14 percent was attributable to the brewery discharges, and 8 percent miscellaneous sources. It was estimated that dairy discharges along the Deschutes River contributed 14 percent of the 70 percent carried by the river. The lake is currently on the WDOE list of impaired water bodies for violations of fecal coliform bacteria and total phosphorus criteria, established in W.A.C. 173-201A. Sources of fecal coliform to the lake, based on studies by the Thurston County Health Department, March 1993, CH2M Hill, 1978, and Entranco Engineers, January 1984, include nonpoint pollution carried by the Deschutes River and Percival Creek, direct storm water outfalls to the lake, brewery discharges, and water fowl waste.

Progress toward Water Quality Improvements

Olympia Brewery Discharges

According to a Pabst Brewing Company report to the Washington State Department of Ecology (WDOE), dated March 24, 1995, the Olympia brewery's annual phosphorus contribution was reduced from an estimated 14 percent of the total Capitol Lake load to 2.1 percent through implementation of new cooling system technology. Unfortunately, the NPDES waste discharge permit, re-issued in 1998, no longer requires the brewery to monitor for total phosphorus in the discharge waters or the receiving water (Deschutes River). Recent samples collected by Thurston County Environmental Health Division staff at brewery discharges #1 and #6 found phosphorus concentrations that were double the mean phosphorus concentrations in the river. (See attached storm water monitoring report) So while the brewery has substantially reduced the amount of phosphorus being discharged to the river, those discharges are still sources of phosphorus that warrant some level of monitoring, particularly during the summer low flow period.

In addition to phosphorus, the brewery's current NPDES permit no longer requires monitoring of turbidity at outfall #5, which discharged runoff from the gravel truck parking lot south of the E Street bridge. Turbidity monitoring was deleted from the revised NPDES permit as a result of monitoring data showing only three violations out of 146 measurements made. However, County Environmental Health staff have observed turbidity plumes along the east shore of the river occasionally during ambient sampling events at the E Street bridge. On one such event on February 14, 2000, the river was sampled mid-stream and in the middle of the plume along the east shore. The river turbidity was 5 NTU, and the turbidity of the plume was 19 NTU. The water quality standard is not more than 5 NTU over background when background is less than 50 NTU. It is possible that the particles in this discharge are so fine that they are carried through the lake and into Budd Inlet. This outfall's contribution compared to the overall sediment load carried in the river might be considered insignificant. However, this type of pollutant discharge is one where technologies are known and available to improve the quality of or remove the direct discharge. WDOE should be encouraged tc re-examine this issue during the next NPDES permit revision.

Golf Course

The Tumwater Golf Course, immediately up-river of the brewery, is in a reach of the river where increased phosphorus concentrations were noted by Entranco Engineers in 1984. A loading estimate of less than 0.1 percent contribution by the golf course was calculated. Although this was a very small source, the City of Tumwater has since assumed ownership and management of the golf course, and has taken steps to improve habitat and water quality conditions. Four acres of riparian buffer has been planted along both sides of the river, which is approximately half the river frontage through the golf course. Changes made by the City in golf course management include a change to granular slow-release fertilizer and a reduction in application rates, discontinued use of chemigation as a fertilizer application method and the addition of wetting agents, and discontinued chemical control of algae and aquatic plants in golf course ponds which discharge directly to the river (Skip Wirtz, Personal Communication, March 2000).

Agricultural Practices

Dairy operations were identified, in 1984, as contributing as much as 14 percent of the annual phosphorus load in the river. The pollutant contribution from two specific dairies were monitored during that study. Since that time, regulatory requirements have been imposed on the dairy industry as a whole which have influenced practices on farms in the Deschutes River watershed. Both of the farms, previously monitored by Entranco, have made improvements in their farm management practices and are currently being operated under interim or draft farm plans (Wym Mathews, Thurston Conservation District, personal communication, March 2000). However, neither farm has an approved farm plan at this time. WDOE has no compliance issues with either dairy at this time (DOE, Ken Cook, personal communication, March 2000).

Shoreline Restoration

Within the past 10 years there have been six stream bank stabilization and riparian restoration projects along the lower and middle reaches of the Deschutes River, in addition to the riparian restoration project along the Tumwater Golf Course. The objective of these projects was to reduce bank erosion. Most of the sites were on lands where the native riparian vegetation had been removed to accommodate activities such as agriculture, golf courses, or residential structures and landscaping. The stabilization method used is referred to as bioengineering, which often included a combination of bank armoring and planting. Bioengineering provides considerably greater habitat value and preserves more of the flood plain functions than tradition rip-rapping, channel hardening, and levee-construction projects. It is not known what the long-term sediment load reduction to the lake will be as a result of these projects. However, these type of restoration projects are a reflection of the growing recognition of the need to protect and restore the function of riparian areas and flood plains, rather than "control" the river. As more aquatic species are added to the list of endangered species, riparian protection and restoration efforts will likely continue throughout the watershed, and involve all aspects of land use.

Threats to Lake Water Quality

Storm Water Quantity and Quality

While water quality improvements have been made in many areas, some changes have occurred since 1984 that represent negative impacts on water quality. Extensive areas in West Olympia, Tumwater Hill, and Mottman Industrial Park have been developed since the 1984 report. This development has increased the impervious surface area contributing runoff to the lower Deschutes River and Percival Creek, which affects both the quantity and quality of runoff into the lake. As peak stream flows increase as a result of greater volumes of storm water generated from paved surfaces, stream channel erosion and sediment rates in the lake increase. This phenomenon is visually apparent in Percival Cove.

During this past winter, Thurston County Environmental Health staff has collected grab samples from some of the storm water outfalls discharging to the Deschutes River between the upper Tumwater Falls and Historical Park. While the outfalls discharging directly into the lake had been sampled several times during lake draw-downs, these four outfalls along the west side of the river had not been sampled. A brief report of the results is attached. The results show that storm water does load additional total phosphorus into the river and lake, and the higher concentrations appear to correlate with high turbidity values. However, the effect on summer conditions in the lake may be minor.

Ground Water Quality

Increasing nutrients in the base flows of the river and streams as land uses degrade shallow ground water is a growing concern. Because the water source for Chambers Creek during the summer low-flow period is almost entirely ground water, Chambers Creek dry-season nitrate data was assessed to determine if a trend exists in the data. The graph on the next page shows a statistically significant increase in the nitrate concentration in Chambers Creek during the dry season, which is a reflection of ground water quality degradation over the past nine years. Since the summer base flows for the Deschutes River and its tributaries are primarily from ground water, increased nutrients in the ground water will increase nutrient loads to the lake. This could exacerbate already nuisance levels of algae and aquatic plants.

Monitoring Needs

To examine possible trends in surface water quality, an attempt was made to compare current water quality conditions in the river, Capitol Lake, Percival Creek, and major tributaries with data collected by Entranco Engineers in 1983. Unfortunately, sufficient differences exist between historic and current sampling locations and methods which prevent the data from being readily comparable. A consistent ambient sampling program is needed to be able to reliably examine long-term trends in water quality conditions of the lake and its major tributaries.

Accidental Spills

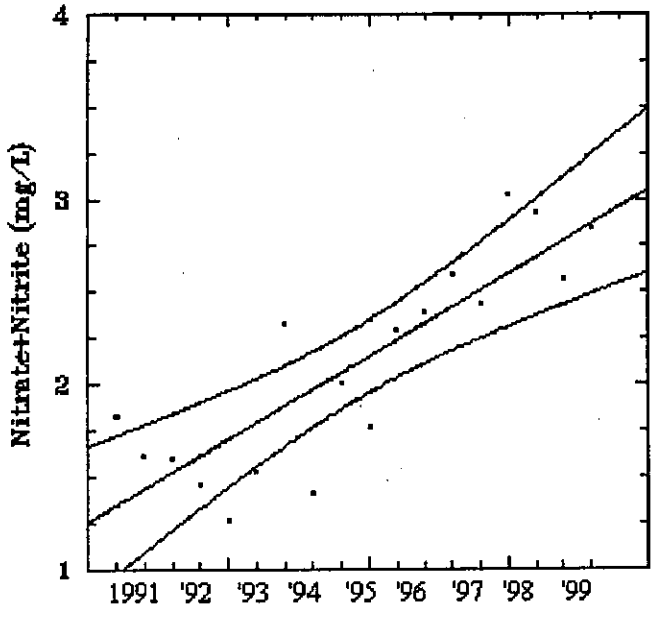
The threat of accidental spills into Capitol Lake is great, given the large number of direct storm water discharges and the intensity of land use in the immediate vicinity of the lake. Examples of spills that

have occurred include:

- February 1996 - City of Tumwater sewer line break , discharging ~1 million gallons/day of raw sewage into the lake for 12 days;
- June 1999 - WDOT contractor applied an emulsified asphalt material onto I-5 during a paving project which was washed directly into the lake during a rain squall;
- March 2000 - 300 gallons of raw sewage was discharged into the lake due to contractor error at the Capitol Lake lift station.
- Also between 1975 and 1997, the brewery reported 15 separate spills to the river of materials ranging from bunker fuel to caustic solution to detergent. (Note: The brewery now has a spill prevention and control plan in place, and the number of reported spills has decreased considerably since the late 1980's.)

Chambers Creek Nitrate Levels

Summer Values (two samples taken per year between July and September)



Recommendations for General Administration Consideration

- Support efforts to develop "0" storm water impact standards for development;
- Request notification from WDOE and provide input when the Miller Brewing Company's NPDES permit is open for renewal/revision;
- Request appropriate agencies to develop and implement spill prevention and rapid response plans for all activities which have the potential to release contaminants to the lake, such as the major transportation corridors (I-5, 101, Capitol Boulevard, Deschutes Parkway, railroad), sewer lines and lift stations, and the State Capitol Campus power plant;
- Support local efforts to protect surface and ground water quality;
- Support routine ambient monitoring of surface and ground water so that water quality trends can be tracked over time.

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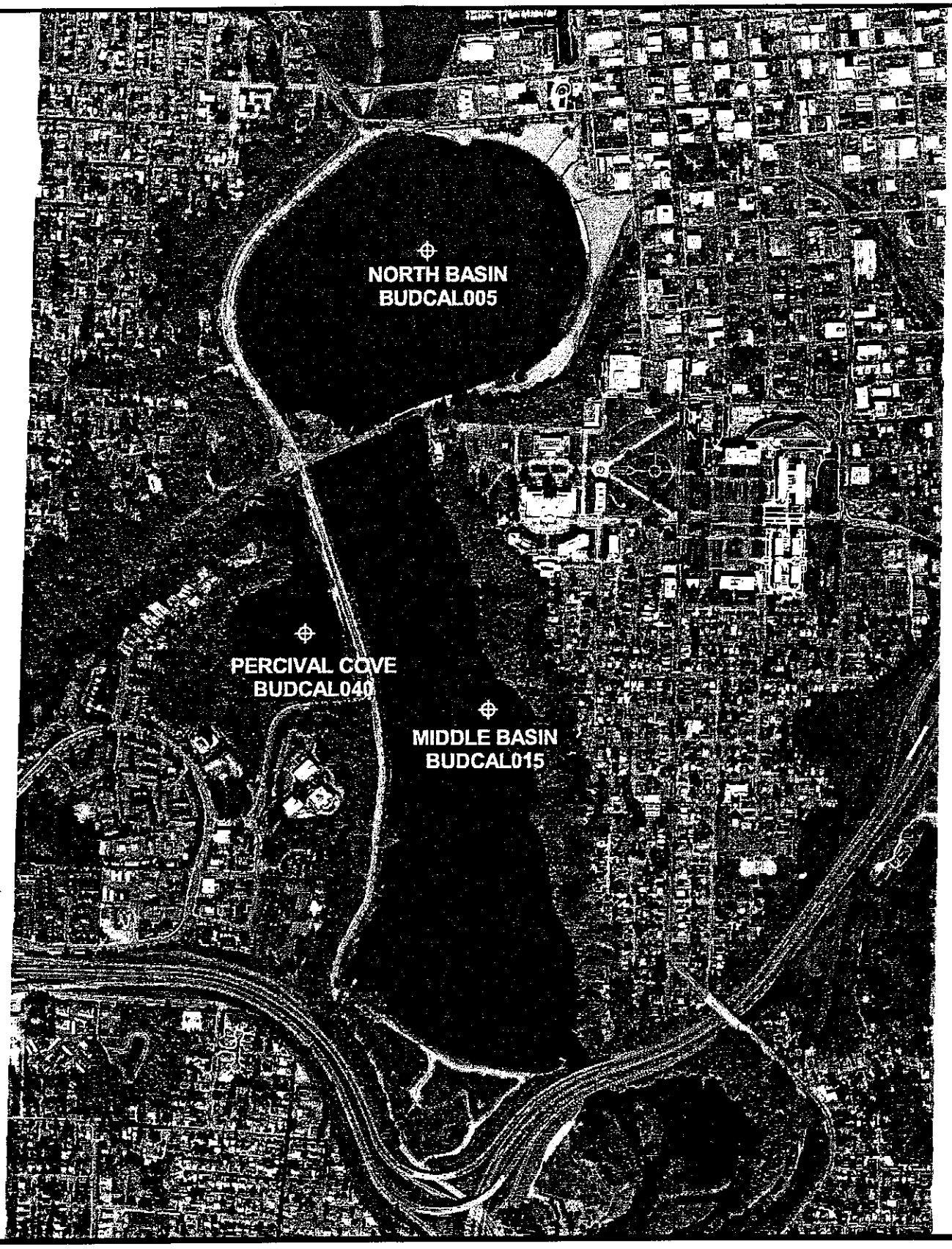

CAPITOL LAKE WATER QUALITY MONITORING SITES

Thurston County Environmental Health Division

400 0 400 800 Feet

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W E
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March 9, 2000

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Capitol Lake

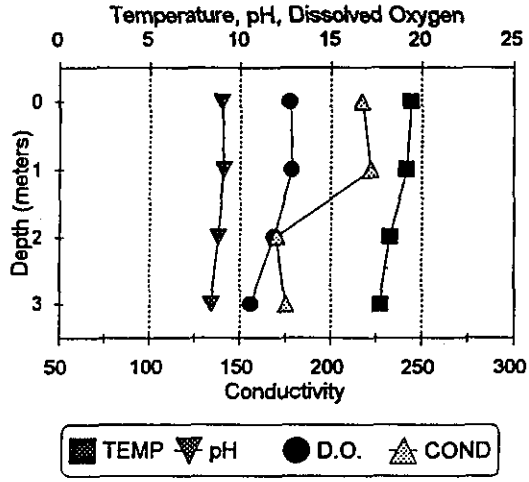
DATE	SITE	DEPTH	TEMP	pH	D.O.	COND
9/22/99	North Basin	0	19.43	9	12.73	217
		1	19.19	9.1	12.85	222
		2	18.25	8.8	11.86	170
		3	17.71	8.4	10.61	175
	Middle Basin	0	19.29	8.6	11.37	157
		1	17.49	8.5	11.59	148
		2	17.1	8.4	11.36	146
		3	16.57	8.2	10.94	146
9/23/99	Percival Cove	0	17.44	9	13.26	127
		1	17.1	8.7	11.15	129
		1.6	16.34	7.7	7.2	138
10/20/99	North Basin	0	12.99	8.8	14.02	173
		1	12.86	9	13.98	171
		2	12.3	8.9	12.72	170
		3	11.58	8.7	11.9	148
	Middle Basin	0	11.72	8.2	11.84	139
		1	11.33	8.3	12	139
		2	10.97	8.6	13.05	140
		2.8	10.79	8.5	11.68	140
	Percival Cove	0	13.55	7.9	11.46	120
		1	12.27	8.1	10.48	118
		1.7	11.88	8	10.15	113

Capitol Lake

September 22, 1999

North Basin

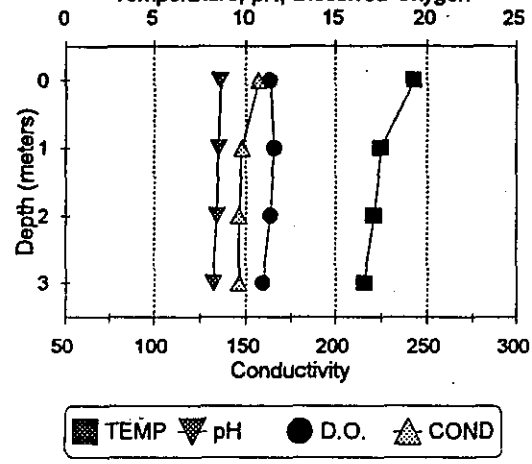
Temperature, pH, Dissolved Oxygen



September 22, 1999

Middle Basin

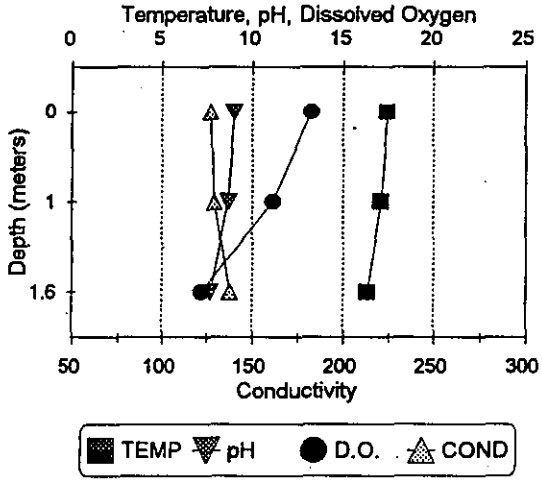
Temperature, pH, Dissolved Oxygen



September 23, 1999

Percival Cove

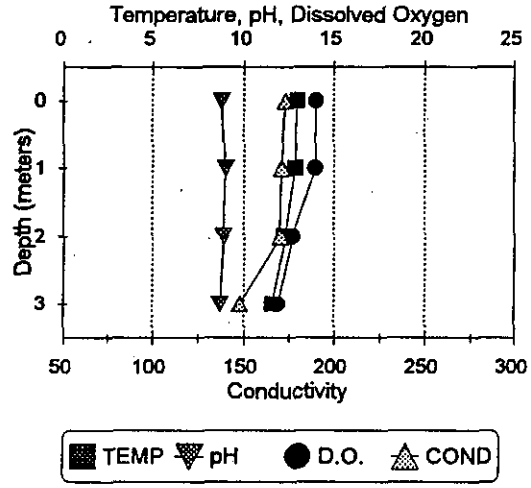
Temperature, pH, Dissolved Oxygen



October 20, 1999

North Basin

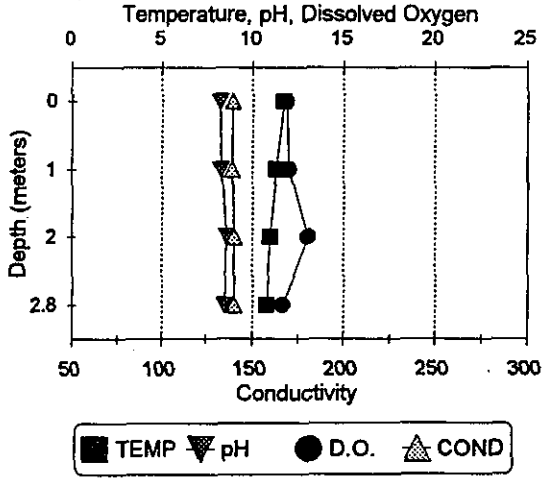
Temperature, pH, Dissolved Oxygen



October 20, 1999

Middle Basin

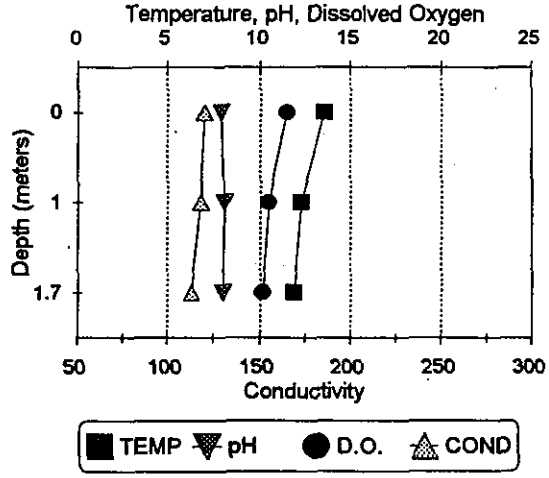
Temperature, pH, Dissolved Oxygen



October 20, 1999

Percival Cove

Temperature, pH, Dissolved Oxygen



Site ID# : BUDCAL005

Site Description	Date	Time	Bott Depth (m)	Bott Sample Depth (m)	Sur TP (mg/L)	Bott TP (mg/L)	Sur TN (mg/L)	Bott TN (mg/L)	Secchi (m)	Chl a (ug/L)	Phae a (ug/L)
Capitol Lake @ Mid- North Basin	9/22/199	12:45	3.20	2.75	0.032	0.032	0.483	0.568	1.83	9.10	3.40
Capitol Lake @ Mid- North Basin	10/20/19	14:45	3.00	2.50	0.041	0.035	0.676	0.625	1.72	26.00	5.90

Avg(Chl a) : 17.5 Avg(Sur TP) : 0.037 Avg(Secchi) : 1.78

Site ID# : BUDCAL015

Site Description	Date	Time	Bott Depth (m)	Bott Sample Depth (m)	Sur TP (mg/L)	Bott TP (mg/L)	Sur TN (mg/L)	Bott TN (mg/L)	Secchi (m)	Chl a (ug/L)	Phae a (ug/L)
Capitol Lake @ Mid- Middle Basin	9/22/199	13:30	3.20	2.75	0.037	0.026	0.689	0.728	2.97	4.00	3.30
Capitol Lake @ Mid- Middle Basin	10/20/19	15:15	2.80	2.25	0.026	0.022	0.816	0.862	2.75	1.60	1.30

Avg(Chl a) : 2.8 Avg(Sur TP) : 0.031 Avg(Secchi) : 2.86

Site ID# : BUDCAL040

Site Description	Date	Time	Bott Depth (m)	Bott Sample Depth (m)	Sur TP (mg/L)	Bott TP (mg/L)	Sur TN (mg/L)	Bott TN (mg/L)	Secchi (m)	Chl a (ug/L)	Phae a (ug/L)
Capitol Lake in Percival Cove	9/23/199	12:30	1.60	1.00	0.046	0.053	0.384	0.470	1.42	23.00	6.40
Capitol Lake in Percival Cove	10/20/19	16:00	1.70	1.25	0.051	0.057	0.330	0.361	1.76	9.10	9.10

Avg(Chl a) : 16.0 Avg(Sur TP) : 0.048 Avg(Secchi) : 1.59

Thurston County Water Resources Monitoring Report — Capitol Lake @ Mid- North Basin

Date	Time	Bott Depth (m)	Bott Sample Depth (m)	Sur TP (mg/L)	Bott TP (mg/L)	Sur TN (mg/L)	Bott TN (mg/L)	Secchi (m)	Chl a (ug/L)	Phae a (ug/L)	Water Color	Algae	Lake Notes
9/22/1999	12:45	3.20	2.75	0.032	0.032	0.483	0.568	1.83	9.10	3.40	#2 CCS, lt. green	Present: Coelastrum, Scenedesmus, Pediastrum, Ankistrodesmus, Fragiliaria, Stephanodiscus, Rhizosolenia, Stauroneis, Chroomonas, Glenodinium	Fecal coliform result - 0 organisms / 100 ml. Algae & Chlorophyll sample composite @ 0.5 & 1.5M depth. No notable aquatic plants at surface. Some narrow leaf pondweed at bottom. Saw numerous school of very tiny fish.
10/20/1999	14:45	3.00	2.50	0.041	0.035	0.676	0.625	1.72	26.00	5.90	#2-3 CCS	Dominant: Stephanodiscus. Present: Aphanizomenon, Carteria, Actinastrum, Asterionella.	Fecal Coliform result - 0 organisms / 100ml. Plant Observation: None visible on surface. Some fragments of elodea and a thin leaved pondweed. Algae & chlorophyll composite sample from 1 & 2M depths.

"Sur" refers to measurements or samples taken at 0.5 meters below the lake surface.
"Bott" refers to measurements or samples taken at approximately 0.5 meters above the lake bottom. The actual depth was reported under "Bott Sample Depth".

Thurston County Water Resources Monitoring Report — Capitol Lake @ Mid- Middle Basin

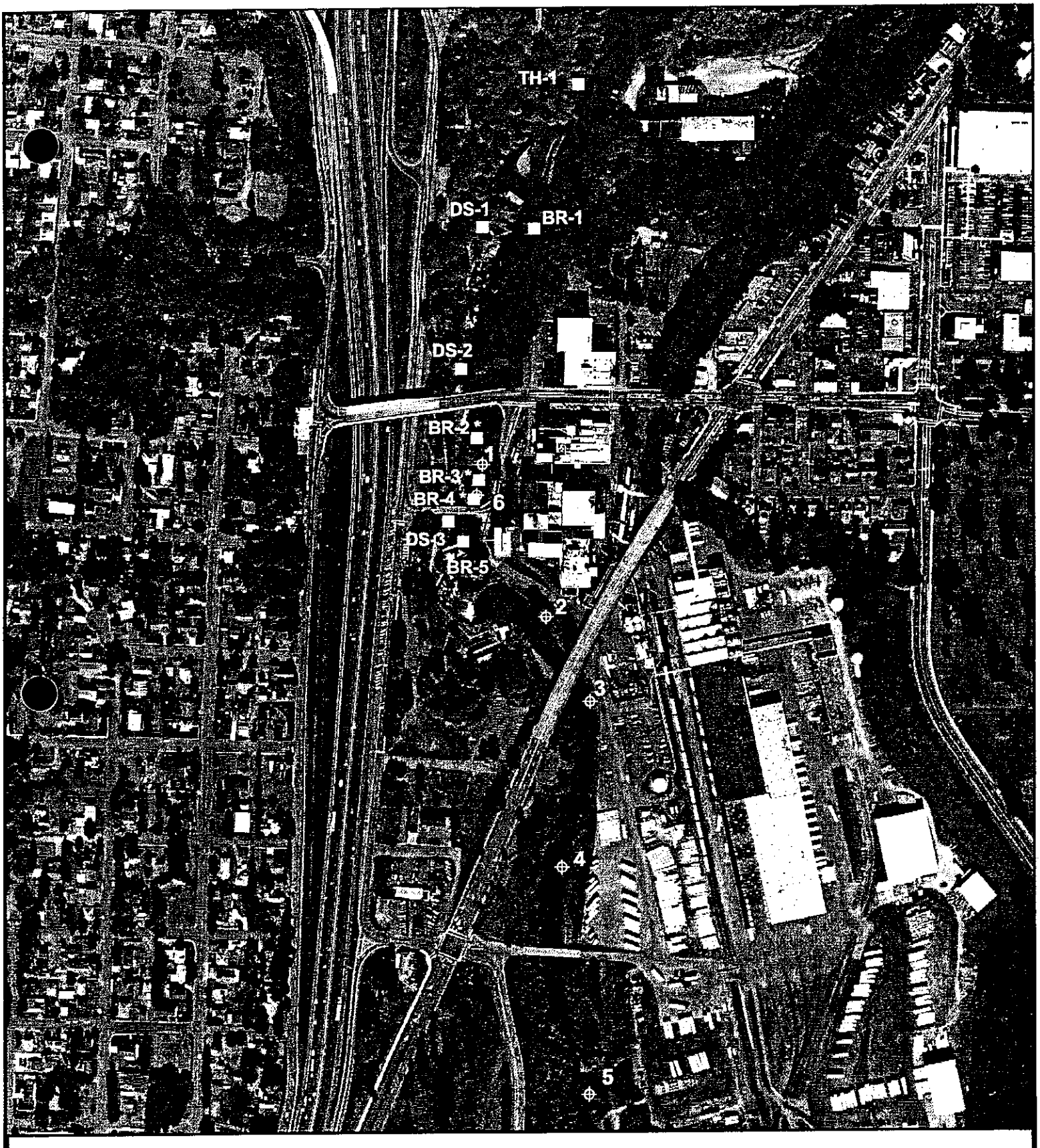
Date	Time	Bott Depth (m)	Bott Sample Depth (m)	Sur TP (mg/L)	Bott TP (mg/L)	Sur TN (mg/L)	Bott TN (mg/L)	Secchi (m)	Chl a (ug/L)	Phae a (ug/L)	Water Color	Algae	Lake Notes
9/22/1999	13:30	3.20	2.75	0.037	0.026	0.689	0.728	2.97	4.00	3.30	#2 CCS, lt. green	Present: Anabaena, Scenedesmus, Microspora, Pandorina, Ankistrodesmus, Rhizosolenia, Stauroneis, Cymbella, Stephanodiscus, Asterionella, Cocconeis, Synedra, Ceratium.	Fecal Coliform result - 0 organisms / 100ml. Algae & Chlorophyll sample collected @ 1M. Secchi disk visibility was to the bottom. Plant Observations: Curly leaf pondweed and elodea beds at or near the surface over ~1/4 of the middle basin @ the south end near I-5. Observed 4 dead stickleback fish, schools of live fish, a bryozoan, & an eagle.
10/20/1999	15:15	2.80	2.25	0.026	0.022	0.816	0.862	2.75	1.60	1.30	#2 CCS	Present: Scenedsmus, Oocystis, Ankistrodesmus, Pediastrum, Fragilaria, Amphora, Navicula, Synedra.	Fecal Coliform result - 0 organisms / 100ml. Algae & Chlorophyll sample composite @ 1 & 2M. Secchi disk visibility to bottom. Plant Observation: Occasional clumps of curly leaved pond weed near surface throughout channel between I-5 bridge and RR tressle. Just north of Marathon Pk thick bed of plants. Much less than last month at the surface. Dead stickleback on bottom near boat launch.

"Sur" refers to measurements or samples taken at 0.5 meters below the lake surface.
"Bott" refers to measurements or samples taken at approximately 0.5 meters above the lake bottom. The actual depth was reported under "Bott Sample Depth".

Thurston County Water Resources Monitoring Report — Capitol Lake in Percival Cove

Date	Time	Bott Depth (m)	Bott Sample Depth (m)	Sur TP (mg/L)	Bott TP (mg/L)	Sur TN (mg/L)	Bott TN (mg/L)	Secchi (m)	Chl a (ug/L)	Phae a (ug/L)	Water Color	Algae	Lake Notes
9/23/1999	12:30	1.60	1.00	0.046	0.053	0.384	0.470	1.42	23.00	6.40	#6-7 CCS, yellow	Dominant: Ceratium & Stephanodiscus. Present: Aphanizomenon, Anabaena, Gomphosphaeria, Eutetramorus, Scenedesmus, Schroederia, Ankistrodesmus, Sorastrum, Actinastrum, Asterionella, Melosira, Tabellaria, Fragillaria, Chroomonas, Cryptomonas.	Fecal Coliform result - 29 organisms / 100ml. Algae & Chlorophyll sample from .75 M depth. Plant Observations: Elodea, and a fine-leaved pondweed present. Nothing at the surface.
10/20/1999	16:00	1.70	1.25	0.051	0.057	0.330	0.361	1.76	9.10	9.10	#6 CCS, yellow-grn	Present: Aphanizomenon, Actinastrum, Scenedesmus, Pediastrum, Cyclotella, Synedra, Melosira, Stephanodiscus, Cryptomonas, Chroomonas.	Fecal Coliform result - 0 organisms / 100ml. Algae & Chlorophyll sample collected @ .75M depth. Not much plant growth observed, but elodea came up with anchor.

"Sur" refers to measurements or samples taken at 0.5 meters below the lake surface.
"Bott" refers to measurements or samples taken at approximately 0.5 meters above the lake bottom. The actual depth was reported under "Bott Sample Depth".



DESCHUTES RIVER OUTFALL SAMPLING SITES

Thurston County Environmental Health Division

200 0 200 400 Feet

⊕ Permitted Brewery Discharges

Outfall Sampling Sites

* Note: These 3 samples probably represent the same discharges identified on the NPDES permit as #1 and #6.

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March 9, 2000

Storm Water and Brewery Discharge Sampling Along Tumwater Falls

Thurston County Environmental Health staff collected grab samples from storm water and brewery discharges to the Deschutes River located between the top of Tumwater Falls and the south end of Tumwater Historical Park. The purpose of the storm water outfall sampling was a screening level evaluation to determine if gross contamination problems exist. The purpose for the brewery discharge samples was to verify that phosphorus concentrations in the cooling water discharges have decreased below concentrations reported in the 984 Entranco Engineers report.

The table below reflects all data collected from each site and the rainfall amount for the day of the sampling. The attached map shows the location of the sampling sites.

Sample Date & Time	Sample Site	Fecal Coliform # /100ml	Turbidity NTU	Total Phosphorus mg/L	Nitrate+Nitrite mg/l	Ammonia mg/L
12/28/99 8:40-9:50 AM Rain - .01"	DS-1	20	1.5	0.022		
	DS-2	50	1.1	0.012		
	DS-3	--	--	--		
	TH-1	--	--	--		
	BR-1	10	2.2	0.121		
	BR-2	<5	1.9	0.125		
	BR-3	<5	2.6	0.113		
	BR-4	<5	3.3	0.106		
	BR-5	<5	2.6	0.093		
1/3/00 13:15-13:45 PM Rain - .77"	DS-1	290	75	0.105		
	DS-2	215	27	0.035		
	DS-3	170	45	0.088		
	TH-1	--	--	--		
2/14/00 11:00-11:30 AM Rain - .47"	DS-1	320	80	0.129	0.710	0.458
	DS-2	120	70	0.165	0.494	0.265
	DS-3	20	35	0.067	0.120	0.219
	TH-1	330	30	0.075	0.741	0.092

Sampling Site Descriptions

DS-1 12" Corrugated metal pipe discharging into a concrete gutter along the foot path. The primary contributing area to this discharge pipe is a section of I-5, although a very small area of Deschutes Parkway run-off also flows to this pipe. Basin size is 2 acres.

DS-2 12" corrugated metal culvert discharging to river just north of the Custer Way overpass. The contributing area is 16.8 acres and encompasses portions of Division St., 2nd Avenue, 3rd Avenue, and West "B" Street on the west side of I-5. The contributing area also includes a section of I-5.

DS-3 12" concrete culvert discharging south of the Division Street bridge. The contributing area is the section of Deschutes Parkway from "C" Street north to the Division Street bridge. The basin size is 1.9 acres.

TH-1 18" culvert discharging to Capitol Lake at the south end of Tumwater Historical Park. The basin is 120 acres and includes the residential area west of the freeway up to Tumwater Hill. It also includes run-off from a small section of Deschutes Parkway and probably part of I-5. Part of the conveyance system for the run-off is through a natural creek channel named DeSoto Creek.

BR-1 through BR -5 These are all cooling water discharges from the brewery which free flow over the bedrock on the east side of the river between the top and the bottom of Tumwater Falls.

Results

The first set of samples was collected during a relatively dry condition so that base flow concentrations discharging from the outfalls could be established, before actual storm water run-off samples were collected. This first event was also when cooling water discharges from the brewery were sampled. Storm water outfall site TH-1, in Historical Park, was not identified and sampled until the third sampling event. During the third event, analysis for nitrate and ammonia were added to obtain additional water quality information.

The total phosphorus concentrations in the brewery discharge samples were roughly one-half to one-tenth of the concentrations reported by Entranco in 1984, which demonstrates the improved cooling technology now employed by the brewing company.

Bacteria levels were consistent, if not somewhat lower than, typical storm water concentrations. Total phosphorus concentrations in the storm water samples were roughly twice the EPA recommended limit of 0.050 mg/l to control accelerated plant growth in streams discharging to a lake or reservoir, but typical of storm water concentrations. The nitrate concentrations in the third sample set were within the expected range for storm water, however, the ammonia levels were slightly higher than expected. For comparison, the mean ammonia level in the river (for the period between 1991 - 1997) is 0.028 mg/l, with a range from less than 0.010 to 0.182. Most local stream concentrations of ammonia are in the hundreths of a milligram per liter, as was the concentration of the TH-1 sample. No further conclusions can be reached regarding the ammonia concentrations in DS-1 through DS-3 without additional investigation. Since the other parameters were not at concentrations strongly indicative of sewage contamination, further investigation may not be warranted at this time.