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DESCHUTES RIVER/CAPITOL LAKE WATER QUALITY ASSESSMENT

by

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Introduction

The Deschutes River and Capitol Lake have had a great deal of water quality and planning work completed in the past. The purpose and direction of the work can be related to the enhancement or preservation of beneficial uses. The drainage has many uses and users with concentrated utilization occurring in Capitol Lake.

Capitol Lake was formed by impounding the Deschutes River and Percival Creek estuary. Impoundment of the estuary accompanied with the diverse usage makes management much more difficult than a normal riverine environment. Management activities to date have generally been oriented toward finding solutions to single problems. The past work has served its purposes well; however, future efforts need to address all users and the impacts individual users have on one another and the system. Both short- and long-term impacts of each use need to be identified. Measures can then be taken to coordinate a management plan which considers all affected.

The task was to review the literature to date and discuss various water quality problems currently present. The literature review deals primarily with water quality problems in the drainage and does not include extensive reviews of dredging-related publications. The resulting Annotated Bibliography also serves as the bibliography for the text. Publications appearing in the Annotated Bibliography were reviewed, but not necessarily cited.

To ascertain present water quality conditions and allow comparison to historic conditions in Capitol Lake, a weekly monitoring program was begun on June 1, 1982 and will continue through September, 1982. Dissolved oxygen, salinity, conductivity, temperature, Secchi disk depth, and fecal coliform data taken to date are presented in Appendix I. Data collected concurrently from Budd Inlet are also included.

This report discusses the historic and current water quality impacts/concerns in light of their beneficial uses. Topics include: The Capitol Lake Swimming Area; Salmon Rearing; Capitol Lake Sedimentation Control; Capitol Lake Depression; and Percival Creek.

Capitol Lake Swimming Area

The swimming area in Capitol Lake has been enjoyed by many members of the community. However, its use has been hampered by violations of Thurston County Health's water quality standards. In response to this, a lake restoration project was initiated which would allow more control over the water quality in the swimming area. Briefly, the project provides: isolation of the majority of the water in the swimming area; disinfection facilities for the wading area; suspended particulate control via aluminum sulfate injection; and dilution with potable water as necessary to keep the quality within acceptable limits (Olympia, 1982). It is hoped that these measures will provide the community with a consistently usable swimming area in the future.

Maintenance Requirements

In the past, swimming area repairs and/or maintenance have been completed during lake drawdowns in the spring. It would be very wise of the City to coordinate with the Washington State Department of Fisheries (WDOF) and complete any required maintenance during the fish release/drawdown in late March. Failure to take advantage may require a later drawdown which might not be possible in light of water quality conditions in early summer.

Future Water Quality Monitoring

It would seem appropriate for the City to monitor the water quality of the new swimming area system often and regularly. Secchi disk measurements could easily be worked into the daily maintenance. Semiweekly fecal coliform analyses should also be completed. In this way, feedback would be immediate and the routine operation/maintenance requirements of the system could be established early on. These data would also let them operate the system more efficiently and inexpensively.

Swimming Beach Closures, Water Quality Standards

The Thurston County Health Department has closed the swimming area in Capitol Lake on many different occasions. Historically, the area has been closed for either fecal coliform bacteria levels in excess of their standard (50 org/100 mls), poor water clarity (criterion has ranged from 3 to 5 feet), or both (Reeves, 1982). Data records at the Health Department indicate some beach closures have been based on one sample.

In June 1982, the Health Department's criterion changed to fecal coliform levels of 100 org/100 mls and water clarity of five feet as measured by an eight-inch black and white Secchi disk. Fecal coliform levels in excess of the standard will now always be verified by an additional sample before closure is made (Reeves, 1982). This verification is imperative as coliforms are log normally distributed.

Many counties do not have such standards and if they do, the standard is not uniform. The U.S. EPA (1976) has published a guideline of 200 org/100 mls for swimming areas. This level is a log mean based on a minimum of not less than five samples taken over not more than a 30-day period. Not more than 10 percent of these samples shall exceed 400 org/100 mls. This criterion is designed to protect fishable-swimmable waters. Washington's Class A criterion is similar in method to EPA's guideline; however, the log mean level is 100 org/100 mls and 10 percent of the samples may not exceed 200 org/100 mls (WDOE, 1977). This criterion applies to flowing, fresh waters of the state. Capitol Lake is a flowing system and not a lake by definition. Its mean detention time falls below the 15-day period established for lakes (WDOE, 1977).

The standards given by U.S. EPA (1976) are for either the Membrane Filter (MF) or the Most Probable Number (MPN) techniques. The Thurston County Health Department primarily uses the MPN method for fecal coliform enumeration in lakes and streams (Reeves, 1982). When compared to the MF technique, the MPN method is more costly to run and has broader confidence limits. One of the Health Department's reasons for minimal verification samples has been the cost of analyses. If a switch was made to the MF method for lakes, streams, and rivers, costs would be lower and more verification samples would be possible.

Bacteria Sources

At present, the Deschutes River appears to be the predominant source of fecal bacteria loading to Capitol Lake. CH_2M Hill (1978) reported a possible fecal source between the WDOE station 13A060 (river mile 0.6) and the lake. A faulty lift station was found to be the major source of the contamination. This source was repaired and the data collected as part of this work indicate concentrations have dropped substantially from the 1977 values.

The geometric mean of data collected below Tumwater Falls, Station 9, from June to August 1982 (92 org/100 mls) is slightly higher than the historical geometric mean of the upstream station 13A060 (26 org/100 mls). This may indicate a low-level source is still present between the two points; however, water quality standards (WDOE, 1977) are usually maintained in the lake. Station 9 has consistently had the highest fecal coliform concentrations of all lake stations.

The CH_2M Hill (1978) report also identified intermittent fecal sources around Olympia's swimming area. The implicated storm drain sources have been identified, bacterial levels quantified, and interim steps taken by the City of Olympia to eliminate them by the end of summer, 1982. The faulty line will be replaced completely prior to the 1983 swimming season (Anderson, 1982).

The fecal coliform levels in the lake this season have been within the state and county standards consistently. It appears that the sources of the lake's fecal coliform problems have been or are in the process of being eliminated. An extensive fecal coliform monitoring program designed to find the source of the problem will be of little value now because fecal coliform levels are very low. The presence of the swimming area curtain also confines and potentially treats any load possibly added by the swimmers.

Water Clarity

The poor water clarity in Capitol Lake is very difficult to remedy. The clarity of the water is directly related to the phytoplankton populations (algae) present in the lake. The phytoplankton respond directly to available sunlight and nutrients. The source of nutrients in the Deschutes drainage is primarily non-point. The CH_2M Hill (1978) report implicated two areas as nutrient sources, as did Orsborn *et al.* (1975). WDOF fish rearing area in Percival Cove is a significant source of nutrients; however, the nutrients do not have a dramatic impact during the algal growing season because the fish are only fed from late September to late May. The reservoir's high flushing rate makes the impact from this source negligible during the period of swimmer use. A steady source of orthophosphorus appears to be present between river miles 0.6 and 4.6. (CH_2M Hill, 1978). The Tumwater Valley Golf Course is the most likely source; however, additional work would be required to verify this.

The nutrient concentrations found in the Deschutes River are similar to other western Washington rivers (Orsborn, *et al.*, 1975). A detailed nutrient budget would be required to determine the relative impacts of the various land uses on the river. Control of phytoplankton in Capitol Lake through a nutrient abatement program on a system dominated by non-point sources is an extremely difficult task. It would require extensive work and quite probably have minimal results for the effort expended. The new swimming area facility should give the City the control it needs to ensure the five-foot clarity standard is met.

The present plan to partially isolate the swimming area water will quite probably satisfy the swimming needs of the lake users. The current plan allows for disinfection, dilution, and particulate removal. If it works as outlined, violations of the Thurston County Health Department's standards should be rare. This does not preclude violations of the clarity standard in the non-supervised areas of the lake where swimming and wading occasionally occur.

Salmon Rearing

The WDOF maintains Washington's largest salmon rearing area in Percival Cove. Historically, the ponds at Percival Cove have followed a schedule whereby two crops of fish are raised per year. The first begins in late September and lasts through the end of March when the "yearlings" are released. The fish are forced into the estuary by either a complete drawdown of the lake or "bumping" (when the lake level is lowered 1 to 3 feet and allowed to fill repeatedly). Of the two methods, a complete drawdown is preferred by WDOF in the spring because they can do required maintenance prior to stocking the ponds with salmon fry. The fry are planted in April, kept until late May or early June, and released. As with the earlier release, bumping or a complete drawing is required to direct the fish into the estuary (Peck, 1982).

A complete drawdown of the lake is also preferred by Olympia's Parks and Recreation Department. They also perform needed maintenance work at the swimming area during these periods (Clark, 1982).

The reservoir is then either allowed to fill up from the Deschutes River and Percival Creek flows or it is back-filled with marine water. Back-filling on the high tides serves several purposes: (1) it fills the lake much faster and restores public access; (2) it kills many of the non-salmonid fish which compete with salmon in the rearing area (Peck, 1982); and (3) it helps control the aquatic macrophytes present in the mid-basin (CH_2M Hill, 1978).

Fisheries maintains and operates a fish ladder at the dam. Historically, when the fish began to return, the ladder was set at one depth at the beginning and remained open until the run had ended. This practice allowed saltwater entry at high tide and discharge at low tide. As a result of the September 1981 fish kill, the normal procedure was altered to minimize saltwater entry (Peck, 1982). It is now believed that saltwater entry is essential to maintain oxygen levels in the depression behind the dam.

A recent WDOF request would only allow discharge from the lake to Budd Inlet via the fish ladder; and, through the dam gates when the tide level was five feet below the lake level. The plan would force all returning salmonids into the fish ladder/trap. The procedure has merit and minimizes stress to returning salmonids; however, WDOF has hopes that their plan may be implemented in the future after Capitol Lake's quality concerns have been addressed. It was not put into effect because saltwater intrusion would be eliminated.

Capitol Lake Sedimentation Control

The sediment deposition in upper Capitol Lake has been a concern since the dam was built. Periodic dredging is necessary to maintain lake depths in the upper basins. A plan has been suggested by Hough (1981) which would minimize the erosion from 54 raw banks in the lower Deschutes River basin by adding rip-rap and vegetation. The report only discusses raw banks in the river downstream of Fennel Road (located upstream of Vail, a short distance). It is important to note that the plan does not address erosion from 11 of the 12 sites identified as the major eroding banks in the drainage (Moore and Anderson, 1979). Moore and Anderson (1979) found that the sediment load from the river above Vail comprised 66 percent of the sediment observed at the mouth during November and December, 1977. Therefore, if implemented and totally effective, the plan suggested by Hough would probably only reduce the sediment load deposited at the lake by 1/3 of its present amount. Nelson (1974) found that the Deschutes River and tributaries above Mitchell Creek (located about 3 river miles upstream of Fennel Road) contributed 88 percent of the river's suspended sediment load. This would indicate that less than a 12 percent reduction in sediments deposited at Capitol Lake would occur as a result of implementation of the plan (Hough, 1981). Although this plan has merit, a cost/benefit analysis seems appropriate in light of the other reports.

Capitol Lake Depression

Tracy (1981) documented the fish kill which occurred on September 9, 1981. His report identified a depression behind the Capitol Lake dam and the intrusion of saltwater into the lake and subsequently the depression. Intrusion primarily occurs if a greater marine water head is present when the dam gates open. Stratification results as this saline water is denser and not flushed out by river flows. Bacterial respiration depletes dissolved oxygen levels and also mediates H_2S buildup when the water becomes anoxic. The tides are often high enough to renew the marine water daily; however, a series of higher high tides preceded the fish kill where the head differential was not great enough to intrude marine water for several days. When the anoxic water was finally flushed out, the H_2S toxicity, immediate oxygen demand of the H_2S, and the anoxic water collectively caused the kill.

Elevations

Any discussion regarding elevations around Capitol Lake must include the point of reference. There are three datums which are important to the Capitol Lake work. A short discussion of each may be beneficial. The mean sea level datum is based on the average height of the surface of the sea for all stages of the tide and is usually determined from hourly readings. The datum is used on the charts and maps of the National Oceanic and Atmospheric Administration (NOAA) National Ocean Survey (formerly the U.S. Coast and Geodetic Survey). The mean lower low water datum is established from the mean of the daily lower low water elevation of the two low tides in a cycle. This reference is used in the tide tables. The City of Olympia's datum was arbitrarily set as the level which probably would not flood during a high tide (Bobbitt, 1982). This datum is not constant and varies with location in the city. The Capitol Lake dam has two staff gages, one on each side of the dam. In order to accurately determine their reference point, the City of Olympia's Survey Division was requested to survey elevations as they related to the three datum points discussed above. Table 1 presents the results which are in reference to the gages on the dam.

Table 1. Elevations of selected datum points.

	Datum Elevation in Feet		
Gage	City of Olympia	NOAA Mean Sea Level	Mean Lower Low Water (tidal datum)
Budd Inlet Side	0.15	10.08	17.92
Capitol Lake Side	0.00	9.93	17.77

As this table illustrates, the elevation of one location can be expressed as three different values. Elevations based on the City of Olympia datum are predominantly used for the lake level and related to the tide levels (mean lower low water datum).

Water Quality Characteristics and Controls

The depression in Capitol Lake is the single-most important factor causing water quality problems in the lake. Its presence dictates continual concern. The general sequence of events which lead to problems in the lake begins with saltwater intrusion. Intrusion into Capitol Lake currently occurs via many routes: the fish ladder; gates opening at high tide when the lake level is equal to or below the tide level; leakage around the dam gate seals; and back-filling the lake with marine water. The amount the gates are open also plays an important role in saltwater entry; however, more data are needed to determine the exact relationship between head height and gate position. The avenue of entry is really not critical because the saltwater, being denser, will flow into the lowest area available. The freshwater/saltwater interface is usually at the six-meter depth. This depth corresponds to the elevation of the withdrawal point of the dam. Occasionally, saltwater will be at the four-meter depth and extend almost to the railroad bridge. Saltwater at this depth is discharged rapidly, leaving saltwater at the six-meter level.

The denser water mass remains until either river flows increase substantially or more saltwater is introduced from the aforementioned sources. If the stratified saline water is not flushed out, decomposition of marine organisms which cannot live in the oxygen-poor environment and detritus consume the dissolved oxygen. Data indicate that the level of D.O. may change from greater than 4 mg/L to less than 1 mg/L in less than 24 hours. The rate of oxygen depletion appears to increase as the season progresses. This should be expected as detritus accumulates. Once the water mass becomes anaerobic, the sulfate-reducing bacteria begin producing hydrogen sulfide (H_2S). Hydrogen sulfide concentrations do not build up as long as an iron (Fe^{+2}) source is available (Hutchinson, 1975). If insufficient iron is available, levels of H_2S increase and the situation which caused the September fish kill occurs. The longer the time period between flushing, the worse the situation becomes.

The time between flushings could last for several days during a range of tides where the higher high is lower than the lake level. A 14.3-foot tide has been required this summer; however, the dam operational manual says the lake level should be at 14.0 feet. At these elevations, some control of the water quality conditions in the depression is possible; however, complete control is not. The single-most effective measure is to open the gates of the dam at high tide and allow marine water into the lake. The rapid withdrawal of lake water is an alternative; however, substantial drops in the lake elevation are required before appreciable water quality improvements are realized. Data indicate that only dilute marine water is present at the bottom of the depression following a drawdown of 4 to 5 feet. The frequency of flushing may also be increased by keeping the lake level lower than the higher high tide. Tracy (1982) suggested lowering the lake level one foot.

Such a measure would definitely help. Minimally, the lake should be lowered to 14.0 feet (-3.75 feet on the dam staff gage). At a level of 14.0 feet, there is one period in August, two in September, and two in October when flushing will not occur. The periods range from two to eight days in length. Lowering the lake on the following days to a level equal to or below the higher high tide would promote flushing during critical times (Table 2).

Table 2. Dates, times, and levels of tides which are lower than current Capitol Lake level of -3.75 feet, 1982.

		Time	Tide Level	Lake Level
			Mean Lower Low Water Datum	City Datum Staff Gage on Dam
August				
Tuesday	24	2214	13.8	-4.0
Wednesday	25	2252	13.2	-4.6
Thursday	26	2338	12.7	-5.1
Friday	27			
Saturday	28	0029	12.8	-5.0
Sunday	29	0128	13.3	-4.5
Monday	30	0224	13.7	-4.1
September				
Thursday	9	2202	13.8	-4.0
Friday	10	2251	13.5	-4.3
Saturday	11	2351	13.1	-4.7
Tuesday	21	2038	13.5	-4.3
Wednesday	22	1006 or 2110	13.0	-4.8
Thursday	23	1111	12.8	-5.0
Friday	24	1230	12.7	-5.1
Saturday	25	1346	12.9	-4.9
Sunday	26	1455	13.2	-4.6
Monday	27	1545	13.6	-4.2
Tuesday	28	1626	13.8	-4.0
October				
Friday	8	1052	13.9	-3.9
Saturday	9	1208	13.9	-3.9
Friday	22	1046	13.9	-3.9
Saturday	23	1152	13.8	-4.0
Sunday	24	1254	13.8	-4.0
Monday	25	1352	13.9	-3.9

The schedule will have impacts on the operation of the fish ladder during time of peak fish passage; however a great potential for severe water quality conditions exists if the depression is not routinely flushed.

River flow, lower temperatures, and higher tides should minimize the problem and concern in late October.

Size and Formation

Inspection of the 1949 hydrograph presented by Bachmann (1974) indicates the depression was not present prior to the dam construction. It was shown on a 1975 map prepared for General Administration by Arvid Grant and Associates. This map shows the maximum depth to be -29 feet (mean sea level datum, Figure 1) at that time.

Recent work completed in July, 1982 by WDOE indicates the depression has deepened from the 1975 levels. Figure 2 depicts the depression in its present state. The outer perimeter has not changed greatly, but the volume has. The map was made using a Si-Tex-Honda continuous recording depth sounder. Transects were made at 10-foot intervals perpendicular to the face of the dam. A total of 30 transects were made, 15 within the log boom area and 15 continuing out from the boom to an artificial line between the Park Department's boat house on the east bank and a stake placed on the west bank. This map should be considered relatively accurate; however some difference exists between the actual location of the hole in 1975 and 1982. This difference probably represents differences in the maps and not that the hole has moved. The log boom undoubtedly caused some amount of error as did the endpoint of the transects in the 1982 mapping. However, relative comparisons may be made between the maps. The 1982 work detected an additional hole between the major depression and the dam. It is relatively small and may have deepened recently or been missed during the 1975 work.

Volume estimations were made using the methods of Lind (1979). Both 1975 and 1982 volumes were calculated to the -15-foot contour line of the major depression. The results are given in Table 3.

Table 3. Historic and current volume estimations of the scoured depression.

Contour Interval	Volume m^3 1975	Volume m^3 1982
-30 to -32	0	23
-25 to -30	56	536
-20 to -25	665	1766
-15 to -20	2445	2987
	2445	5312

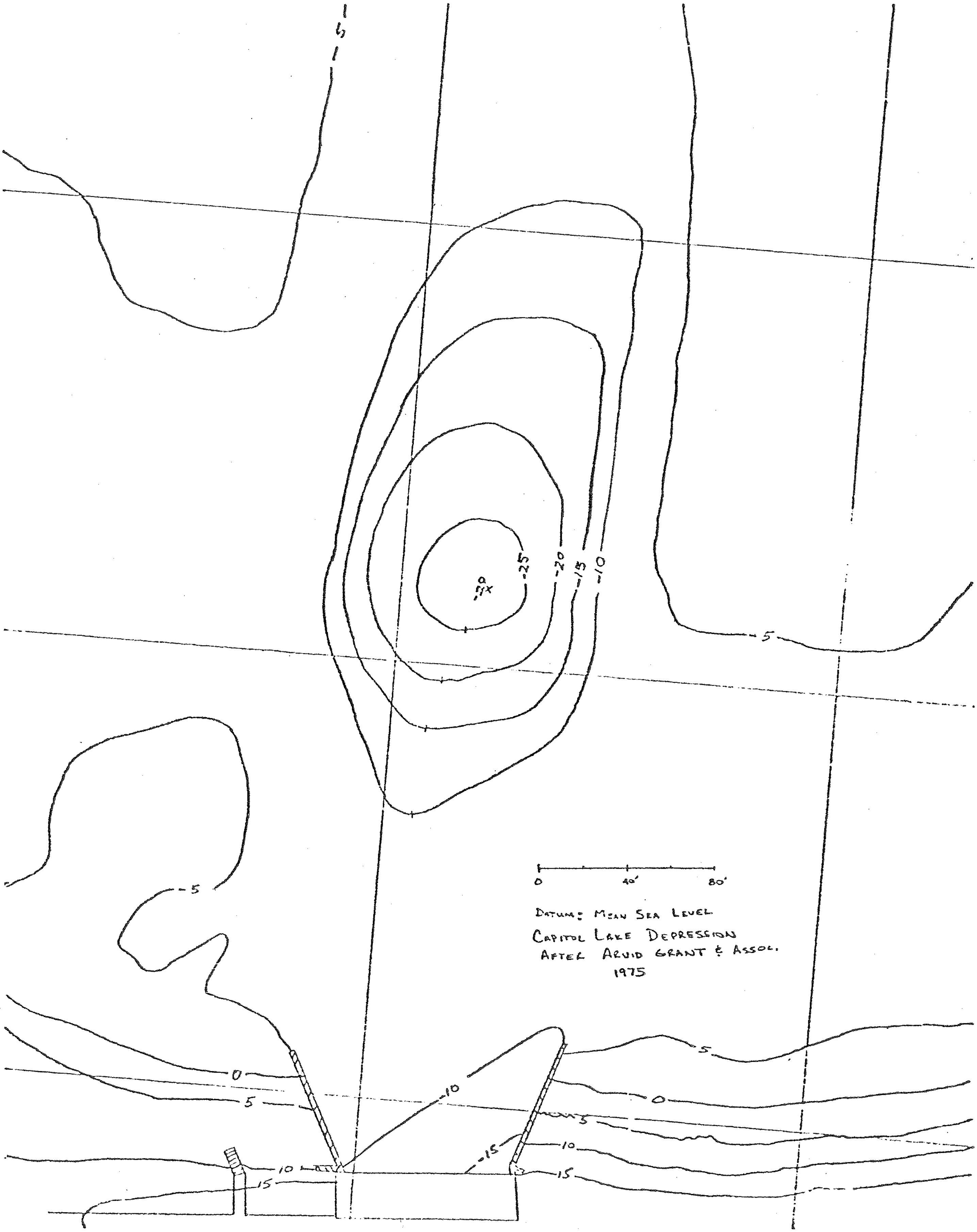

Figure 1. Map of Capitol Lake depression, 1975.

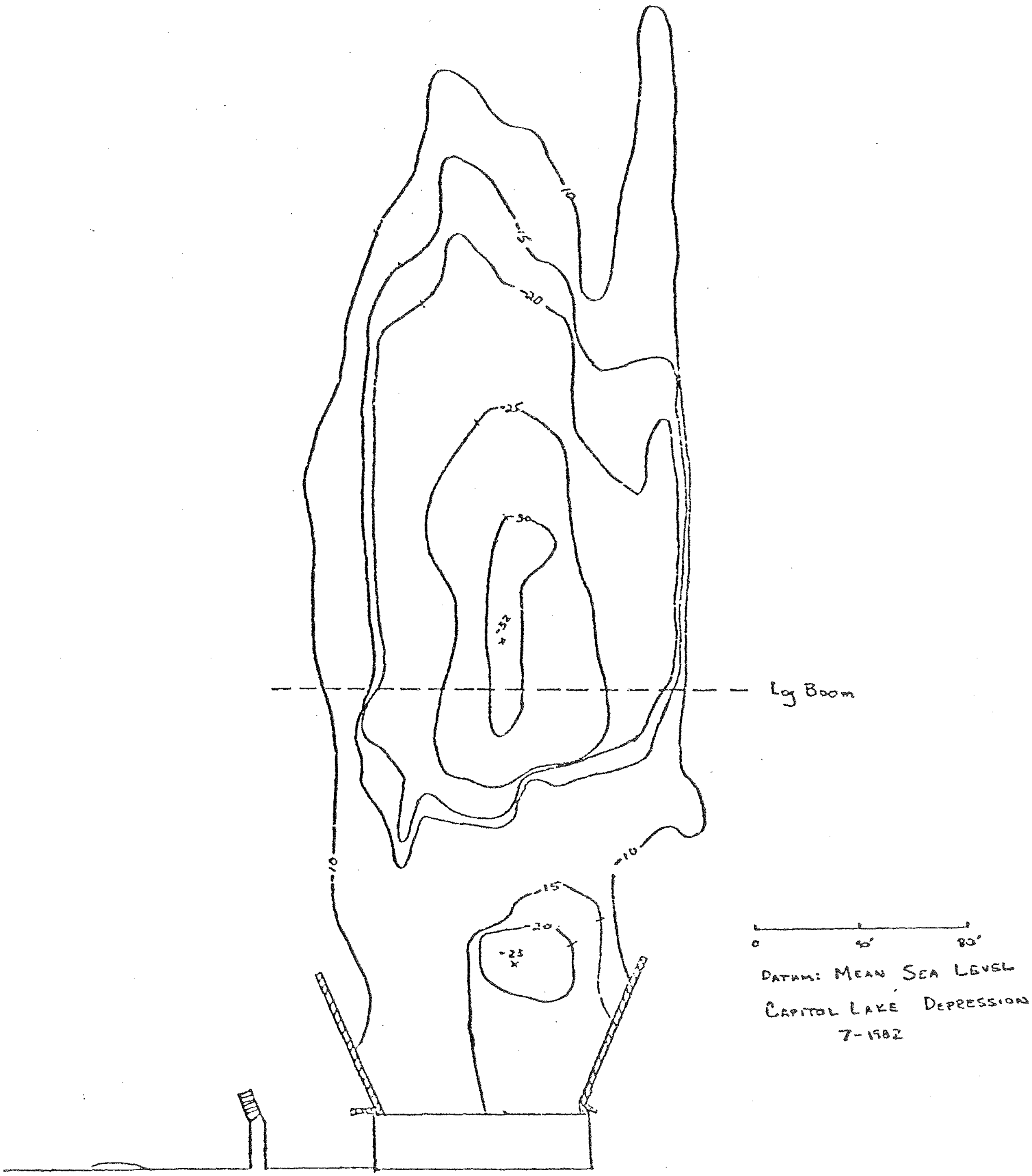

Figure 2. Map of Capitol Lake depression, 1982.

These data indicate that the volume of the major hole has doubled since 1975. The volume of the smaller hole is 300 m^3.

It is very unlikely that the scouring is a steady process which occurs at a uniform rate year after year. Scouring probably occurs only at times when the empty reservoir is filled rapidly with marine water. Conversations with General Administration personnel indicate that the reservoir has been filled during one high tide period. A standing wave is formed when such rapid filling occurs and is undoubtedly made worse if the gates are opened when the water in Budd Inlet is much higher than the existing lake level. CH_2M Hill (1978) reported turbidity of the reservoir increased following back-filling. It appears that the increased turbidity was due to erosion of material behind the dam.

Dam Operation

The operation of the Capitol Lake dam is the responsibility of the Department of General Administration. In the past, concern over the operation of the dam has been minimal; however, since the fish kill occurred the procedures and operation have been scrutinized. The dam operation is continuously monitored electronically. Inspection of this record indicated the dam is not operating as it was designed (Singleton, 1982). General Administration has contacted Technical Systems, Inc. (TSI), the firm which installed the controls at the dam, and arranged to have all components of the operational system calibrated. As of this writing, TSI has not inspected the dam; however, it appears that the calibration will be completed by mid-September (Sweet, 1982). At that time, a determination should be made as to how the new operational procedures will affect water quality in the depression. If intrusion is minimized as it is supposed to be (Sweet, 1982), saltwater flushing will not occur and the potential for another fish kill is great. Alterations in the operational procedures may have to be made at that time to prevent water quality degradation.

Solutions for Water Quality Problems

There are several possible solutions to the water quality problems caused by the presence of the depression. Regardless of the measure(s) taken to remedy the water quality problems, interim dam operational techniques have to be taken to ensure adequate dissolved oxygen levels are maintained in the hole, and further scouring is minimized. Backfilling the lake following draining should only occur gradually and if necessary, over several high tides. The gates should never be opened when a head difference greater than six inches exists. Excessive turbulence has to be avoided.

The following discussion of solutions is an attempt to bring out consideration of each. It should be noted that these methods may not be the only way to solve the problems and regardless of the actual plan, an engineering report needs to be prepared.

Filling

This measure would have no operation and maintenance expenses after the initial costs. This assumes the fill material will not continually settle. Geologic surveys have been made in the area and they would have to be consulted to determine the settling potential. The initial fill material should be fine enough to prevent honey-combed areas which would trap large amounts of water. This stagnant water would be a constant source of H_2S. The fine material should be used until the fill is about to the -20-foot contour. The remainder of the fill, up to the -15-foot level, should be rip-rap. Approximately 5,300 m^3 (7,000 yd^3) of fill would be required if no material sank into the bottom muds. Saltwater intrusion would not be a concern after filling the hole.

Aeration

Several designs are available. The equipment would have to be designed for the volume and oxygen consumption rates in the system. The equipment will either have to be anchored securely or removable during high flow periods. Operation and maintenance costs can be quite high if a high aeration efficiency is required. The equipment would have to be run from June through September or October. Depending on the system used, aeration can minimize stratification and promote mixing. It has been said that aerators act as cheap circulation pumps (Smith, 1975). Saltwater intrusion would probably not have to be minimized with this plan.

Pumping

Marine water could be pumped back into Budd Inlet. Pumps would have to be large enough to pump water out before its quality degraded and caused problems in the receiving water. Operation and maintenance may be high. The amount of saltwater intrusion would probably have to be minimized. Methods are discussed later in text.

Destratification

Circulate the water so stratification cannot occur. Pumps should be removable or anchored well and operation and maintenance may be high. Saltwater intrusion would probably not have to be minimized.

Stop Marine Water Intrusion

Marine water could be kept out of the lake by altering several factors. Backfilling the lake with marine water would have to be eliminated. This would mean slower filling following fish release, aquatic macrophytes would become a much greater problem, and the Department of Fisheries might have to rehabilitate the lake to remove undesirable fish species. It also means that dam operation would have to be modified. When and how wide the gates could open would have to be determined and modified. This assumes the present controls can be set as needed. If not, the controls may have to be altered. The seals on the dam would need to be replaced now and routinely from now on. Operation of the fish ladder will also have to be changed. At present, it would have to be raised and lowered by hand.

A contingency plan would have to be developed regarding what to do if saltwater got into the lake by mistake. One other problem which has not been discussed is that the freshwater in the depression will probably stratify and become anoxic even without saltwater intrusion. This could be a problem at fall turnover. Keeping all saltwater out, all of the time seems to be difficult and eliminates the backfilling benefits mentioned earlier. The plan probably depends upon controlling too many variables and groups to succeed very well.

Most of the above plans will require additional water quality monitoring to ensure the system is adequate and working properly. The filling plan would not require any additional work if the hole were filled to the point where stratification could not occur.

Percival Creek

Percival Creek does not appear to adversely impact the water quality of the lake; however, the amount and type of development occurring in the Percival Creek drainage should be noted. Sedimentation may become more of a problem in the future. The potential for a spill of a toxicant also increases in commercially zoned land. Either one could potentially impact the salmon rearing facility. To date, the water quality work conducted on the drainage has been minimal, primarily because there have not been any noted problems.

ANNOTATED BIBLIOGRAPHY

Anderson, D., 1982. Washington State Department of Ecology, Southwest Regional Office, Olympia, WA.

Arvid Grant and Associates, Inc., 1974. Water Pollution Control and Abatement Plan for Deschutes River Basin. Project Report Grant #DE-SDB 72.07, WDOE.

The report presents a small amount of data and discusses "pollution" problems in very general terms. It also states that no non-point problems exist; however, some will probably be identified in the future. Report primarily addresses the area's sanitary sewerage needs with very little relation to water quality conditions or improvements resulting from sewering areas.

Bachmann, J.W., 1974. Saving a beautiful lake. Olympia WA. 35 pp.

Gives a good history of the lake and contains some maps and hydrographs. Outlines plans for further lake development and maintenance.

Bobbitt, G., 1982. City of Olympia Engineering Dept., Survey Division, Olympia, WA.

CH_2M Hill, 1978. Water Quality in Capitol Lake. Olympia, WA. Report prepared for Washington Depts. of Ecology and General Administration. 79 pp.

The report considers: bacteria quantification and sources; effect of the fish rearing program in Percival Cove on the water quality in the lake; nutrient sources; and recommendations to manage or abate sources. The bacterial survey was based on a grid pattern of samples and used fecal coliform-to-fecal streptococcus ratios to identify sources. No major bacterial sources were noted; however, two discharges in the swimming area were identified as occasional sources. The major bacterial loading was from the Deschutes River and waterfowl. The data indicated a low level, continuous source of bacteria was present in the Deschutes River below the WDOE/STORET routine station. Nutrients in the lake are high. The noted source was the Deschutes River. A nutrient ammonia and total phosphorus source was indicated in the river below the WDOE/STORET station. They also noted a continuous input of orthophosphorus in the lower four miles of the river. The importance of nutrient loading sources is the: Deschutes River; Percival Creek (N); and rearing pond/creek for phosphorus. Concentrations of ammonia and orthophosphorus in the pipe in the swimming area were significantly different from other stations. The nutrient sources in the swimming area increased orthophosphorus concentrations in the immediate lake area. Winter nutrient loading is greater because of increased flow; however, in-lake orthophosphorus concentrations do not change. The limiting nutrient in the

lake alternates from N to P. Nutrient limitation will be difficult because of the loading's non-point nature. Phytoplankton populations declined dramatically following lake flushing. Flushing severely limited *Anabaena* and increased Secchi depth. D.O. % saturation was also significantly different in the swimming area. D.O.s declined after flushing. They attributed this to algal and plant decay after flushing in June. Lesser declines occurred with subsequent flushing in July and September.

The fecal coliform work was not definitive. Their method was hampered by very high background coliform levels.

CH2M Hill, 1976. Capitol Lake Restoration Summary; Draft Environmental Impact Statement; and Design Engineering Report, prepared for Department of General Administration, 15 pp; 73 pp; and 67 pp.

Reports all deal with sediment accumulation and plans for removal.

Clark, D., 1982. Olympia Parks and Recreation Dept., Olympia, WA.

Haag, R. Associates, Inc. and CH2M Hill, 1976. Capitol Lake Recreation Plan; Environmental Impact Statement and Design Report, prepared for Department of General Administration, 65 pp and 91 pp.

Reports deal with park plans for the lake area and dredge spoils dumping sites.

Hough, G.H., 1981. Deschutes River Report. Thurston Conservation District. Olympia, WA. 14 pp.

This report discusses solutions to stop erosion from 54 banks identified in 1970 by the Soil Conservation Service. These banks are all located downstream of Fennel Road (upstream of Vail a short distance). This report does not address erosion from 11 of the 12 sites identified as major eroding banks in the drainage (Moore and Anderson, 1979). The sediment from the river above Vail was 66 percent of the sediment observed at the mouth during November and December, 1977.

Hutchinson, G.E., 1975. A Treatise on Limnology. Volume 1, part 2 - Chemistry of Lakes. Wiley and Sons. 1015 pp.

Kittle, L. and H. Tracy, 1982. Lower Budd Inlet Marine Resource Damage Assessment (MRDA) September 10, 1981. Memorandum to Bruce Cameron, WDOE, January 19. 13 pp.

Resource damage assessment of the September, 1981 fish kill. Suggestions are presented for (1) future resource protection and (2) a water quality monitoring program.

Kramer, Chin and Mayo, Inc., 1973. An engineering study of the Percival Creek drainage basin, prepared for the City of Olympia, WA.

The report is primarily concerned with the development of a stormwater drainage plan to preserve Percival Creek. The primary concern is siltation and scouring caused by increased flows due to surface runoff and its subsequent impact on the fishery. No water quality data were collected or included.

Kruger, D.M., 1979. Effects of Point Source Discharges and Other Inputs on Water Quality in Budd Inlet, Washington. Wash. Dept. Ecology Report. DOE 79-11, 40 pp.

Report addresses bacteria, nutrients, and dissolved oxygen/BOD loading to Budd Inlet. Bacteria are loaded almost equally by three sources: Moxie Creek; Deschutes River/Percival Creek; and the LOTT treatment plant. Eighty percent of the orthophosphorus is loaded by the LOTT plant and Deschutes River contributes 80 percent of the nitrate. This, however, does not significantly increase Budd Inlet nutrient concentrations because Puget Sound waters are naturally nutrient rich. Eighty-one percent of the BOD loading is discharged by the STP. The D.O. sags which are present occur as a result of Capitol Lake flushing, phytoplankton blooms/dieoff, and optimal weather conditions. Some of these findings are in contrast to memo by Yake, 1981.

Lind, O.T., 1979. Handbook of Common Methds in Limnology. 2 ed., Mosby Co. 199 pp.

Moore, A., 1982. Outfall Sampling to Capitol Lake During March, 1982 Drawdown. Memorandum to Joan Thomas, WDOE, April 13, 6 pp.

Sanitary and nutrient survey of pipe influent sources to Capitol Lake during March, 1982 drawdown. This survey photographed and sampled all major inputs to Capitol Lake. Two sources appeared to significantly load bacteria to the lake. Both sources were found in the swimming area. These inputs discharge into a vortex circulation system and may concentrate in the summer months. Flows during the surveys were also estimated. The steam plant discharge contained the highest nutrient concentrations.

Moore, A. and D. Anderson, 1979. Deschutes River Basin Suspended Sediment Transport Study. Wash. Dept. Ecology Project Report. WDOE-PR-7. 21 pp.

The goal of the study was to identify sediment loading areas in the watershed and determine th(significance of each after quantification. The report determined that 7 percent of sediments reaching Capitol Lake during the study period originated from bank and bed erosion of the Deschutes River mainstem. Twelve banks were identified as major sediment sources. One below Vail and 11 above Vail.

Nelson, L.M., 1974. Sediment Transport by Streams in the Deschutes and Nisqually River Basins, WA. November 1971 - June, 1973. USGS Open-file Report. Tacoma, WA. 33 pp.

This report identifies the Deschutes River above the confluence of Mitchell Creek as contributing 88 percent of the river's suspended sediment load. They also predict the yearly load for the drainage to be 25,000 tons. Developed discharge vs. suspended sediment concentration relationships for the river. The annual, estimated, average sediment deposition in Capitol Lake is 30,000 cubic yards are deposited. Estimated the Upper basin would be filled in 6 to 8 years; middle segment in 60 years, and the lower in 60 years. Report contains a bathymetric map. They state that land use practices in the lower basin probably has minor effects on the magnitude of sediment deposition.

Nih, W.C., 1976. Supplemental flow and sediment tests of Capitol Lake hydraulic model, report for Wash. Dept. General Administration.

The report discusses effects of various dredge spoils fill sites in and around the lake. Recommendations are made which enhance circulation in certain areas.

Olympia, City of, 1982. Capitol Lake Swim Beach Restoration Project #OD1205. June.

Plan to improve water quality in the Capitol Lake swimming beach. Request for bids to do the job which would attach a hypalon curtain to existing pilings. It would extend from the surface to the bottom. A diffusor system would also be installed to diffuse a freshwater source into the area. No monitoring work will be required in the swimming area.

Orsborn, J.F., *et al.*, 1975. Hydraulic and Water Quality Research Studies and Analysis of Capitol Lake Sediment and Restoration Problems, Olympia, WA. Project 7374/9, 12-1310 report. Wash. Dept. General Administration, 315 pp.

The report is written in two major sections: the first deals with hydraulogy and the second concerns water quality. The second section was the only part of the report reviewed. It contains a detailed historical review of water quality data. Nutrients placed lake in meso-eutrophic class. N and P ratios did not indicate limitation of phytoplankton during the work. Surface loadings of N and P were approximately 100 times greater than dangerous and 10 to 100 times higher than some eutrophic waters. Vollenweider's 1968 model was used for this comparison; however, it does not include the impact of very short residence time. The nutrient budget is only an estimation as minimal data were used. The nutrient concentrations present in the system are similar to other western Washington rivers. Saltwater flushing is noted as being important to aquatic weed control. Capitol Lake is eutrophic, but does not show all characteristics because of the high flushing rate and saltwater backfilling.

Peck, L., 1982. Washington State Dept. of Fisheries, Olympia, WA.

Prescott, S., 1981. Capitol Lake Fecal Coliform Levels and Lake Flushing. Memorandum to John Bernhardt, WDOE, October 2, 1981. 2 pp.

Summarizes monitoring work performed in August, 1981. Fecals were highest in the vicinity of the swimming area near pipes the CH_2M Hill report mentioned as being possible sources of fecal contamination.

Reeves, H., 1982. Thurston County Health Dept., Olympia, WA.

Singleton, L., 1982. Capitol Lake Dam Operation. Memorandum to Joan Thomas, WDOE, July 16, 1982. 2 pp.

The memo discusses several inconsistencies in the dam operation and suggests that the entire system be calibrated and checked by Technical Systems, Incorporated (TSI). TSI installed new controls in late 1981.

Smith, S.A., D.R. Knauer, and T.L. Wirth, 1975. Aeration as a Lake Management Technique. Tech. Bul. 87, Wisconsin Dept. of Nat. Res., Madison, WI. 39 pp.

Sweet, B., 1982. Washington State Dept. of General Administration, Buildings and Grounds Division, Olympia, WA.

Tracy, H.B., 1981. Mechanics of the H_2S Releases from Capitol Lake into Budd Inlet. Memorandum to John Spencer, WDOE, October 9. 5 pp.

Documents the Budd Inlet fishkill of September 9, 1981. Report identified the stratified depression behind the dam as the source of H_2S and anoxic water, responsible for the mortalities. It details conditions which led to the fishkill.

Tracy, H.B., 1982. Capitol Lake. Memorandum to Mike Palko/Bruce Cameron, WDOE, June 24. 3 pp.

Discusses lowering the lake level to promote flushing of anoxic marine waters out of the depression, in addition to other "band-aid" fixes for the Capitol Lake problem.

USEPA, 1976. Quality Criteria for Water. Washington DC. 501 pp.

WDOE, 1975. 303(e) Water Quality Management Plan Water Resource Inventory Area 11, 13, Nisqually-Deschutes Basin. TR 75-5. 102 pp.

Summarized data to date of publication. Discusses potentially significant nutrient impacts from the Tumwater Falls Golf Course and farming. Information is somewhat dated. Addresses many data needs.

WDOE, 1977. Washington State Water Quality Standards. Dept. of Ecology, Olympia WA. 33 pp.

WDOE, 1980. Deschutes River Basin, Instream Resources Protection Program Including Proposed Administrative Rules. (Water Resources Inventory Area 13).

Sets minimum in-stream flows and gives a good discussion of beneficial uses as it relates to wildlife protection.

WDOE, 1971-present. WDOE Water Quality Data for the Deschutes River.

_____, 1976-1977. Deschutes River at Capitol Way Bridge 13A050, r.m. 0.3

_____, 1977-present. Deschutes River at E Street Bridge 13A060, r.m. 0.6

_____, 1971-1977. Deschutes River near Olympia (at Henderson Br.) 13A080, r.m. 4.6

_____, 1971-present. Deschutes River near Rainier 13A150, r.m. 21.61

Yake, W.E., 1981. Seasonal Nutrient Depletion at Ambient Marine Stations in Puget Sound; Implications for Discharge of Nutrients to Embayments like Budd Inlet. Memorandum to Dick Cunningham, WDOE, December 22. 3 pp.

A seasonal NO_3-N depletion is apparent in 50 to 60 percent of the stations. Data analysis showed NO_3-N fell to less than 0.01 mg/L for two to three months during the summer as did orthophosphate concentrations. This is evident in poorly mixed areas. These same areas experience algal blooms which can cause problems. The Kruger (1979) report did not consider NH_3-N loading which may double or triple nitrogen loaded to Budd Inlet and contribute to the algal bloom/D.O. sag problems.

APPENDIX I

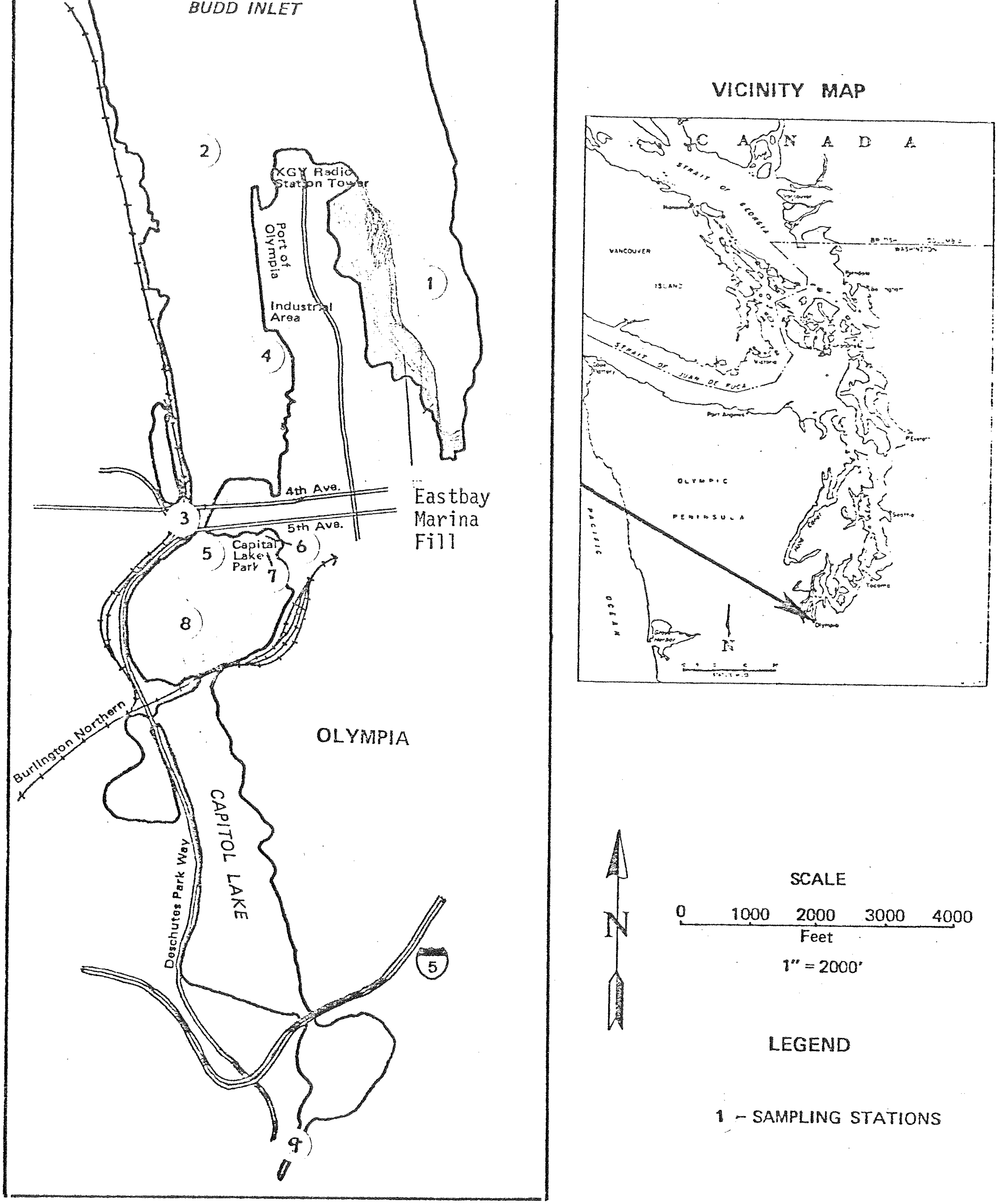

Figure A-I. Map of lower Budd Inlet and Capitol Lake showing landmarks and sampling stations.

Capitol Lake/Budd Inlet Monitoring Data

June 1, 1982 Time: 1050 - 1230 Lower Low of 2.5 at 0935

Station	Depth*	Conductivity (umhos/cm^2)	Salinity (o/oo)	Temperature (°C)	Diss. Oxygen (mg/L)	Fecal Coliforms (#/100 mls)	H_2S (mg/L)	Secchi Disk (feet)
1	S	29.5	22.2	16.3	12.8	6**		
	B	33.0	27.6	12.5	10.5			
2	S	30.7	25.1	13.2	10.5	7**		
	B	33.1	28.0	11.9	9.0			
3	S	24.8	19.8	13.0	10.3	31		
	B	26.3	21.2	12.7	9.3			
4	S	33.1	27.1	12.2	10.1	13**		
	B	33.7	28.8	11.3	9.8			
5	S	0.5	0.3	17.1		7**		
	2	0.2	0.1	17.0	12.8			
	4	0.2	0.1	16.2	12.6			
	6	27.5	22.2	12.9	10.2			
	8	27.8	23.3	12.7	8.8			
	10	29.1	23.8	12.6	8.7			
	11	28.9	23.7	12.7	7.6		N.D.	
6	S					16**		
7	S					11**		

*S = Surface; B = Bottom; numbers indicate depth in meters.
**Estimated count.
N.D. = None detected.

Capitol Lake/Budd Inlet Monitoring Data

June 3, 1982 Time: 1130 Lower Low of 0.5 at 1054

Station	Depth*	Conductivity (umhos/cm^2)	Salinity (o/oo)	Temperature (°C)	Diss. Oxygen (mg/L)	Fecal Coliforms (#/100 mls)	H_2S (mg/L)	Secchi Disk (feet)
5	S	0.2	0.01	16.7	11.7			
	2	0.3	0.1	16.4	11.9			
	4	0.8	0.5	14.5	12.0			
	6	32.0	26.5	12.7	9.1			
	8	32.2	26.7	12.4	9.2			
	10	32.5	26.6	12.2	8.6		N.D.	

*S = Surface; B = Bottom; numbers indicate depth in meters.
N.D. = None detected.

Capitol Lake/Budd Inlet Monitoring Data

June 8, 1982 Time: 1430 - 1600 Lower Low of -1.2 at 1335

Station	Depth*	Conductivity (umhos/cm^2)	Salinity (o/oo)	Temperature (°C)	Diss. Oxygen (mg/L)	Fecal Coliforms (#/100 mls)	H_2S (mg/L)	Secchi Disk (feet)
1	S	33.3	24.6	17.7	10.3	<1		4.0
	B	34.3	28.1	12.9	7.9			
2	S	27.5	22.4	15.8	10.1	9**		4.5
	B	33.0	25.4	12.7	7.4			
3	S	18.4	13.9	14.2	10.5	22		
	B	32.4	26.3	13.9	9.9			
4	S	23.7	17.6	15.6	9.9	6**		6.0
	B	34.4	28.0	13.4	9.2			
5	S	0.2	0.1	16.5	12.3	<1		6.0
	2	0.4	0.2	15.9	12.4			
	4	1.3	0.8	15.0	11.7			
	6	29.1	23.0	14.2	9.1			
	8	32.3	26.3	13.6	9.5			
	10	32.4	26.5	13.2	8.0			
6	S					6**		6.25
7	S					7**		
8	S	0.1	0.0	16.8	12.5	1**		5.75
	B	0.5	0.3	14.1	12.2			
9	S					40		
LOTT discharge boil						210		

*S = Surface; B = Bottom; numbers indicate depth in meters.
**Estimated count.

Capitol Lake/Budd Inlet Monitoring Data

June 14, 1982 Time: 0900 - 1115 Lower High of 10.4 at 1122

Station	Depth*	Conductivity (umhos/cm^2)	Salinity (o/oo)	Temperature (°C)	Diss. Oxygen (mg/L)	Fecal Coliforms (#/100 mls)	H2S (mg/L)	Secchi Disk (feet)
1	S	33.7	27.5	13.3	9.3	18**		7.0
	B	33.7	28.6	11.6	7.9			
2	S	33.1	27.6	12.3	8.9	25		8.0
	B	32.3	27.6	11.3	6.9			
3	S	27.1	25.1	12.8	7.2	10**		
	B	31.9	27.0	11.7	4.8			
4	S	31.8	25.9	13.2	7.6	21		12.0
	B	34.3	29.2	11.8	7.1			
5	S	0.1	0.0	17.1	11.9	11**		4.75
	2	0.5	0.2	16.9	11.6			
	4	2.4	1.6	16.2	9.9			
	6	33.0	27.0	13.2	7.5			
	8	33.1	27.3	13.0	8.0			
	10	33.2	27.3	13.0	7.5		N.D.	
6	S					10**		5.0
7	S					26		
8	S	0.2	0.0	17.1	12.0	23		5.0
	B	0.3	0.1	14.4	10.2			
9	S					26		

*S = Surface; B = Bottom; numbers indicate depth in meters.
**Estimated counts.
N.D. = None detected.

Capitol Lake/Budd Inlet Monitoring Data

June 21, 1982 Time: 0950 - 1200 Lower Low of -3.6 at 1212

Station	Depth*	Conductivity (umhos/cm^2)	Salinity (o/oo)	Temperature (°C)	Diss. Oxygen (mg/L)	Fecal Coliforms (#/100 mls)	H_2S (mg/L)	Secchi Disk (feet)
1	S	35.3	26.7	17.1	7.9	14*		5.5
	B	34.1	28.3	12.6	***			
2	S	34.7	27.6	15.2	6.4	50		9.5
	B	34.0	28.8	11.7	***			
3	S	30.7	24.2	13.8	8.1	64**		9.0
	B	33.9	28.7	11.8	***			
4	S	31.9	24.6	14.0	6.0	630**		6.0
	B	34.3	28.7	12.1	***			
5	S	0.0	0.0	21.8	11.8	23		5.0
	2	0.0	0.0	21.8	12.2			
	4	20.0	14.2	17.5	7.8			
	6	26.2	19.4	16.0	6.8			
	8	30.1	23.1	15.3	6.7			
	10	30.4	23.5	14.9	6.4		N.D.	
6	S					24		6.0
7	S					18**		
8	S	0.0	0.0	21.9	***	5**		6.0
	3	0.7	0.4	19.0	***			
	4	22.9	16.5	16.5	***			
9	S					48		

*S = Surface; B = Bottom; numbers indicate depth in meters.
**Estimated count.
***Meter malfunction, data not available.
N.D. = None detected.

Capitol Lake/Budd Inlet Monitoring Data

June 23, 1982 Time: 1130 - 1400 Lower Low of -3.4 at 1346

Station	Depth*	Conductivity (umhos/cm^2)	Salinity (o/oo)	Temperature (°C)	Diss. Oxygen (mg/L)	Fecal Coliforms (#/100 mls)	H_2S (mg/L)	Secchi Disk (feet)
1	S	35.2	25.1	19.3	9.4			
	B	35.3	28.6	13.1	7.3			
2	S	37.3	28.2	17.1	8.1			
	B	35.5	29.7	12.3	7.5			
3	S	25.4	18.5	16.7	7.2			
	B	34.9	28.5	13.2	3.4			
3W	Bottom sample 30 feet west of 3				6.0			
3E	Bottom sample 30 feet east of 3				4.8			
	Bottom at 4th Avenue bridge				5.4			
	Bottom at Yacht Club				6.0			
	Bottom at Yacht Club				6.5			
	Bottom in Percival Landing				6.0			
	Bottom south of Fiddlehead Marina				6.3			
4	S	29.6	21.1	18.3	6.2			
	B	35.0	28.5	13.4	5.6			
5	S	1.0	0.5	22.0	11.0			
	2	1.0	0.6	20.6				
	4	3.0	1.8	19.2				
	6	28.5	21.0	16.8				
	8	30.2	22.8	16.3				
	10	30.6	22.5	16.0	3.4			

*S = Surface; B = Bottom; numbers indicate depth in meters.

Capitol Lake/Budd Inlet Monitoring Data

June 28, 1982 Time: 1000 - 1200 Lower High of 10.7 at 1213

Station	Depth*	Conductivity (umhos/cm^2)	Salinity (o/oo)	Temperature (°C)	Diss. Oxygen (mg/L)	Fecal Coliforms (#/100 mls)	H_2S (mg/L)	Secchi Disk (feet)
1	S	27.5	21.4	14.3	8.1	18**		
	B	35.1	29.0	12.8	6.9			
2	S	32.3	25.7	14.0	7.9	57		
	B	35.2	29.5	12.4	7.4			
3	S	25.0	19.0	14.9	7.0			
	B	35.1	29.3	12.5	5.8			
4	S	24.6	18.5	15.4	7.4			
	B	35.1	29.0	12.6	6.7	14**		
5	S	0.5	0.2	20.4	11.5	1**		5.0
	2	0.4	0.2	19.4	9.1			
	4	1.0	0.6	18.1	7.2			
	6	25.9	19.3	16.2	6.1			
	8	28.6	21.7	15.5	4.3			
	10	29.3	22.5	15.4	2.3		N.D.	
6	S					11**		5.0
7	S					8**		
8	S	0.3	0.1	20.1	11.3	5**		5.0
	B	0.3	0.2	16.8	8.4			
9	S					48		

*S = Surface; B = Bottom; numbers indicate depth in meters.
**Estimated count.
N.D. = None detected.

Capitol Lake/Budd Inlet Monitoring Data

July 6, 1982 Time: 1415 - 1700 Higher High of 14.7 at 2003

Station	Depth*	Conductivity (umhos/cm^2)	Salinity (o/oo)	Temperature (°C)	Diss. Oxygen (mg/L)	Fecal Coliforms (#/100 mls)	H_2S (mg/L)	Secchi Disk (feet)
1	S	35.1	26.2	16.8	9.5	2**		5.0
	B	35.5	28.4	14.5	8.5			
2	S	36.4	27.7	16.5	10.1	<1		7.5
	B	35.2	29.2	12.6	7.4			
3	S	18.8±	13.6	15.9	10.5			
	B	35.7	28.2	15.4	8.5			
4	S	30.3	22.2	17.2	8.5	69		7.5
	B	35.2	28.8	13.1	8.3			
5	S	1.2	0.7	19.3	17.7	4**		3.5
	2	1.5	0.8	18.6	18.3			
	4	12.8	8.8	17.1	9.9			
	6	27.4	20.7	15.5	3.6			
	8	27.7	21.2	15.2	2.8			
	10	27.7	21.1	15.2	2.9			
6	S					19**		3.0
7	S					55		
8	S	0.8	0.4	19.4	16.2	5**		4.0
	B	19.5	13.5	18.2	14.8			
9	S					68		

Discharge by steam plant

pH = 8.5
Cond. = .294
NO_3-N = 1.3
NO_2-N = <0.05
NH_3-N = 0.10
O-PO_4-P = 0.20
T-PO_4-P = 0.20
Fecals = 84
Temp. = ∿90°F

*S = Surface; B = Bottom; numbers indicate depth in meters.
**Estimated counts.

Capitol Lake/Budd Inlet Monitoring Data

July 12, 1982   Time: 1000 - 1220   Lower High of 11.1 at 0950

Station	Depth*	Conductivity (umhos/cm^2)	Salinity (o/oo)	Temperature (°C)	Diss. Oxygen (mg/L)	Fecal Coliforms (#/100 mls)	H_2S (mg/L)	Secchi Disk (feet)
1	S	35.2	24.5	20.3	15.5	<1		4.5
	B	35.5	28.6	13.6	9.3			
2	S	32.5	24.2	17.2	11.8	6**		7.0
	B	32.1	24.7	15.3	8.4			
3	S	23.4	16.9	16.3	10.5	27		7.0
	B	35.6	28.8	13.9	6.1			
4	S	29.9	21.7	17.8	10.8	13**		8.5
	B	35.3	28.8	13.5	6.1			
5	S	0.2	0.2	21.4	13.2	3**		4.5
	2	0.3	0.1	20.4	13.2			
	4	0.5	0.2	18.2	11.3			
	6	28.4	20.9	16.4	7.8			
	8	28.9	22.0	15.4	4.7			
	10	29.3	22.2	15.3	4.8			
6	S					39		4.5
7	S					20		
8	S	0.3	0.09	20.8	13.1	3**		4.0
	B	0.4	0.2	18.3	10.8			
9	S					200		

Discharge by steam plant   Temp. ~94°F
Sampled on 7/13/82   Fecals <3

*S = Surface; B = Bottom; numbers indicate depth in meters.
**Estimated count.

Capitol Lake/Budd Inlet Monitoring Data

July 19, 1982 Time: 0930 - 1130 Lower Low of -2.8 at 1109

Station	Depth*	Conductivity (umhos/cm^2)	Salinity (o/oo)	Temperature (°C)	Diss. Oxygen (mg/L)	Fecal Coliforms (#/100 mls)	H_2S (mg/L)	Secchi Disk (feet)
1	S	36.4	27.6	16.3	8.6	5**		7.0
	B	35.6	28.9	13.6	7.3			
2	S	32.0	24.3	15.8	7.5	21		12.0
	B	35.5	29.0	13.2	7.0			
3	S	16.5	11.6	16.0	9.5	100		10.0
	B	35.6	29.0	13.3	4.0			
4	S	24.0	18.2	15.9	8.7	32		9.0
	B	35.7	29.0	13.7	6.2			
5	S	0.0	0.0	18.5	12.1	14**		6.5
	2	0.0	0.0	18.4	12.3			
	4	0.0	0.0	16.3	8.5			
	6	30.9	23.9	14.9	6.2			
	8	31.9	25.5	13.9	4.4			
	10	32.0	25.5	13.8	3.0			
6	S					23		5.0
7	S					30		
8	S	0.0	0.0	18.6	12.3	6**		5.0
	B	6.2	4.2	15.7	9.5			
9	S					670**		

*S = Surface; B = Bottom; numbers indicate depth in meters.
**Estimated count..

Capitol Lake/Budd Inlet Monitoring Data

July 26, 1982 Time: 1230 - 1445 Higher High of 14.7 at 1114

Station	Depth*	Conductivity ($umhos/cm^2$)	Salinity (o/oo)	Temperature (°C)	Diss. Oxygen (mg/L)	Fecal Coliforms (#/100 mls)	H_2S (mg/L)	Secchi Disk (feet)
1	S	37.2	25.4	21.2	11.1	1**		5.5
	B	36.5	28.7	14.5	7.2			
2	S	38.1	26.8	20.1	11.9	6**		7.5
	B	36.4	29.3	14.1	7.2			
3	S	35.1	25.2	18.6	7.5	14**		6.5
	B	36.9	29.1	15.6	4.7			
4	S	26.7	26.7	20.1	9.3	4**		7.0
	B	29.7	29.7	13.7	5.8			
5	S	0.9	0.4	21.5	15.4	1**		4.0
	2	1.1	0.6	19.4	16.2			
	4	25.0	17.9	17.2	5.3			
	6	25.5	18.3	17.2	5.3			
	~8	25.4	18.3	17.3	6.2			
	10	Not sampled.						
6	S					11**		3.5
7	S					12**		
8	S	1.0	0.5	22.6	14.7	3**		3.5
	B	0.7	0.2	21.7	14.8			
9	S					56**		

*S = Surface; B = Bottom; numbers indicate depth in meters.
**Estimated counts.

Capitol Lake/Budd Inlet Monitoring Data

August 2, 1982 Time: 1000 - 1230 Lower Low of -0.5 at 1109

Station	Depth*	Conductivity (umhos/cm^2)	Salinity (o/oo)	Temperature (°C)	Diss. Oxygen (mg/L)	Fecal Coliforms (#/100 mls)	H_2S (mg/L)	Secchi Disk (feet)
1	S	34.7	28.2	13.5	6.5	25		12.2
	B	35.9	29.4	13.4	5.8			
2	S	31.6	25.2	13.6	9.7	65		17.0
	B	35.6	29.5	13.0	5.9			
3	S	25.0	21.5	16.3	6.5	75		13.0
	B	35.6	29.0	13.3	4.9			
4	S	24.3	18.6	14.9	6.8	1000**		10.5
	B	35.4	29.0	13.1	4.7			
5	S	0.0	0.0	18.0	11.3	6**		4.0
	2	0.0	0.0	18.1	11.1			
	4	0.0	0.0	18.1	10.7			
	6	22.6	16.3	16.4	4.8			
	8	23.6	17.4	16.3	0.5			
	10	24.0	17.7	15.9	0.5		N.D.	
6	S					42		4.5
7	S					84		4.5
8	S	0.0	0.0	18.2	10.5			4.5
	B	0.0	0.0	16.2	11.5			
9	S					390		

*S = Surface; B = Bottom; numbers indicate depth in meters.
**Estimated counts.
N.D. = None detected.

Capitol Lake/Budd Inlet Monitoring Data

August 9, 1982 Time: 0940 - 1200 Lower High of 12.1 at 0940

Station	Depth*	Conductivity (umhos/cm^2)	Salinity (o/oo)	Temperature (°C)	Diss. Oxygen (mg/L)	Fecal Coliforms (#/100 mls)	H_2S (mg/L)	Secchi Disk (feet)
1	S	30.9	22.6	17.0	11.8	17**		7.0
	B	36.8	29.7	13.7	6.0			
2	S	29.6	21.8	16.0	8.7	31		8.0
	B	36.8	30.0	13.1	6.0			
3	S	25.0	18.7	15.2	8.7	6**		12.0
	B	36.6	29.6	13.3	4.5			
4	S	30.3	22.4	16.2	8.2	67		9.5
	B	36.5	29.6	13.3	5.2			
5	S	0.1	0.0	19.0	11.8	1**		7.0
	2	0.1	0.0	18.1	12.0			
	4	0.4	0.2	17.1	9.6			
	6	29.9	23.0	14.7	7.1			
	8	31.9	25.1	13.9	1.4			
	10	32.4	25.7	13.7	1.0			
6	S					86**		8.0
7	S					21		8.0
8	S	0.1	0.1	19.2	12.2	<1		7.0
	B	2.0	1.2	16.2	8.7			
9	S					100		

*S = Surface; B = Bottom; numbers indicate depth in meters.
**Estimated count.

Capitol Lake/Budd Inlet Monitoring Data

August 16, 1982 Time: 1330 - 1540 Higher High of 14.4 at 1719

Station	Depth*	Conductivity (umhos/cm²)	Salinity (o/oo)	Temperature (°C)	Diss. Oxygen (mg/L)	Fecal Coliforms (#/100 mls)	H_2S (mg/L)	Secchi Disk (feet)
1	S	39.3	28.4	18.8	14.5	1**	6.0	6.0
	B	36.2	28.9	13.8	4.1			
2	S	38.6	28.4	17.7	14.1	1**		5.0
	B	36.2	29.1	13.9	7.4			
3	S	33.2	18.4	15.6	9.1	19**		9.0
	B	36.8	29.3	14.4	4.8			
4	S	37.3	27.2	18.0	10.0	3**		12.0
	B	36.1	28.9	13.6	5.2			
5	S	3.1	1.9	18.6	16.3	26		2.5
	2	26.3	19.3	16.3	17.1			
	4	31.1	23.7	15.6	10.0			
	6	32.0	24.4	15.5	5.4			
	7	32.5	24.7	15.2	5.5			
6	S					33		2.5
7	S					4**		
8	S	3.1	1.9	18.4	16.3	16**		2.5
	B	30.5	23.1	15.8	7.1			
9	S					18**		

*S = Surface; B = Bottom; numbers indicate depth in meters.
**Estimated counts.

Capitol Lake/Budd Inlet Monitoring Data

August 23, 1982 Time: 1100 - 1400 Lower low of 2.5 at 1523

Station	Depth*	Conductivity (umhos/cm^2)	Salinity (o/oo)	Temperature (°C)	Diss. Oxygen (mg/L)	Fecal Coliforms (#/100 mls)	H_2S (mg/L)	Secchi Disk (feet)
1	S	35.1	24.1	20.0	10.2	7**		6.0
	B	37.0	29.7	13.8	5.0			
2	S	31.8	22.3	19.1	10.0	15**		5.0
	B	36.1	28.6	14.2	5.3			
3	S	26.0	18.7	16.8	9.8	15**		7.5
	B	36.6	28.7	15.4	4.8			
4	S	32.5	22.8	19.2	10.1	20		5.0
	B	35.9	28.8	14.1	5.1			
5	S	1.3	0.6	22.0	13.8	8**		4.5
	2	1.5	0.8	21.6	15.2			
	4	15.2	10.0	19.1	10.7			
	6	23.2	16.2	18.3	6.6			
	8	28.1	20.4	18.0	4.1			
	10	29.8	21.7	17.2	3.6			
6	S					16**		
7	S					9**		
8	S	1.3	0.7	23.1	13.7	<1		4.0
	B	11.7	7.4	21.0	14.0			
9	S					20		

*S = Surface; B = Bottom; numbers indicate depth in meters.
**Estimated count.

Capitol Lake/Budd Inlet Monitoring Data

August 30, 1982   Time: 1100 - 1400   Higher high of 13.7 at 1716

Station	Depth*	Conductivity (umhos/cm^2)	Salinity (o/oo)	Temperature (°C)	Diss. Oxygen (mg/L)	Fecal Coliforms (#/100 mls)	H_2S (mg/L)	Secchi Disk (feet)
1	S	36.7	29.1	14.4	5.0	68**	8.5	
	B	36.7	29.4	14.2	4.8			
2	S	32.9	25.4	15.0	8.1	34	6.5	
	B	36.5	29.7	13.6	4.7			
3	S	20.1	14.6	15.8	6.7	23		
	B	36.6	29.5	13.9	3.6			
4	S	32.8	24.9	15.7	7.2	64	11.0	
	B	36.6	29.3	14.3	3.5			
5	S	0.7	0.3	18.3	10.5	26	6.5	
	2	0.7	0.3	18.2	10.5			
	4	1.1	0.6	17.5	9.8			
	6	30.6	22.2	17.2	1.9			
	8	31.0	22.6	17.2	1.3			
	10	31.0	22.8	17.1	1.3			
6	S					49	6.0	
7	S					41		
8	S	0.6	0.3	18.5	10.5	10**	6.5	
	B	0.7	0.3	17.5	9.5			
9	S					6**		

*S = Surface; B = Bottom; numbers indicate depth in meters.
**Estimated count.

Capitol Lake/Budd Inlet Monitoring Data

September 7, 1982 Time: 1130 - 1330 Higher low of 3.0 at 1454

Station	Depth*	Conductivity (umhos/cm^2)	Salinity (o/oo)	Temperature (°C)	Diss. Oxygen (mg/L)	Fecal Coliforms (#/100 mls)	H_2S (mg/L)	Secchi Disk (feet)
1	S	37.5	28.7	15.5	7.8	4**		9.2
	B	36.8	29.0	14.3	4.7			
2	S	35.8	27.0	16.3	5.8	14**		13.0
	B	36.5	29.3	14.0	4.3			
3	S	24.5	22.5	15.3	4.3	60		14.0
	B	37.1	28.2	16.3	5.2			
4	S	36.0	27.3	16.0	--	19**		17.0
	B	36.7	29.4	13.9	--			
5	S	0.5	0.1	19.5	13.4	7		5.0
	2	0.5	0.2	18.5	13.4			
	4	0.7	0.3	17.1	9.4			
	6	24.5	20.2	15.9	4.5			
	8	32.7	25.4	14.7	2.2			
	10	33.3	26.0	14.8	--			
6	S					63**		5.0
7	S					50		
8	S	0.4	0.0	19.3	13.2	1**		5.0
	B	0.2	0.0	17.8	12.4			
9	S					92		

*S = Surface; B = Bottom; numbers indicate depth in meters.
**Estimated count.

Cap.tol Lake/Budd Inlet Monitoring Data

September 13, 1982 Time: 1130 - 1330 Higher high of 14.8 at 1610

Station	Depth*	Conductivity (umhos/cm^2)	Salinity (o/oo)	Temperature (°C)	Diss. Oxygen (mg/L)	Fecal Coliforms (#/100 mls)	H_2S (mg/L)	Secchi Disk (feet)
1	S	34.0	26.5	13.9	7.0	9**		12.0
	B	39.4	31.1	12.9	5.9			
2	S	38.2	29.5	14.3	6.6	1**		14.0
	B	38.9	30.9	13.2	6.0			
3	S	26.0	19.4	14.5	6.4	60**		11.5
	B	38.8	30.5	14.1	5.0			
4	S	32.8	25.1	14.3	6.1	31		14.0
	B	38.6	30.5	13.0	5.3			
5	S	2.5	1.5	16.2	10.1	13**		
	2	3.2	1.8	15.3	9.7			
	4	3.4	1.9	14.8	7.0			
	6	33.7	25.5	14.1	1.1			
	8	34.1	26.0	13.7	1.0			
	10	34.5	26.4	13.8	0.2		N.D.	4.0
6	S					16**		3.5
7	S					11**		
8	S	3.6	2.0	16.0	10.4	2**		4.0
	B	3.5	2.0	14.8	9.7			
9	S					63		

*S = Surface; B = Bottom; numbers indicate depth in meters.
**Estimated count.