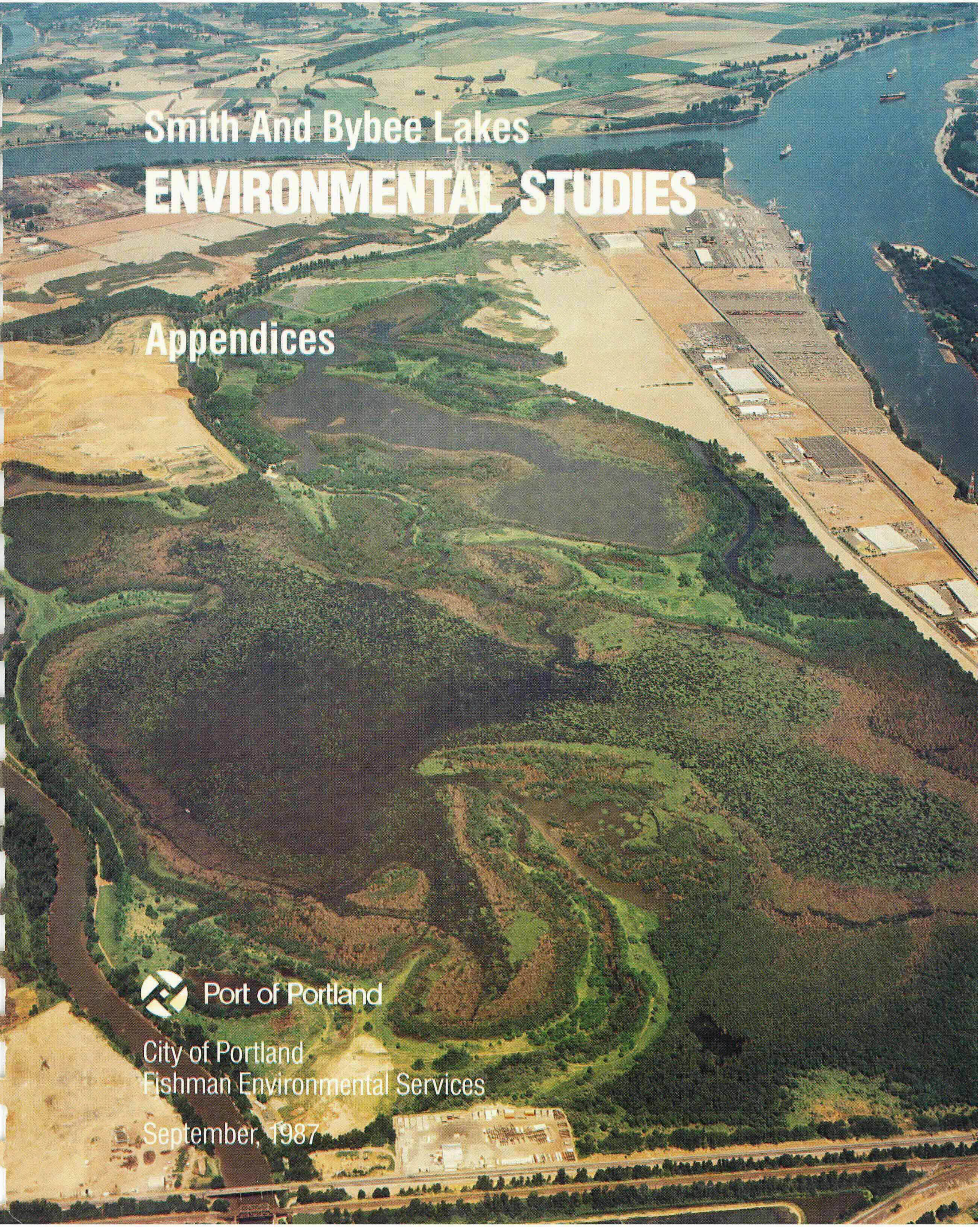

Smith And Bybee Lakes
ENVIRONMENTAL STUDIES

Appendices

Port of Portland

City of Portland
Fishman Environmental Services

September, 1987

SMITH and BYBEE LAKES ENVIRONMENTAL STUDIES

Technical Appendices

PREPARED BY

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Scientific Resources, Inc.
Phillip K. Gaddis

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Port of Portland
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SMITH and BYBEE LAKES ENVIRONMENTAL STUDIES

Technical Appendices

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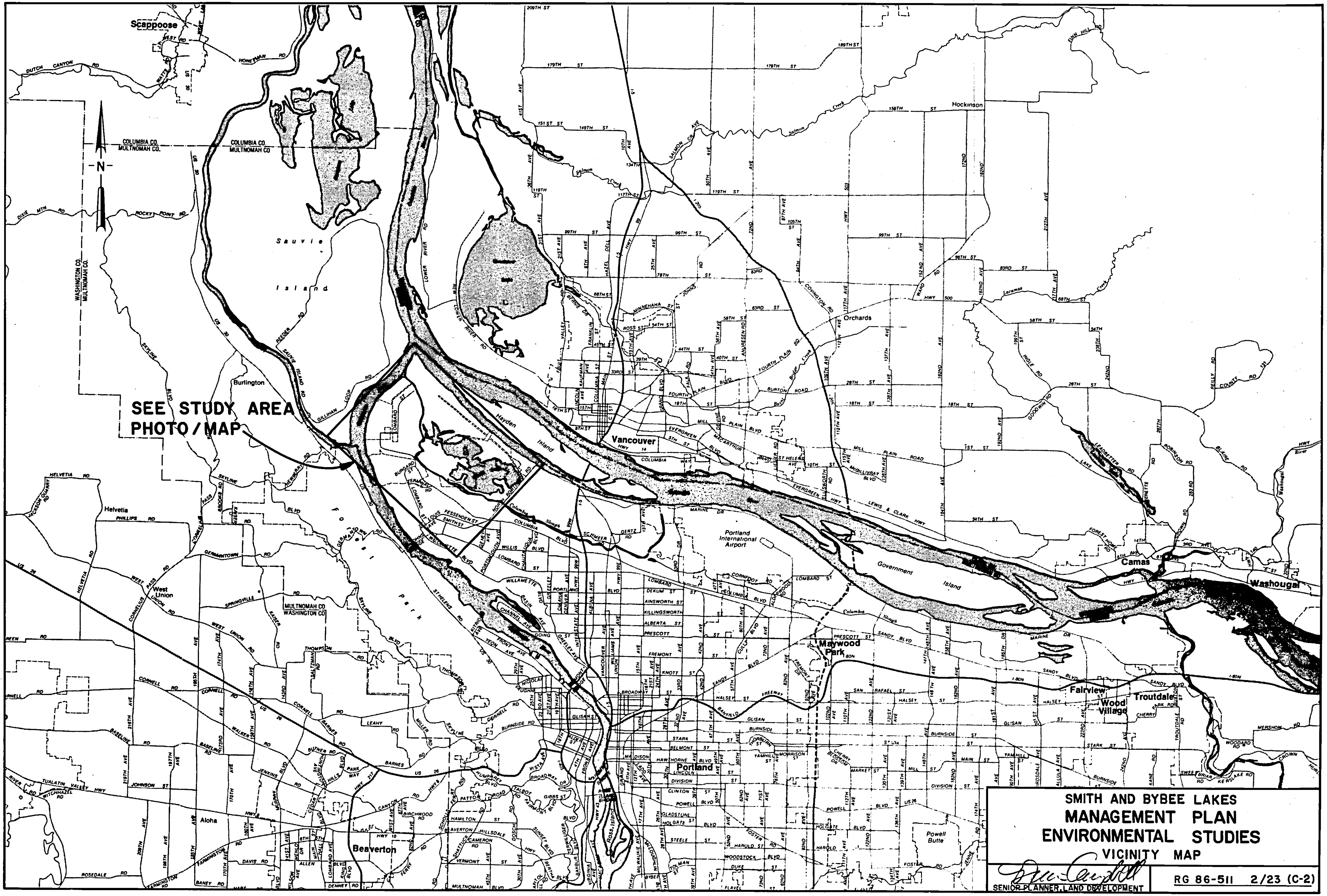
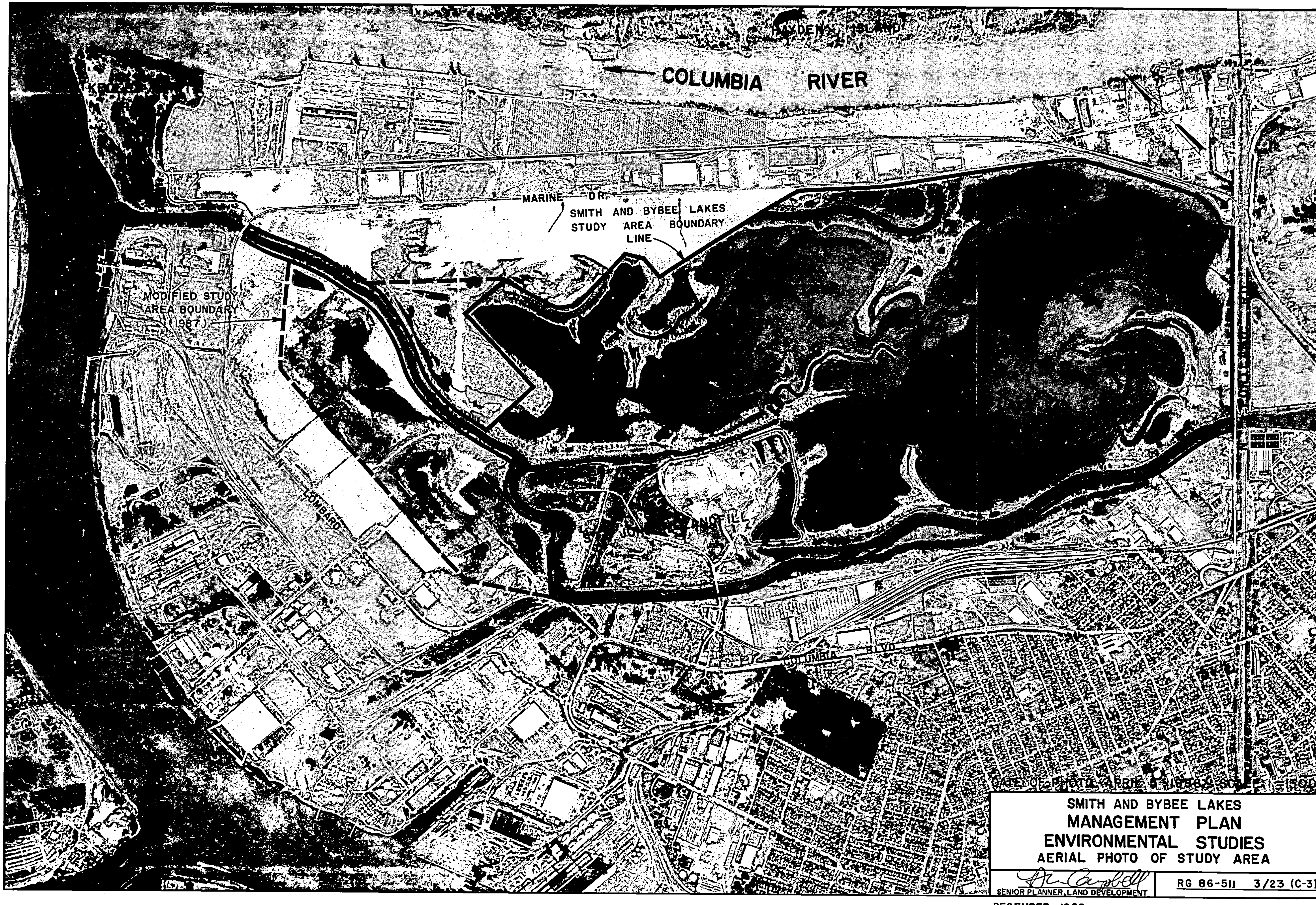


DECEMBER 1986



SMITH AND BYBEE LAKES
MANAGEMENT PLAN
ENVIRONMENTAL STUDIES
AERIAL PHOTO OF STUDY AREA

SENIOR PLANNER, LAND DEVELOPMENT

RG 86-511 3/23 (C-3)

DECEMBER, 1986

A SURFACE WATER HYDROLOGY

Ogden Beeman & Associates, Inc.

Consulting in the development of ports, waterways, and marine facilities

522 S.W. 5th Avenue
Portland, Oregon 97204
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SMITH AND BYBEE LAKES ENVIRONMENTAL STUDIES

TECHNICAL APPENDIX A: Surface Water Hydrology

Prepared by:

Ogden Beeman and Associates, Inc.

Project Sponsored by:

Port of Portland
and
City of Portland, Bureau of Environmental Services

Project Managed By:

Fishman Environmental Services

December, 1986

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1. Background and Objectives

1.1 Background

Smith and Bybee Lakes drainage basin encompasses approximately 1600 acres in the northwest Portland area (see Figure A-1). The lakes are shallow and are interconnected via tenuous channels and marshy areas. The lakes water surface is perched at an elevation of 10.4 feet above mean sea level (msl) by a holding weir constructed in 1982 at the single remaining outlet to North Slough/Columbia Slough. The lakes become directly interconnected with the surrounding tidal backwaters of North Slough/Columbia Slough, the Willamette River, and the Columbia River when the river levels exceed 10.4 feet (msl). When the surrounding river level is less than the weir level (10.4 feet msl) the perched lakes are an isolated hydrologic basin which responds to water balances within the basin. Hydrologically, the lakes are within a relatively small drainage area and have few contributing influent or effluent streams. The banks of the lakes are highly vegetated as well as containing a high concentration of macrophytes within the lakes.

1.2 Objective

The objective of this Appendix is to analyze available data and prepare a water budget for Smith and Bybee Lakes which characterizes significant water sources and losses influencing lake levels, and to describe the relationships between water level and corresponding surface area and water volumes for Smith and Bybee Lakes.

2. Methods

2.1 Water Budget

A hydrologic water budget essentially presents the balance between water sources (inflow), water losses (outflow), and resulting net change in lake water volume. When inflow exceeds outflow, lake water volume increases and the lake level rises accordingly. Similarly, when outflow exceeds inflow lake water volume decreases and the lake level falls. For a given time period, a water budget may be estimated by correlating observed lake level (volume) changes with known or estimated water sources and losses.

The first step in determining a water budget is identifying the major sources and losses of water in the drainage basin. Sources

OGDEN BEEMAN & ASSOC., INC.

LEGEND

DATUM — ALL ELEVATIONS = U.S.G.S.

- LANDFILL DIKE
- CONTROL STRUCTURE
- TREE / SHRUB LINE-SMITH & BYBEE LAKES ; SHORELINE-COLUMBIA SLOUGH
- STUDY AREA BOUNDARY / TOP OF BANK (APPROX. 30 FT.)
- APPROX. LAKE SHORE LINE (10.5 FT. CONTOUR)
- DRAINAGE BASIN
- APPROXIMATE SMITH LAKE AND BYBEE LAKE BOUNDARY

Port of Portland

GRAPHIC SCALE IN FEET

500 0 500 1000 1500 2000 2500

DECEMBER , 1986

SMITH AND BYBEE LAKES
MANAGEMENT PLAN
ENVIRONMENTAL STUDIES
SMITH AND BYBEE LAKES DRAINAGE BASIN

SUBMITTED BY: [signature]
SENIOR PLANNER , LAND DEVELOPMENT

DRAWING NO.: RG 86-511 1/23 (C-1)

FIGURE A-1

identified were:

- Precipitation
- Storm water discharges and local runoff
- Seepage from groundwater, when groundwater level is higher than lake level

The water losses from the lake are:

- Evaporation and evapotranspiration
- Seepage to groundwater, when groundwater is lower than lake level
- Losses from leakage around the dikes and from the holding weir that exists at the south-west end of Smith Lake

The typical water budget equation for a given time period is:

Inflow - Outflow = Change in Water Volume

where,

Change in Water Volume = (Change in Lake Level) x (Water Surface Area)

Inflow = precipitation + runoff + discharges in + groundwater seepage in

Outflow = evaporation + evapotranspiration + discharges out + groundwater seepage out

Each of the terms in the water budget equation can be measured or estimated with reasonably available methods except for groundwater seepage. Since groundwater seepage is the unknown, all other water budget terms are measured or calculated and the remainder is attributed to groundwater seepage.

The holding weir admits Columbia River/Willamette River backwater via North Slough/Columbia Slough when the river levels exceed 10.4 feet msl. Consequently the only valid periods to either determine or apply a water budget are when the river backwater is below the weir level (10.4 feet) and the lakes are in the isolated condition.

No previous lake level data was available for Smith-Bybee Lakes in the isolated condition; therefore the water budget is estimated based only on data collected by this study during the period November 8, 1985, to August 28, 1986.

During the monitoring period lake levels were measured on a regular basis at the holding weir by Fishman Environmental Services.

Precipitation data was obtained from:

- National Oceanic and Atmospheric Administration Portland Weather Service Station

- Oregon State University North Willamette Experiment Station

- Washington State University Southwestern Washington Experiment Station

Pan evaporation data was obtained from:

- Oregon State University's North Willamette Experiment Station

- Washington State University's Southwestern Washington Experiment Station

Lake evaporation and evapotranspiration was determined by converting the pan evaporation data. Conversion of pan evaporation to lake evaporation and lake evapotranspiration was estimated by applying experimentally derived coefficients. In addition, river level information was obtained from the Corps of Engineers, Portland District and the Port of Portland. The static head (elevation) difference between the river level and the lake levels is a determining factor for the direction and magnitude in which seepage might occur. When the lake level is above the river level, seepage should occur out of the lake. As the head difference increases, so should the seepage rate. When river levels exceed the control weir elevation, i.e., 10.4 feet msl, inundation by river backwater dominates lake levels and water budget terms are irrelevant.

2.2 Surface Area and Volume

The relationship between water level and corresponding surface area and water volumes for Smith and Bybee lakes were determined by establishing floodplain contours at the 6, 8, 10, 12 and 14 foot (mean sea level) contours. References used to establish the contours were as follows:

- o Port of Portland, 1"=500' scale photographs dated June 19, 1985 and July 8, 1985
- o Port of Portland, 1"=1000' scale April 5, 1986 photograph
- o Port of Portland, 1"=500' September 1983 infra-red photograph
- o January 6, 1970, 1"=500' topographic map by Towill Inc. that was revised by the Port of Portland in June of 1982
- o Port of Portland topographic maps of dredge fill in the north portion of the Bybee Lake region

The areas encompassed by the 6, 8, 10, 12, and 14 foot contours were then planimetered to determine the acreage. This data was graphed and then curve-fitted using the least squares method to produce a mathematical relationship between lake elevation and surface area in acres encompassed by Smith & Bybee Lakes.

By using the average end area method of volume calculations, the measured surface areas at known elevations were used to determine a lake elevation/volume relationship. This data was also graphed and the equation derived by least squares curve fit.

3. Results

3.1 Water Budget

The results of the water budget are tabulated in Table A-1. The dates listed are days that lake levels were measured. Precipitation and evaporation are tabulated as an accumulation between the periods in which lake levels were measured and are listed in units of acre-feet per day. Evapotranspiration is combined with lake evaporation and is tabulated as lake evaporation only. Surface runoff from rainfall on the bankline fringe is also shown in acre-feet per day. The small contribution of flow into the lake through small drainages and culverts was estimated to approximately equal the losses out of the lakes via leaks through the holding weir. These flows are not significant (less than one

SMITH & BYBEE LAKES WATER BUDGET

DAY NO.	DATE	COLUMBIA RIVER MEAN DAILY LEVEL crd	msl	LAKE LEVEL AT DAM (feet)	LAKE CAPACITY (ac-ft)	DELTA LAKE CAPACITY PER DAY (ac-ft/d)	LAKE AREA (acres)	DELTA LAKE AREA PER DAY (ac/d)	PRECIPITATION PRECIP (in.)	PRECIP (ac-ft/d)	EVAPORATION PAN EVAP (in.)	EVAP (in.)	LAKE EVAP (ac-ft/d)	SURFACE RUN OFF (ac-ft/d)	AVE. LAKE PREC -EVAP (P-E) (ac-ft/d)	NET PRECIP+ SR-EVAP (ac-ft/d)	DELTA LAKE CAPACITY (ac-ft/d)	* SEEPAGE (ac-ft/d)	DAY NO.	DATE	
8	08-Nov-85	5.90	7.72	7.75	1309		838												8	08-Nov-85	
						3.22		0.49	0.36	5.04	-0.08	-0.06	-0.78	0.92	4.25	5.17	3.22	-1.95			
13	13-Nov-85	6.03	7.85	7.77	1325		841												13	13-Nov-85	
						9.42		1.36	1.80	9.78	-0.17	-0.12	-0.65	1.73	9.13	10.86	9.42	-1.43			
26	26-Nov-85	5.46	7.28	7.92	1448		858												26	26-Nov-85	
						10.95		1.20	6.29	7.46	-0.28	-0.20	-0.23	1.15	7.23	8.38	10.95	2.57			
89	28-Jan-86	5.30	7.12	8.71	2137		934												89	28-Jan-86	

116	24-Feb-86	16.20	18.02	11.19															116	24-Feb-86	

140	20-Mar-86	8.22	10.04	11.29															140	20-Mar-86	

152	01-Apr-86	9.30	11.12	11.19															152	01-Apr-86	
																		---			LAKE NOT ISOLATED
165	14-Apr-86	7.23	9.05	10.69															165	14-Apr-86	

173	22-Apr-86	6.86	8.68	9.36															173	22-Apr-86	

177	26-Apr-86	9.20	11.02	9.67															177	26-Apr-86	

183	02-May-86	8.15	9.97	9.76	3153		1004												183	02-May-86	
						0.00		0.00	0.29	8.09	-0.37	-0.26	-7.22	0.90	0.86	1.76	0.00	-1.76			
186	05-May-86	7.10	8.92	9.76	3153		1004												186	05-May-86	
						0.00		0.00	0.24	5.02	-0.25	-0.18	-3.66	0.56	1.36	1.92	0.00	-1.92			
190	09-May-86	7.63	9.45	9.76	3153		1004												190	09-May-86	
						3.74		0.21	1.24	5.47	-3.15	-2.20	-9.73	0.60	-4.26	-3.66	3.74	7.39			
209	28-May-86	7.60	9.42	9.83	3224		1008												209	28-May-86	

217	05-Jun-86	11.71	13.53	9.93															217	05-Jun-86	
																		---			LAKE NOT ISOLATED
225	13-Jun-86	6.93	8.75	10.42															225	13-Jun-86	

229	17-Jun-86	6.70	8.52	10.26	3668		1032												229	17-Jun-86	
						-13.94		-0.72	0.02	0.57	-0.52	-0.36	-10.42	0.06	-9.85	-9.79	-13.94	-4.15			
232	20-Jun-86	6.70	8.52	10.22	3626		1030												232	20-Jun-86	
						-22.54		-1.18	0.00	0.00	-1.80	-1.26	-17.96	0.00	-17.96	-17.96	-22.54	-4.58			
238	26-Jun-86	4.63	6.45	10.09	3491		1023												238	26-Jun-86	
						-13.78		-0.73	0.03	0.43	-1.33	-0.93	-13.19	0.04	-12.77	-12.72	-13.78	-1.05			
244	02-Jul-86	2.88	4.70	10.01	3408		1018												244	02-Jul-86	
						0.00		0.00	0.41	17.39	-0.32	-0.22	-9.50	1.84	7.89	9.74	0.00	-9.74			
246	04-Jul-86	2.81	4.63	10.01	3408		1018												246	04-Jul-86	
						-15.29		-0.84	0.78	3.28	-4.27	-2.99	-12.58	0.36	-9.29	-8.94	-15.29	-6.36			
266	24-Jul-86	4.81	6.63	9.71	3102		1001												266	24-Jul-86	
						-29.92		-1.78	0.01	0.09	-2.29	-1.60	-14.74	0.01	-14.65	-14.64	-29.92	-15.28			
275	02-Aug-86	3.23	5.05	9.44	2833		985												275	02-Aug-86	
						-10.56		-0.68	0.01	0.06	-3.87	-2.71	-17.03	0.01	-16.97	-16.96	-10.56	6.41			
288	15-Aug-86	2.91	4.73	9.30	2696		977												288	15-Aug-86	
						-18.51		-1.29	0.00	0.00	-3.24	-2.27	-14.07	0.00	-14.07	-14.07	-18.51	-4.44			
301	28-Aug-86	3.10	4.92	9.05	2455		960												301	28-Aug-86	

* - = Seepage out of lakes
\+ = Seepage into lakes

TABLE A-1

cubic foot per second) and are therefore omitted from the tabulation. Seepage, listed in acre-feet per day, represents the groundwater term necessary to balance the water budget equation after accounting for the other parameters of change, i.e., change in lake water volume (level), precipitation, runoff, and evaporation.

The graph shown in Figure A-2. identifies the observed lake level, the Columbia river level, cumulative precipitation, cumulative evaporation, and the net precipitation minus evaporation for the study period beginning November 1, 1985 and ending on August 28, 1986. Also shown in the figure is the elevation of the holding weir at 10.4 feet m.s.l.

3.2 Surface Area and Volume

Figure A-3 displays the surface area of Smith and Bybee lakes (combined) on the abscissa and the water surface elevation on the ordinate. Figures A-4 and A-5 show the elevation versus area relationship for the individual Smith Lake and Bybee Lake, respectively.

The graph in Figure A-6 shows the relationship between lake water surface elevation (in feet above mean sea level) versus corresponding lake water volume (in acre feet) for the combined Smith and Bybee Lake area. Figures A-7 and A-8, respectively, show the elevation/volume relationship for the individual Smith and Bybee Lakes.

3.3 Discussion

The available data on which to base a water budget estimate for Smith-Bybee lakes is limited to the monitoring period of November 8, 1985 to August 28, 1986. This data period is significantly interrupted by inundation of the lakes during winter floods (February and March), failure of the weir water level control structure during and following the winter floods (repaired on April 22, 1986), and inundation by the Columbia River Spring freshet (May - June). Nonetheless, important periods of lake recharge during late fall and winter, and lake level decline during summer and early fall were recorded.

The two driving factors in relation to the rise and fall of the lake levels are precipitation and evaporation. Surface runoff from rainfall on the bankline fringe is small. There is also a groundwater seepage factor, but it is also relatively small in comparison to the contributions of rainfall and evaporation.

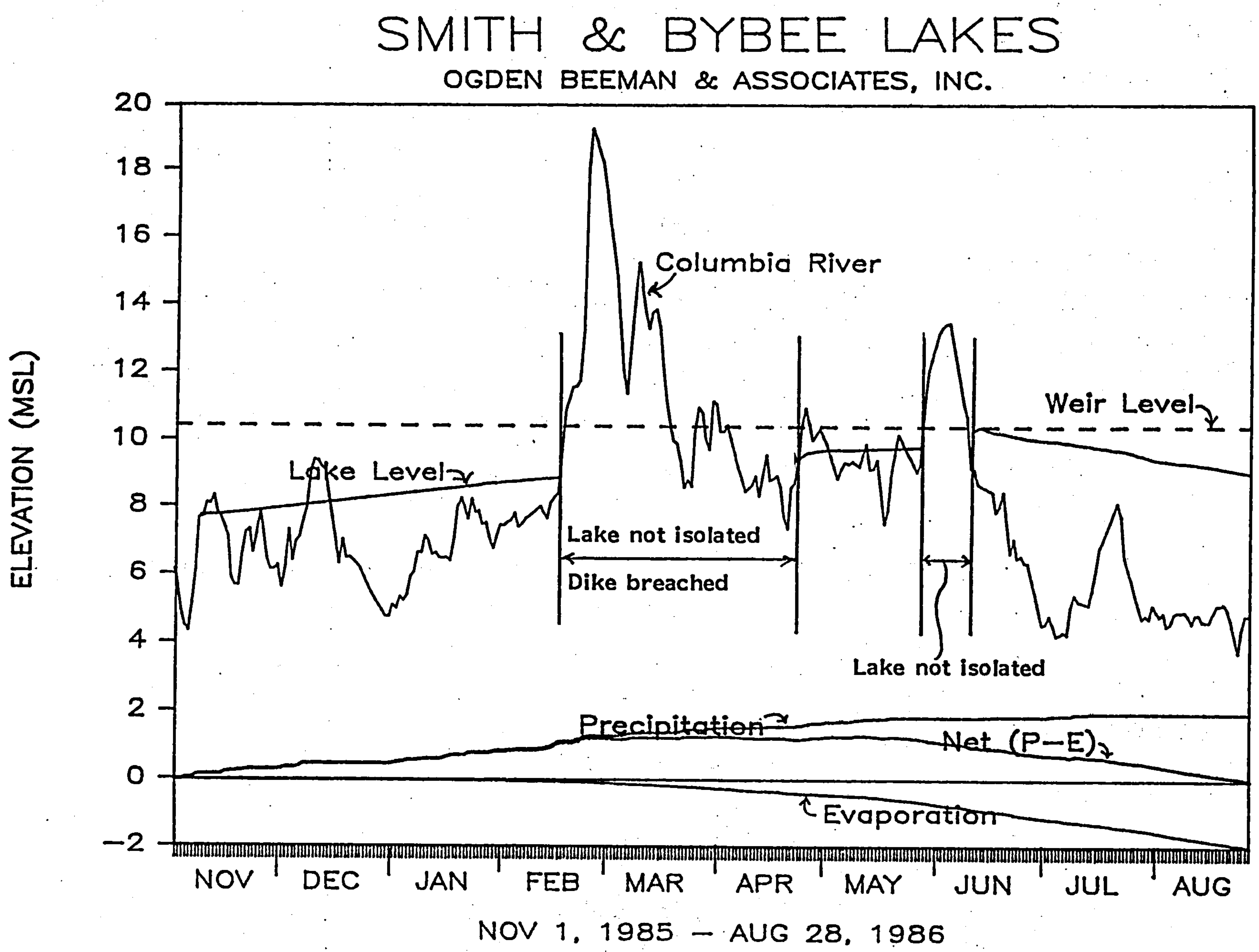


FIGURE A-2
SURFACE HYDROLOGY DATA

ELEVATION/AREA CURVE
SMITH & BYBEE LAKES

AUGUST 4, 1986

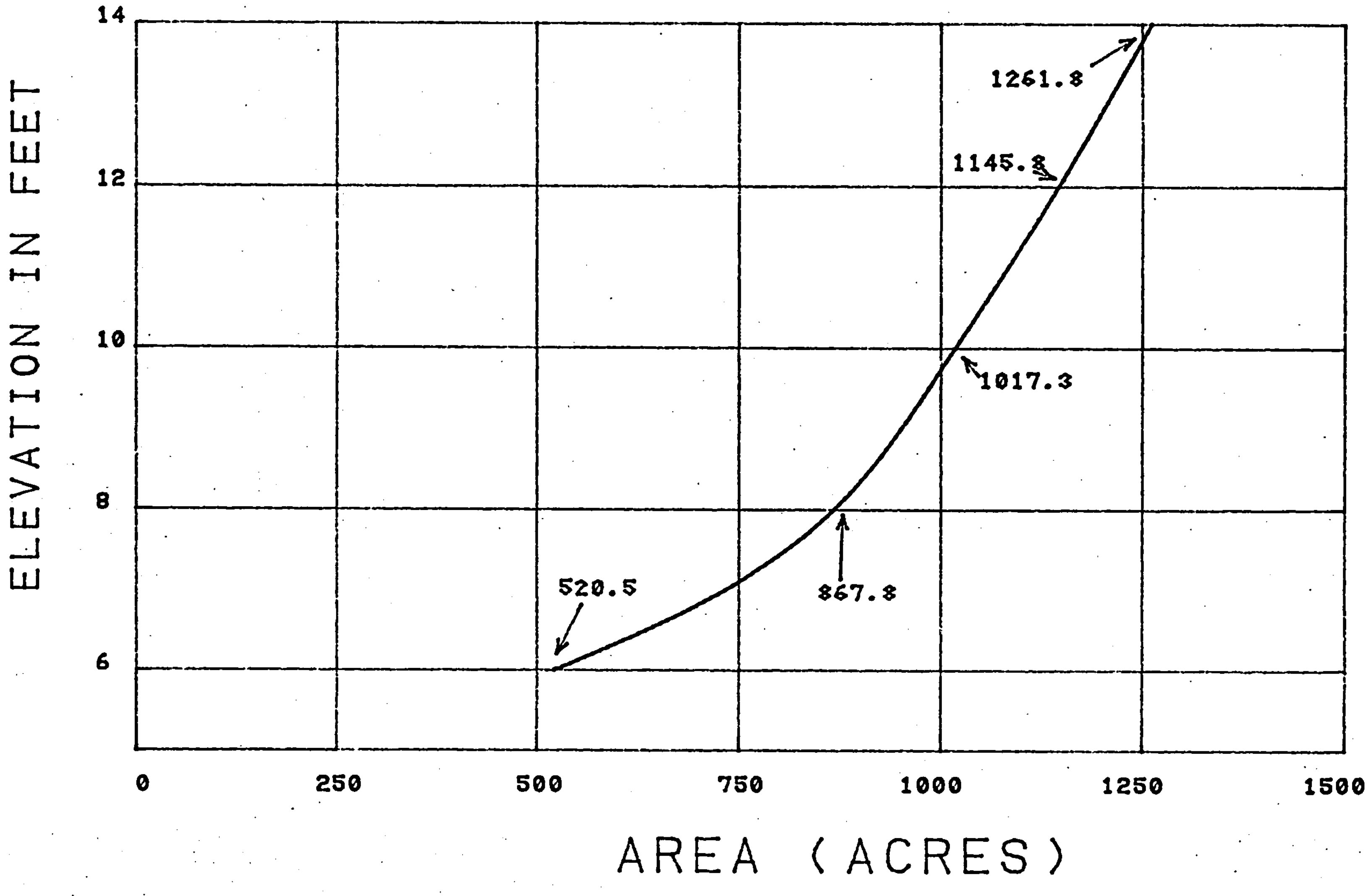


FIGURE A-3

ELEVATION/AREA CURVE
SMITH LAKE

AUGUST 4, 1986

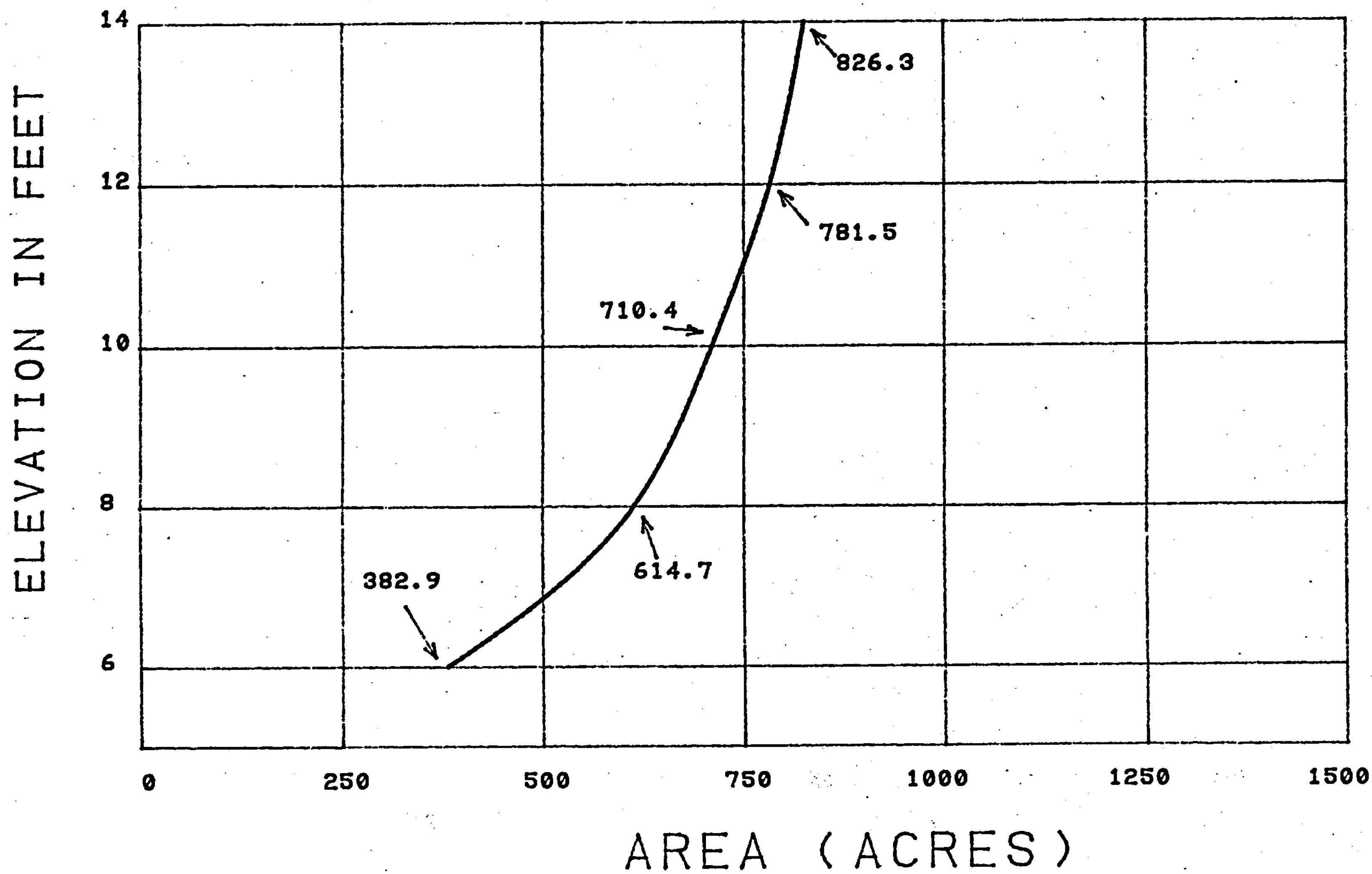
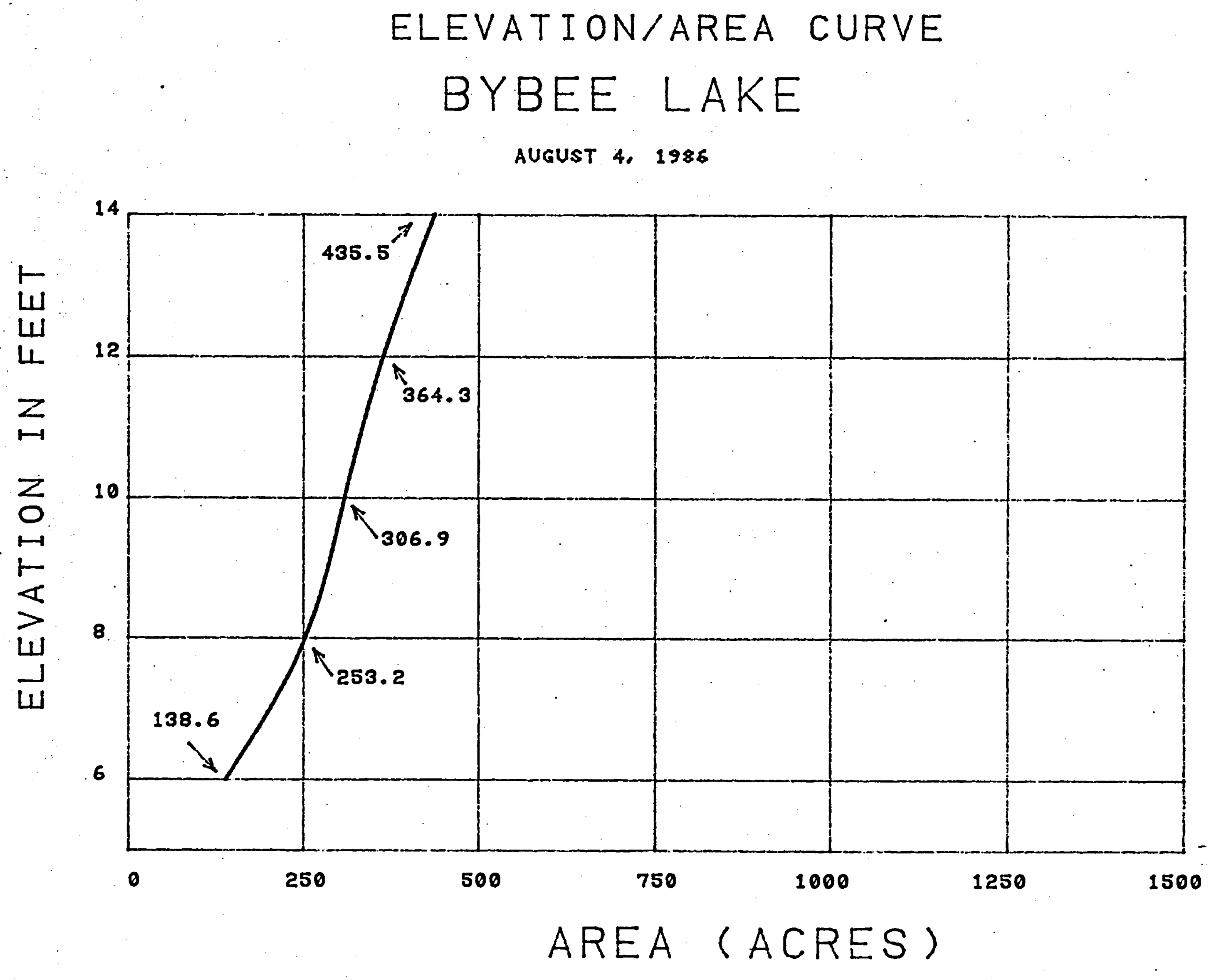


FIGURE A-4



ELEVATION/AREA CURVE
BYBEE LAKE
AUGUST 4, 1986
ELEVATION IN FEET
14
12
10
8
6
435.5
364.3
306.9
253.2
138.6
0
250
500
750
1000
1250
1500
AREA (ACRES)

FIGURE A-5

ELEVATION/CAPACITY CURVE

SMITH & BYBEE LAKES

AUGUST 4, 1986

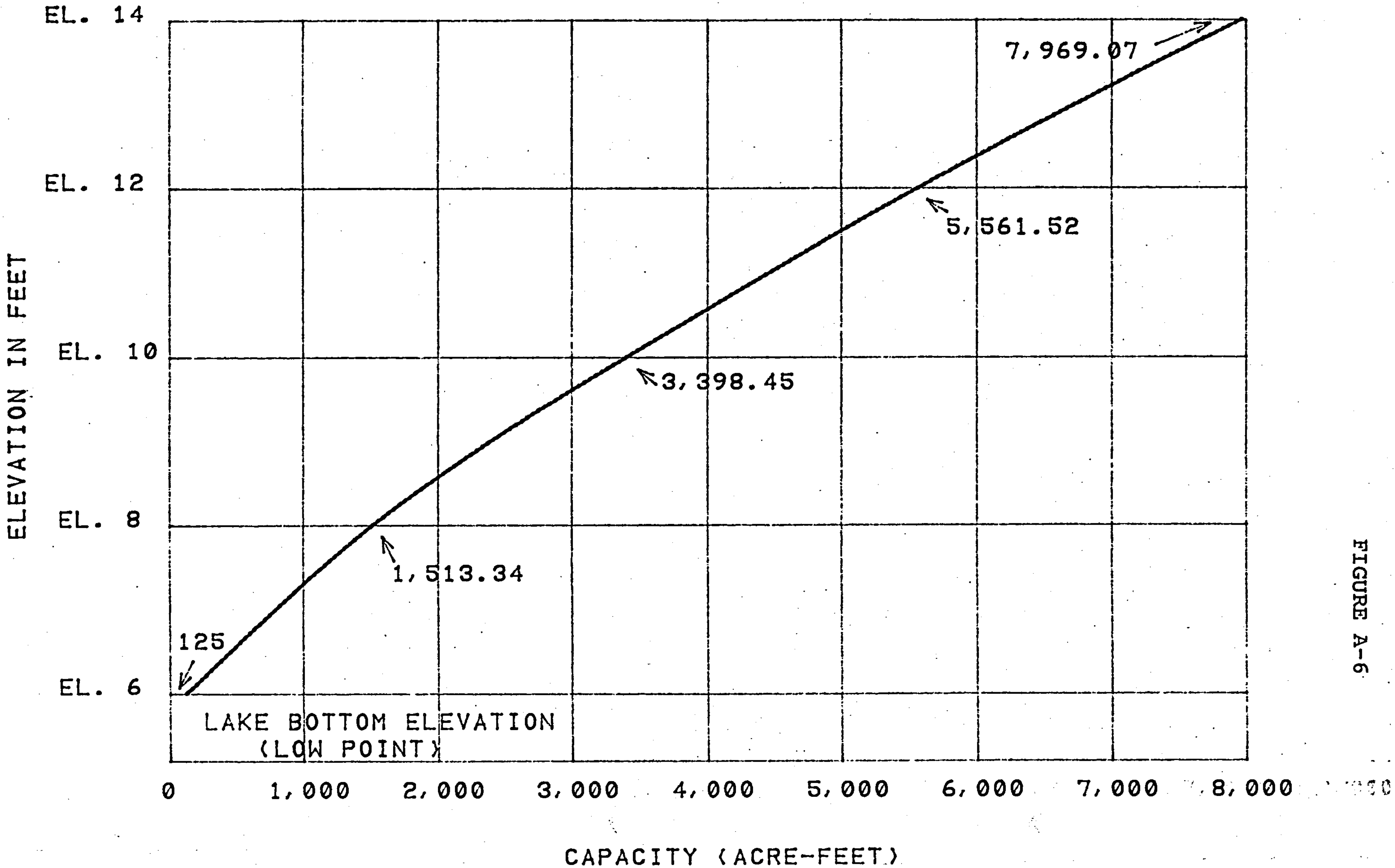


FIGURE A-6

ELEVATION/CAPACITY CURVE

SMITH LAKE

AUGUST 4, 1986

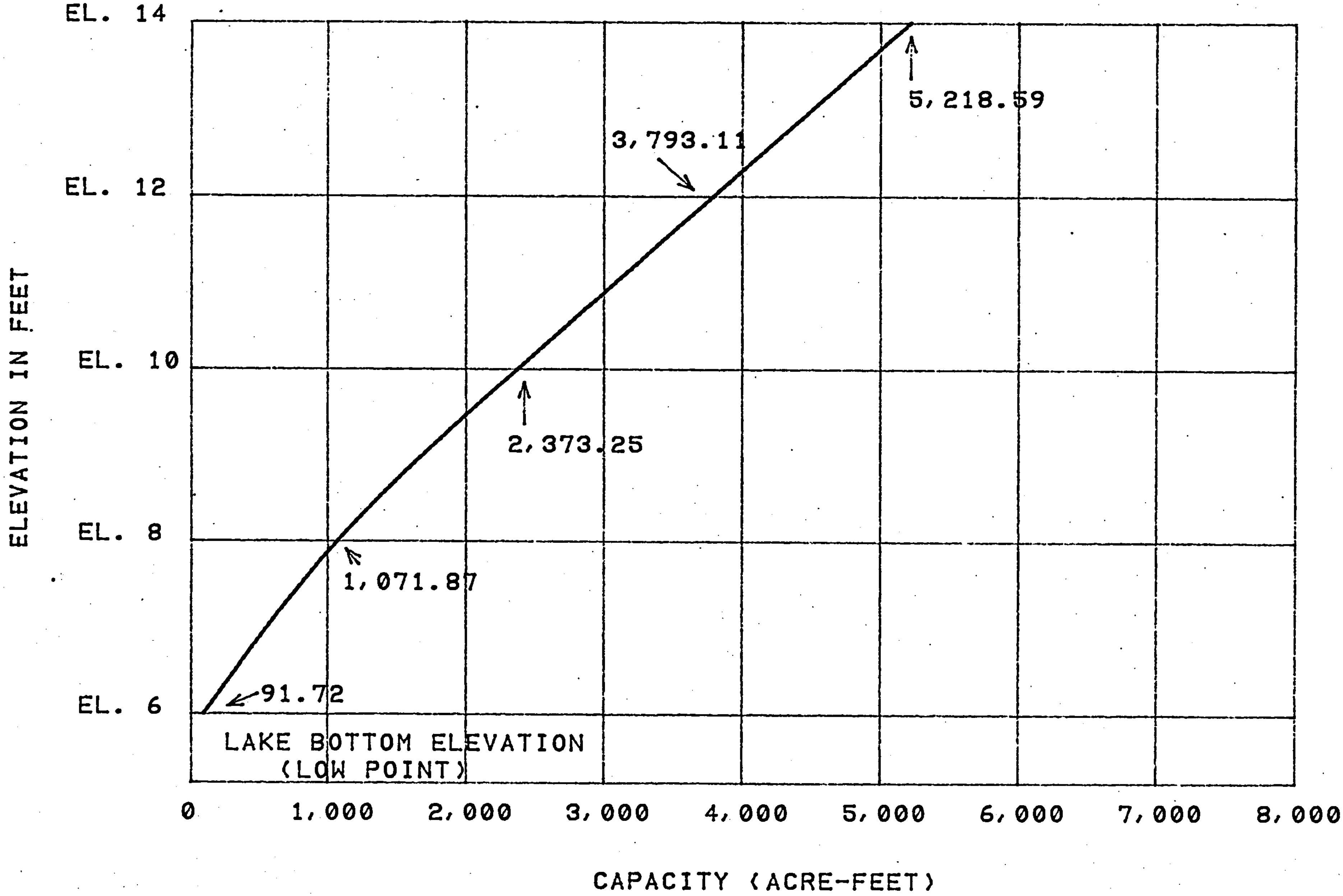


FIGURE A-7

ELEVATION/CAPACITY CURVE

BYBEE LAKE

AUGUST 4, 1986

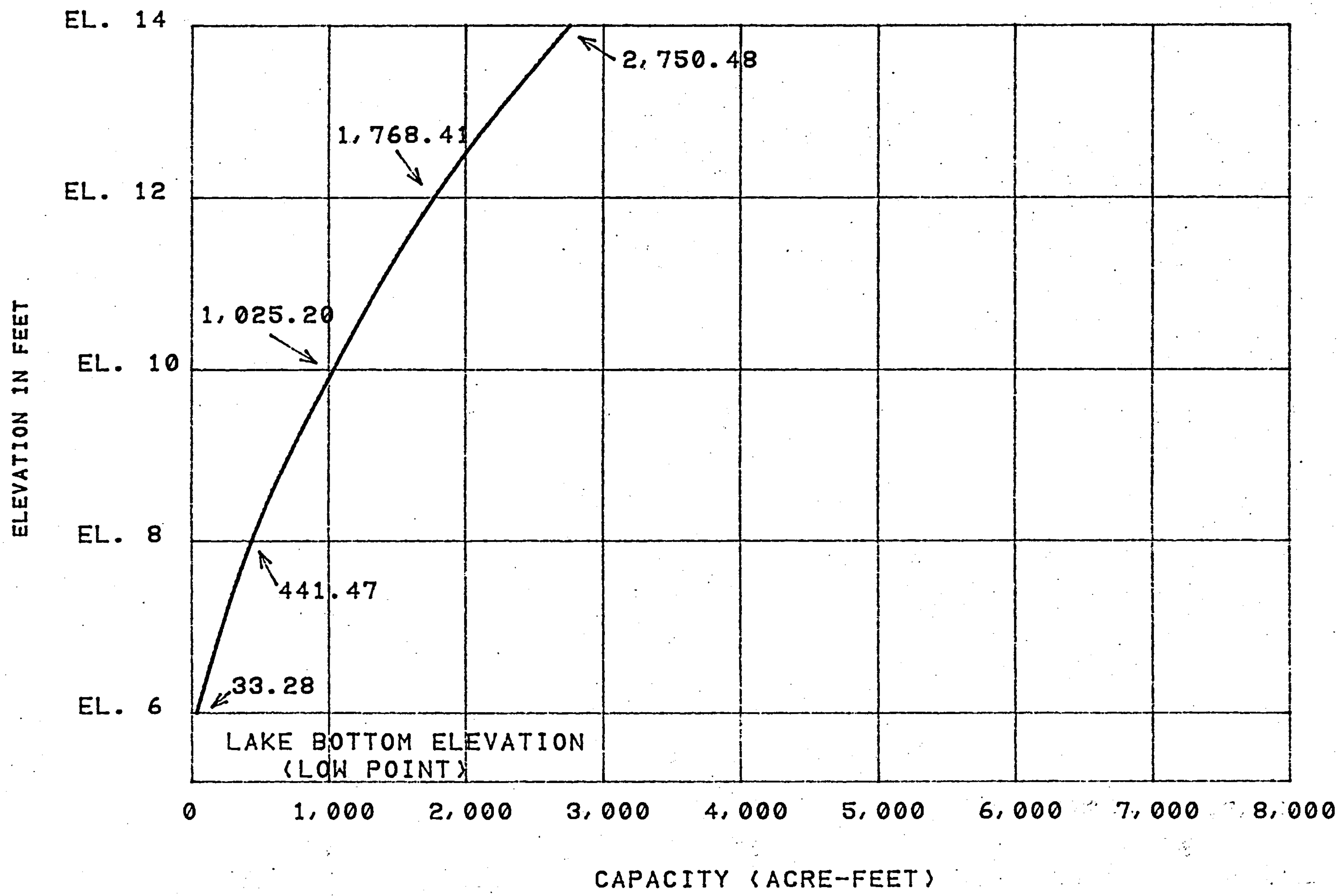


FIGURE A-8

It is recognized that groundwater seepage can be mathematically predicted if extensive data are available on soil permeability and the static head (elevation) differential between the lake and the groundwater table. However, specific data are not available and such predictions are beyond the scope of this study. It is noted that order-of-magnitude calculations based on general data show that the potential for groundwater seepage into or out of Smith-Bybee lakes is minor (Shannon & Wilson, Inc., 1986: see Technical Appendix B). This tends to confirm the above water budget analysis which also shows groundwater seepage to be small compared to precipitation and evaporation.

Generalization of the data shows that the water budget for Smith-Bybee lakes in the isolated condition can be approximated in simple terms: precipitation minus evaporation. This is confirmed by the close parallel between the observed change in lake levels during recharge and decline, and the cumulative net precipitation minus evaporation (P-E) curve for the same time periods as shown on Figure A-2. This translates the water budget relationship to terms of water elevation or depth rather than its correlating volumes.

When the lakes are not inundated by Columbia and/or Willamette River flood backwaters, the trend is for the lake level to fall in the summer months and rise in the late fall and winter. This can be expected given the typical Portland area weather patterns. Inundation of the lakes can be expected with the Willamette River freshet usually occurring in the winter months and the Columbia River freshet which usually occurs in late spring. The graph shown in Figure A-9 identifies the river level observed from November 1, 1985 to August 28, 1986 and the average river level for the period of record from 1971 to 1980. Also shown on the graph is the elevation of the holding weir at the lakes outlet. Note that the levels shown are daily averages and that the river levels actually fluctuate tidally. Thus the lakes could be recharged with river water on occasion at high tide.

4. Conclusions

The estimated water budget for Smith-Bybee lakes is presented in Table A-1 for the observed period of November 8, 1985 to August 28, 1986. Water budget terms are relevant only when the lakes are in the isolated condition, i.e., when river backwater levels are below the perched control weir elevation of 10.4 feet msl.

Based on the limited data the following conclusions are identified:

- Major water budget terms are precipitation and evaporation.

COLUMBIA RIVER @ VANC. WASH.

OGDEN BEEMAN & ASSOCIATES, INC.

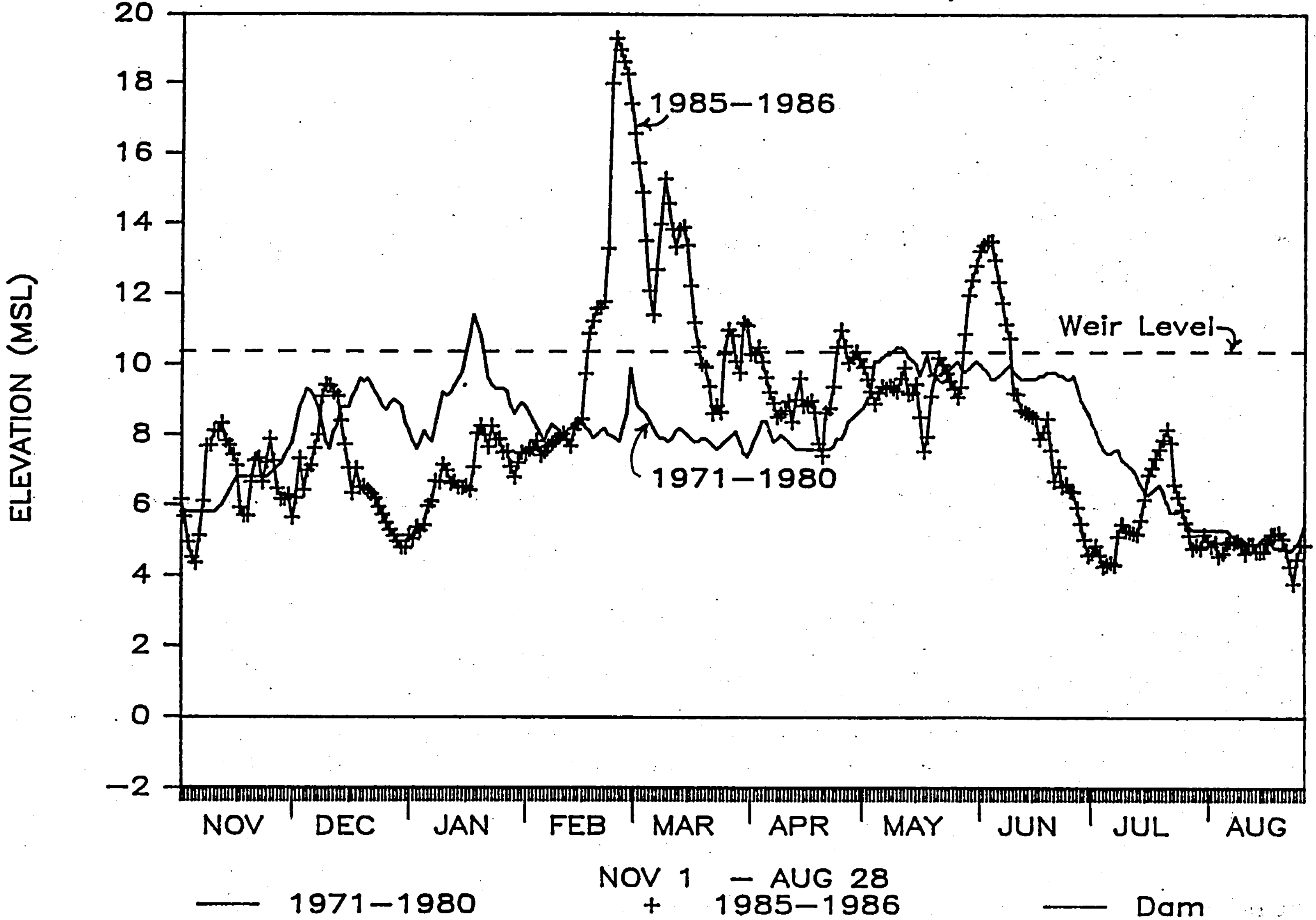


FIGURE A-9

- Surface runoff from the bankline fringe and other surface water inflows and outflows are small in comparison to precipitation and evaporation.

- Groundwater seepage into and out of the lakes is also relatively minor.

For concept planning purposes a surrogate measure of the water budget may be approximated by the simple terms of precipitation minus evaporation (P-E). This reduces the water budget to elevation (depth) terms.

B GROUNDWATER HYDROLOGY

SMITH AND BYBEE LAKES ENVIRONMENTAL STUDIES

TECHNICAL APPENDIX B:

GROUND-WATER HYDROLOGY OF THE SMITH AND BYBEE LAKES REGION, PORTLAND, OREGON

Report Prepared by:

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Staff Consultant
Geohydrology

and

DAVID G. LIVERMORE
Geohydrologist

November, 1986

Shannon & Wilson, Inc.
Geotechnical Consultants
Portland, Oregon

Project Sponsored by:

PORT OF PORTLAND and CITY OF PORTLAND
BUREAU OF ENVIRONMENTAL SERVICES

Project Managed by:

FISHMAN ENVIRONMENTAL SERVICES
Portland, Oregon

GROUND-WATER HYDROLOGY OF THE
SMITH AND BYBEE LAKES REGION,
PORTLAND, OREGON

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TECHNICAL APPENDIX B:

GROUND-WATER HYDROLOGY OF THE SMITH AND BYBEE LAKES REGION, PORTLAND, OREGON

Section 1: BACKGROUND AND OBJECTIVES

Shannon & Wilson was retained by Fishman Environmental Services to prepare a report describing the groundwater flow system in the vicinity of Smith and Bybee Lakes, with particular emphasis on vertical seepage relationships and potential for contamination migration from St. Johns Landfill. In preparing this report, existing data from published and unpublished reports, including proprietary information from Shannon & Wilson project files, were used extensively in mapping the significant geohydrologic features of the Columbia River floodplain. Many of the site-specific reports contain detailed boring information dating back 30 years or more. Every reasonable effort has been made to interpret and compile these data accurately onto a common reference map of the region. For site-specific application of these data, original project reports from property owners should be consulted and professional conclusions drawn accordingly.

Section 2: METHODS OF ANALYSES

Ground-water geochemical data for monitoring wells in the St. Johns Landfill were obtained from the Oregon Department of Environmental Quality's (DEQ) computerized data base. Data files, designated as STORET numbers STJOHN 15 through STJOHN 52, inclusive, contain the available monitoring records of groundwater static water-level measurements and water quality data (i.e., pH, conductivity, temperature, dissolved ion concentration) for monitoring wells at the landfill for the period of September 24, 1974 through May 14, 1985. More recent sampling results were obtained directly from DEQ laboratory files or provided by Metro through Fishman Environmental Services.

Section 2: METHODS OF ANALYSES (cont'd)

The complete and current data base (as of August 5, 1986) is provided as Table B-3 in Section 7 of this report. Additional geochemical data for leachate within the landfill were obtained from five monitoring wells drilled for the Dioxin Study Report prepared by Ecology and Environment, Inc., (1986). More frequent measurements of ground-water levels at selected landfill monitoring wells were conducted by Fishman Environmental Services for the period of June 5 through October 22, 1986.

Compilation of these data into a comprehensive data base does not, unfortunately, resolve shortcomings due to incomplete and infrequent monitoring of static water levels and heavy metals. Changes in measuring point elevations with little documentation also complicates the analysis of data. Additionally, the use of several different laboratories for the collection and analysis of ground-water samples provides little assurance of an internally consistent data base due to differences in accuracy and precision of analyses. Also because downgradient or upgradient monitoring has not been conducted off-site, it is not possible to measure the migration of contaminants outside the solid waste boundary, or to monitor deep penetration in the central part of the Landfill.

Subsurface geologic data were compiled from reports obtained from Shannon & Wilson proprietary files in addition to reports provided by the Port of Portland through Fishman Environmental Services. These data, generally in the form of boring logs, were used to prepare subsurface contour maps of the highly permeable gravel and sand aquifer beneath and adjacent to St. Johns Landfill.

Section 3: GROUND-WATER HYDROLOGY

3.1 Description of Aquifer Framework: The Smith-Bybee Lakes region is part of a major wetlands area along the Columbia River floodplain in north Portland (Figs. B-1a, B-1b). Fine grained overbank sediments formed during flood stages of the Columbia River immediately underlie these wetlands (Plate

Section 3: GROUND-WATER HYDROLOGY (cont'd)

3.1 Description of Aquifer Framework: (cont'd)

B-1). The overbank deposits contain buried remanents of old river channels at unpredictable locations which appear as isolated sand lenses in cross-section. Nearly all of the overbank sediments are considerably less than 6,000 years old. Beneath Bybee Lake, the overbank sediments thin and are in direct contact with highly permeable catastrophic flood deposits of Pleistocene gravel (Bretz, 1925, pt. 2) which are about 18,000 to 20,000 years old. In the rest of the area, an intervening layer of sand is present at the top of the gravel, as shown in cross-section beneath St. Johns Landfill, and in the main channel reach of the Columbia River. These two sand layers coalesce and thicken to the northwest just beyond the line of section near the northwest end of the gravel mound beneath Bybee Lake (Plates B-1 and B-2).

In the upriver direction towards Smith Lake, the overbank sediments (about 50 to 70 feet in thickness) rest directly on a sloping gravel surface which is buried at about -40 to -60 feet elevation under Smith Lake (Plate B-3). The surface of the gravel mound plunges steeply downriver from Bybee Lake beneath sand deposits to elevations of about -100 to -200 feet. The thick sand layer in contact with gravel beneath St. Johns Landfill (cross-section, Plate B-1), appears to continue south-eastward, rising to an elevation of about -30 at Columbia Boulevard Treatment Plant near the southeast corner of Smith Lake (Plate B-2). The thick sand wedge near the Columbia River channel (cross-section, Plate B-1), is traceable upriver beneath the I-205 Bridge, Government Island, and near the mouth of Sandy River.

An eroded bedrock surface of the Troutdale Formation is portrayed schematically in cross-section (Plate B-1) below the thick layer of Pleistocene gravels. Several previous reports on St. Johns Landfill have incorrectly described these Pleistocene gravels as the Troutdale Formation (Sweet, Edwards & Associates, Inc., 1983; Ecology & Environment, Inc., 1986). These major aquifer systems have distinctly different origins, and drilling and permeability characteristics. Both formations have been traced in the

Section 3: GROUND-WATER HYDROLOGY (cont'd)

3.1 Description of Aquifer Framework: (cont'd)

subsurface downriver from the Columbia River Gorge through the City of Portland's Blue Lake Well Field, the East Well Field, and the West Well Field near the Portland Airport (Willis, 1977, 1978). According to McFarland, Luzier, and Willis (1982), Luzier Hydrosciences (1985), and Luzier and Willis (in preparation), marine seismic surveys, borings, and aquifer testing resulted in the delineation of a buried bedrock canyon of the Columbia River about 300 feet below the present floodplain. Highly permeable Pleistocene gravels and sands occupy the bedrock canyon for a mapped distance of about 9 miles from the mouth of the gorge to the Portland Airport. This buried canyon (cut into bedrock of the Troutdale Formation), follows the general course of the present Columbia River floodplain and probably passes through the area of the cross-section (Plate B-1), and extends downriver beneath Sauvie Island and beyond the Trojan Nuclear Power Plant where it has been mapped by Shannon & Wilson to a depth of about 600 feet below the valley floor in Washington.

3.2 Description of Ground-water Flow System: The Pleistocene gravel aquifer beneath the Smith-Bybee Lakes region is one of the most productive aquifers in Oregon. Shannon & Wilson's design work at Columbia Boulevard Treatment Plant in 1970, demonstrated the need for unusual dewatering requirements because of the very high permeabilities in the Pleistocene gravel aquifer. Aquifer tests at the project site and nearby deep gravel wells revealed specific capacities of 200 to 1000 gal/min per foot of drawdown. To put these numbers in perspective, production wells completed in the gravel would be capable of producing 10,000 gal/min (22 cubic feet/sec), with less than 50 feet of drawdown. The City of Portland Water Bureau has already developed large capacity production wells of 5,000 to 10,000 gal/min capacity in upriver extensions of the Pleistocene gravel aquifer near the Portland Airport and at Blue Lake Park (Luzier and Willis, In Preparation; McFarland, Luzier, and Willis, 1982)

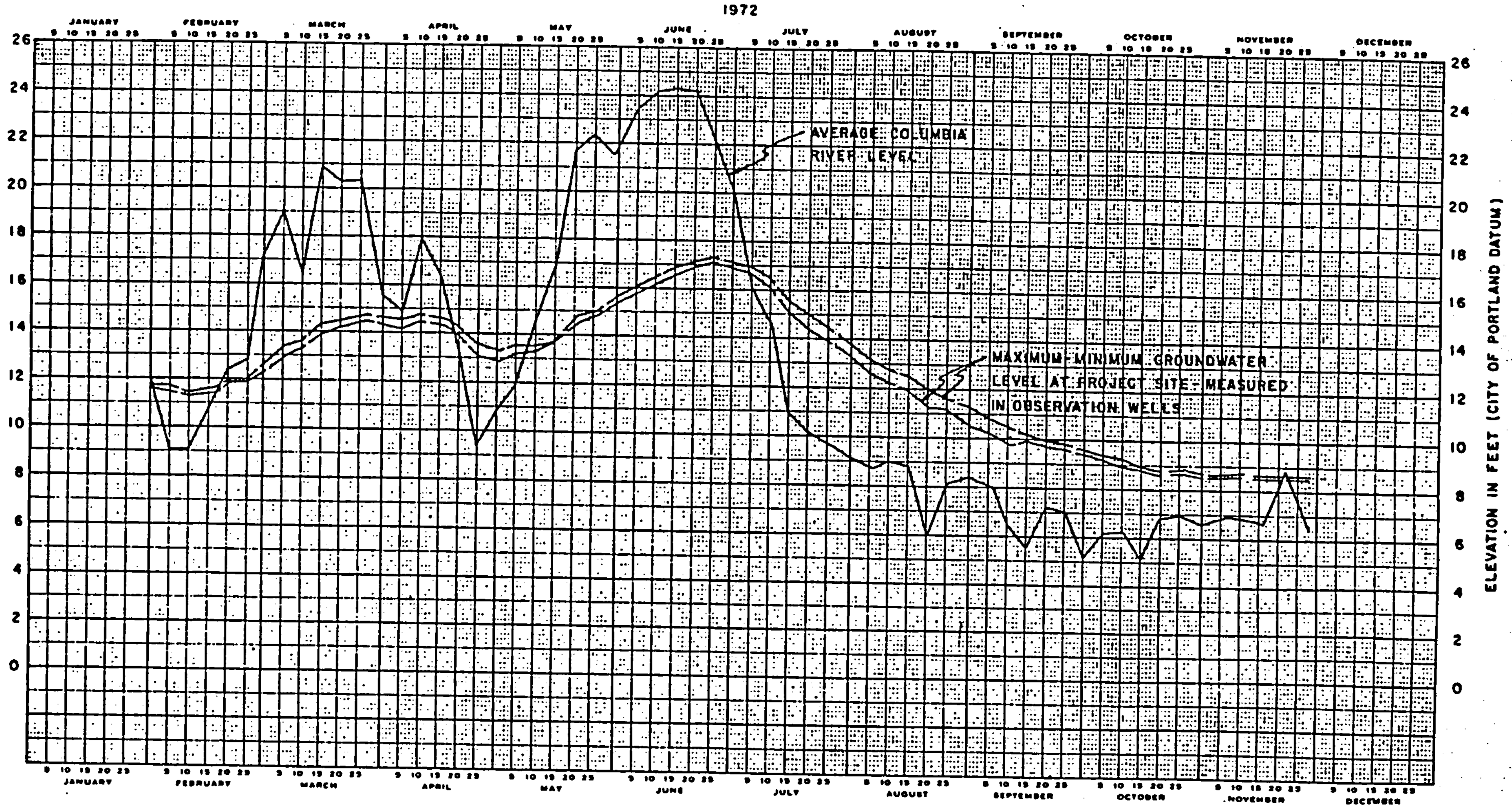
Section 3: **GROUND-WATER HYDROLOGY** (cont'd)

3.2 Description of Ground-water Flow System: (cont'd)

Because the Pleistocene gravel aquifer and the intervening sands have a good hydraulic connection with the Columbia River in the Smith-Bybee Lakes area and in upstream reaches of the floodplain, the River bed acts as a regional outflow boundary for ground water in the Pleistocene deposits. During low River stage (shown for example as +6 feet elevation in the cross-section, Plate B-1), ground-water flow in the gravel and sand converges towards points of lowest pressure (predominately the River channel), as portrayed by the arrows. The Columbia River also indirectly influences regional head distribution within the underlying Troutdale Formation to depths of more than 800 feet below sea level as shown by Luzier and Willis, (In Preparation).

During high stages of the Columbia River which typically occur twice a year in March and June (such as +19 feet elevation stage shown for example, Plate B-1), the River floods the wetlands area to about the same stage for many weeks, hydraulically blocking and recharging the low pressure ground-water outflow boundary in the River channel. As a consequence, natural ground-water pressures start rising in the Pleistocene gravel aquifer because of confinement by the fine-grained overbank sediments, and continued influx of ground-water from upgradient regions and surface flooding.

An excellent example of this process is afforded by detailed hydrographs of stage and water-level fluctuations measured by Shannon & Wilson in 1972 (Fig. B-2), adjacent to the southeast corner of Smith Lake. A comprehensive series of measurements in piezometers completed in the underlying gravel aquifer show how ground-water pressures or levels rise and decay quickly in response to changes in River stage. Note that soon after the summer peak in River stage of 24 feet, ground-water levels started declining after having peaked at 17 feet, but these levels remained about 1 to 2 feet higher than River stage throughout the summer. This difference in head or pressure provides a small but steady driving force for ground-water movement to the main River channels, and for upward leakage into any



COLUMBIA BLVD. TREATMENT PLANT
PORTLAND, OREGON

SITE GROUNDWATER LEVEL
VS. COLUMBIA RIVER LEVEL

NOVEMBER, 1972 0-430

SHANNON & WILSON, INC.
PORTLAND, OREGON

PLATE 7

SMITH AND BYBEE LAKES
MANAGEMENT PLAN
ENVIRONMENTAL STUDIES

FIGURE B-2

HYDROGRAPHS OF OBSERVATION WELLS
IN THE GRAVEL AQUIFER NEAR
COLUMBIA BOULEVARD TREATMENT PLANT,
1972

Section 3: GROUND-WATER HYDROLOGY (cont'd)

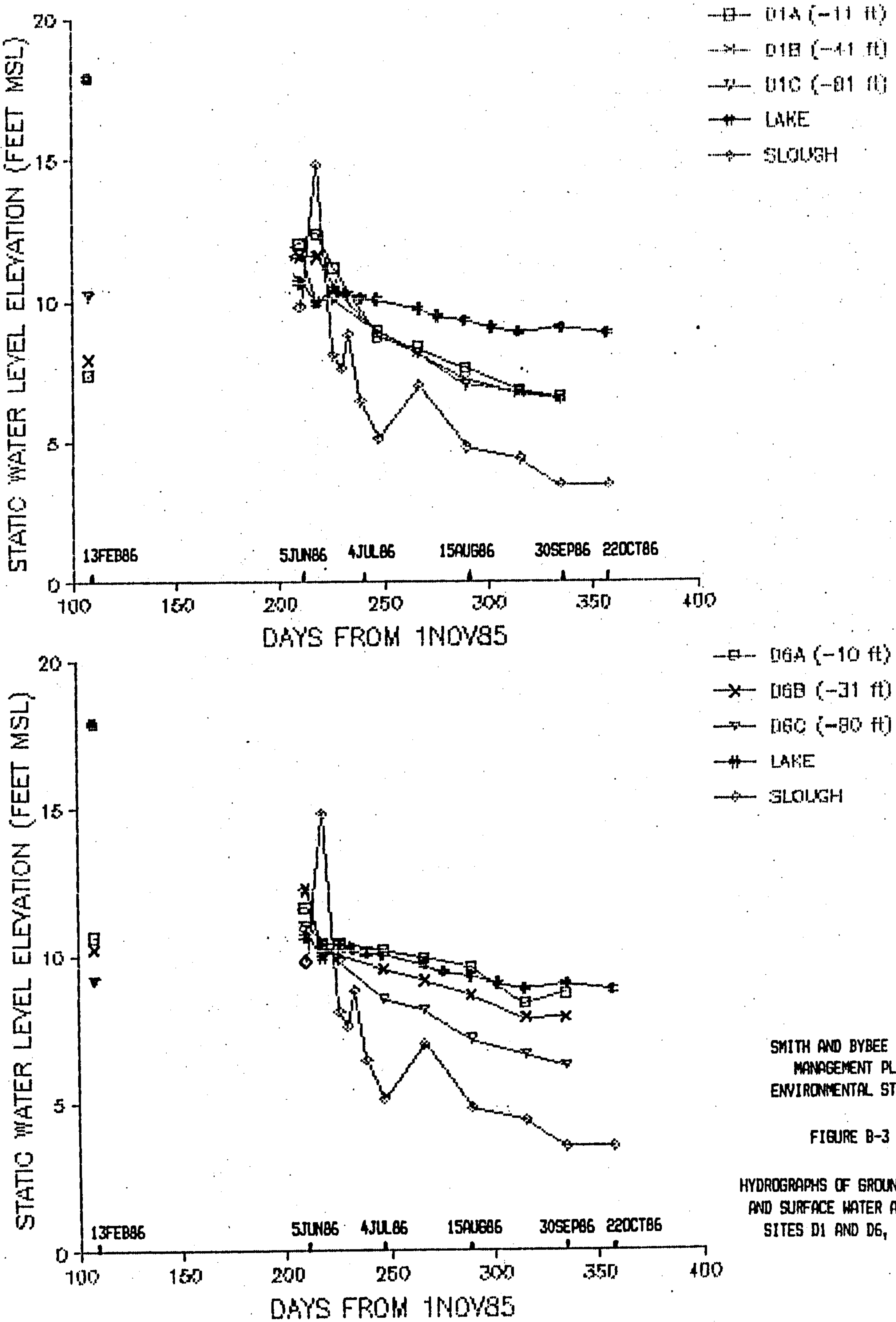
3.2 Description of Ground-water Flow System: (cont'd)

wetlands and swamps, lakes, and sloughs with water levels at a lower elevation than the ground-water surface.

The native conditions of 1972 in the wetlands no longer prevail because floodwaters are now trapped during major flood recessions at the 10.5 foot elevation stage in Smith-Bybee Lakes. Therefore, had this stage control for the Lakes been in place in 1972, one can see from the hydrographs and head differences, that upward ground-water leakage into the wetlands would have occurred mostly from early July until the first week in September, when ground-water levels would have receded approximately to the same elevation as the Lakes. Thereafter, lake levels and ground-water levels, both in simultaneous recession, would have produced little apparent net water exchange because of such small head differences.

Summer measurements of ground-water levels in 1986 by the project team (Fig. B-3; Table B-4, Appendix), show head variations with depth in two sets of perimeter wells. Well D1 (Fig. B-3, upper graph), completed in a thick sequence of silt and clay, shows little head variation with depth. Well D6 (Fig. B-3, lower graph), in which the deepest piezometer is completed in the gravel aquifer, shows a definite pattern of decreasing head with depth. In contrast to the 1972 data, in 1986, heads in the gravel aquifer decrease from 15 to 4 feet from mid-June to early October, whereas over the same period in 1972 heads dropped from 24 to 9 feet. These data reflect the important fact that the late spring peak in the Columbia River flood stage at 14 feet (hydrograph; Technical Appendix A; Figure A-9) was uncharacteristically low in 1986. As a result the dammed water surface in Smith-Bybee Lakes remained at an elevation at or above the heads in the underlying silts and gravel aquifer, so that the driving force for upward leakage of ground water into the wetlands during this period was absent.

Our subsurface mapping suggests that a small area of the bottom of Bybee Lake is a window into the underlying Pleistocene gravel aquifer (see



SMITH AND BYBEE LAKES
MANAGEMENT PLAN
ENVIRONMENTAL STUDIES

FIGURE B-3

HYDROGRAPHS OF GROUND-WATER AND SURFACE WATER AT WELL SITES D1 AND D6, 1986

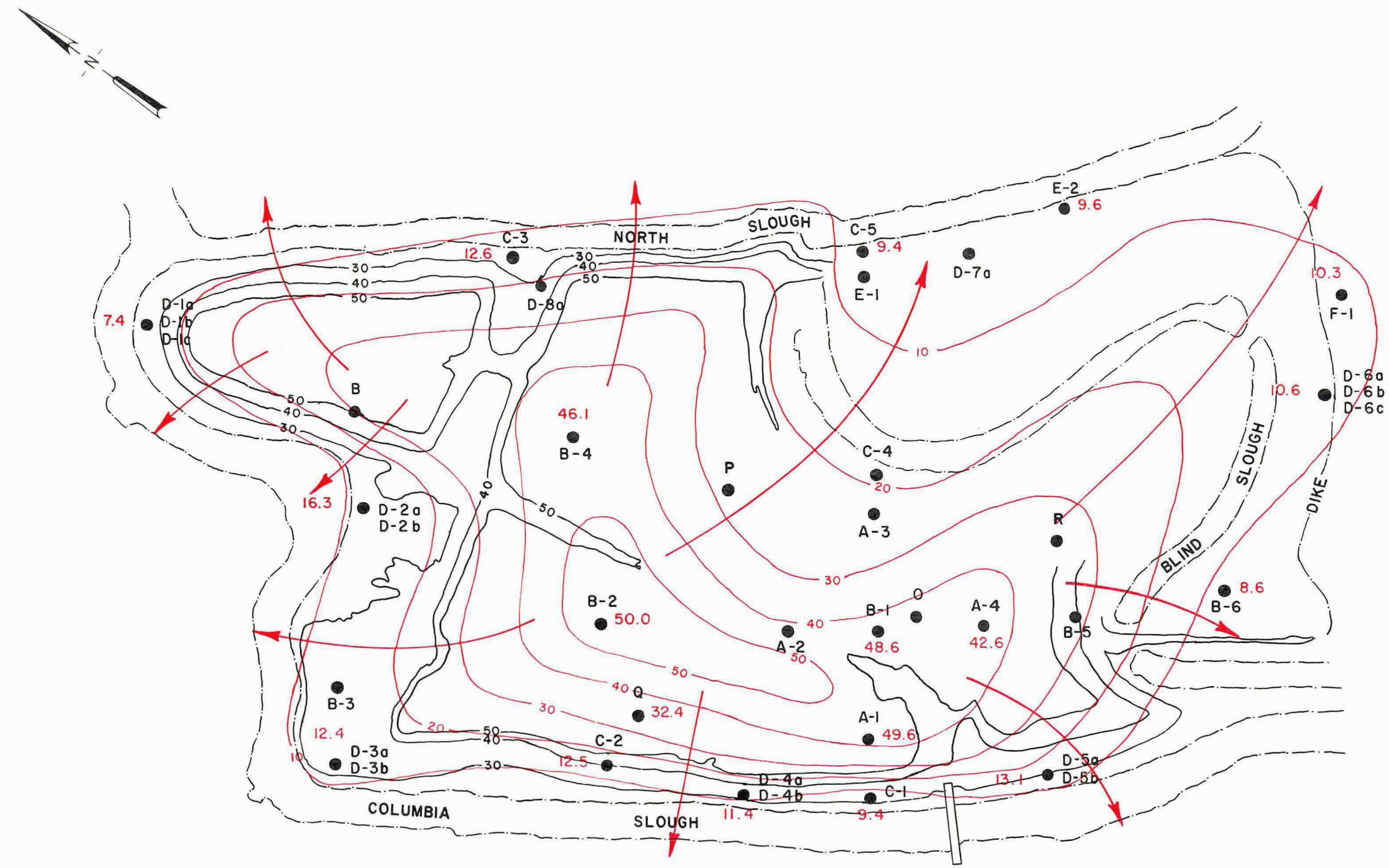
Section 3: **GROUND-WATER HYDROLOGY** (cont'd)

3.2 Description of Ground-water Flow System: (cont'd)

cross-section Plate B-1). Borings show that the top of the gravel aquifer rises slightly above sea level and coincides approximately with the bottom of Bybee Lake. Lake bottom sediments may thin to less than five feet and allow an exchange of groundwater and surface water in the northwest arm of Bybee Lake. A gravel window at the Lake bottom might help explain why Bybee Lake, unlike Smith Lake, has been reported by Sweet, Edwards & Associates, (1983) to respond to tidal fluctuations transmitted by the Columbia River. Bybee Lake, therefore, appears to be an outflow/inflow boundary for ground water in the Pleistocene gravel aquifer, depending on the direction of the head difference which will vary during the year.

The cross-section of Plate B-1, shows two areas of ground-water mounding and downward seepage into overbank sediments and the Pleistocene gravel aquifer. In the sand fill underlying North Rivergate Industrial Park, ground-water mounding has occurred due to rainfall and cyclic influx of floodwater. Ground water within the sand fill may enter Smith and Bybee Lakes directly as shown (Plate B-1), but during extended River low flow periods, steeper gradients would prevail along the River side, causing the axis of the ground-water "ridge" to shift towards the wetlands.

3.3 Leachate Mounding At St. Johns Landfill: Leachate mounding within the garbage mass at St. Johns Landfill (Plate B-4), has risen well above the original 1905 wetlands surface (dotted line), reaching elevations of 30 to 50 feet in February 1986. As shown in section, saturation levels in the garbage undergo a cyclic fluctuation of about 5 to 10 feet annually, due to influx of rainfall, and fluid losses by evaporation, runoff, drainage, and ground-water leakage. The leachate mound (plan view Fig. B-4), maintains a persistent head difference above the sloughs, lakes, and the ground-water surface in the Pleistocene gravel aquifer. As one would expect, the native ground-water surface (typically 8 to 10 feet elevation) in the highly permeable Pleistocene gravel aquifer, cannot be raised or mounded measurably



PREPARED BY: SHANNON & WILSON, INC.

ELEVATION CONTOURS ON THE LEACHATE MOUND AT ST. JOHNS LANDFILL, FEBRUARY, 1986

LEGEND

—50— CONTOUR LINES

● MONITORING WELL SITE

→ GENERALIZED DIRECTIONS OF GROUNDWATER FLOW

—50— LEACHATE MOUND ELEVATIONS, FEB., 1986

Port of Portland

GRAPHIC SCALE IN FEET

500 0 500 1000 1500 2000 2500

DECEMBER, 1986

SMITH AND BYBEE LAKES

MANAGEMENT PLAN

ENVIRONMENTAL STUDIES

LEACHATE MOUND ELEVATIONS

SENIOR PLANNER, LAND DEVELOPMENT

RG 86-511 4/23 (C-4)

FIGURE B - 4

Section 3: **GROUND-WATER HYDROLOGY** (cont'd)

3.3 Leachate Mounding At St. Johns Landfill: (cont'd)

in response to the limited quantity of downward leakage from the Landfill. Complete saturation is present from the leachate surface in the garbage, downward through hundreds of feet of sediments and water-bearing material. Fluid pressures, however, vary vertically in response to permeability changes. Fluid pressures in the leachate mound have risen, therefore, in order to overcome the resistance to downward flow through the low permeability overbank sediments. As portrayed in the cross-section, the leachate-rich ground water moves downward along curved flowpaths to outflow boundaries of lower head such as the adjacent sloughs and the underlying aquifers of gravel and sand.

Compared to fresh ground water, leachate contaminated ground water at St. Johns Landfill can penetrate faster and sink deeper partly because it is denser due to large concentrations of dissolved substances, and partly because fluid viscosity is lower from warming (20° to 36°C vs about 10°C) caused by chemical and biological degradation of the garbage.

The above description of the ground-water flow system at St. Johns Landfill differs from conclusions of other recent investigations. According to Sweet, Edwards & Associates (1983), and Ecology and Environment, Inc. (1986), downward migration of contaminated ground water at St. Johns Landfill is limited by an upwelling of deep ground water from the "Troutdale Formation". These investigators suggest that the buoyant region thus created beneath the Landfill would force contaminants to move laterally into the adjacent sloughs. Key cross-sections used in the previous investigations to portray these features are reproduced in this report in Figure B-5. These sections cross about the same path as our cross-sections (Plates 1 and 4), but with an opposite viewpoint (looking upriver). An upwelling region of groundwater flow beneath the Landfill (as portrayed by the large arrows, (Figs B-5a and B-5b), in our opinion is not justified on

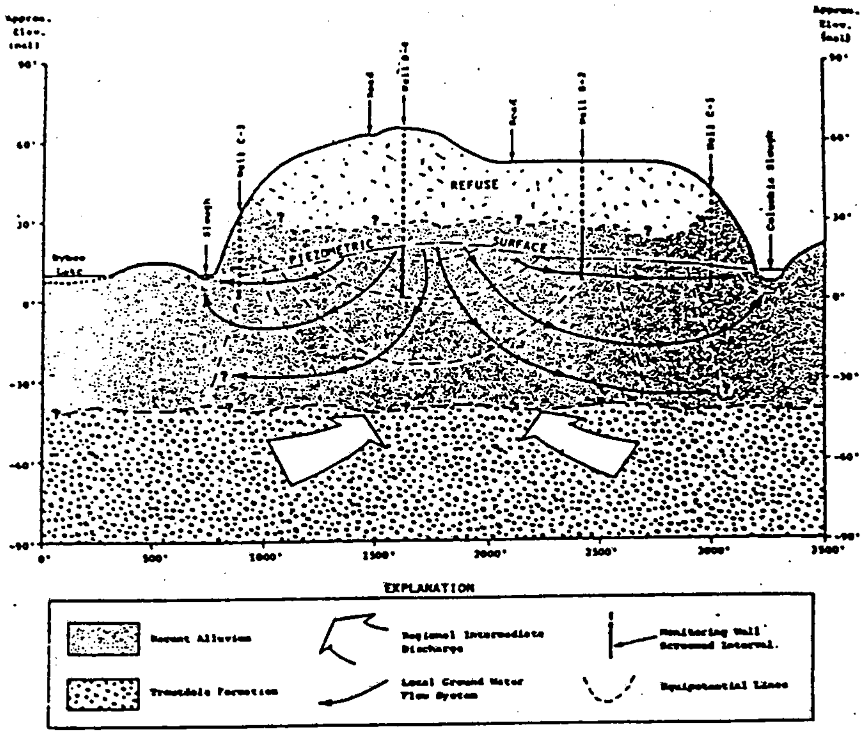


FIGURE 4
METRO/ST. JOHNS SANITARY LANDFILL
Diagramatic Cross-Section

FROM: SWEET, EDWARDS AND ASSOCIATES, INC. 1983

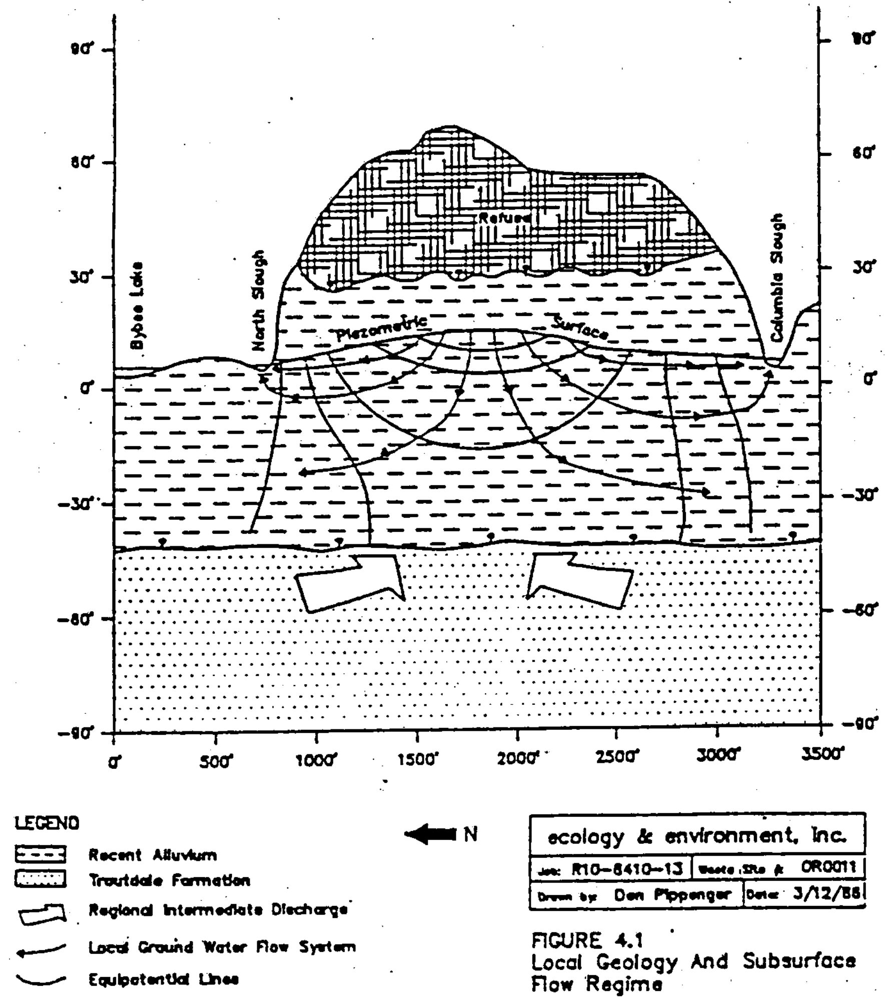


FIGURE 4.1
Local Geology And Subsurface Flow Regime
St. Johns Landfill
Portland, OR

SMITH AND BYBEE LAKES
MANAGEMENT PLAN
ENVIRONMENTAL STUDIES

FIGURE B-5

PREVIOUSLY PUBLISHED CROSS-SECTIONS SHOWING THE GROUND-WATER FLOW SYSTEM AT ST. JOHNS LANDFILL

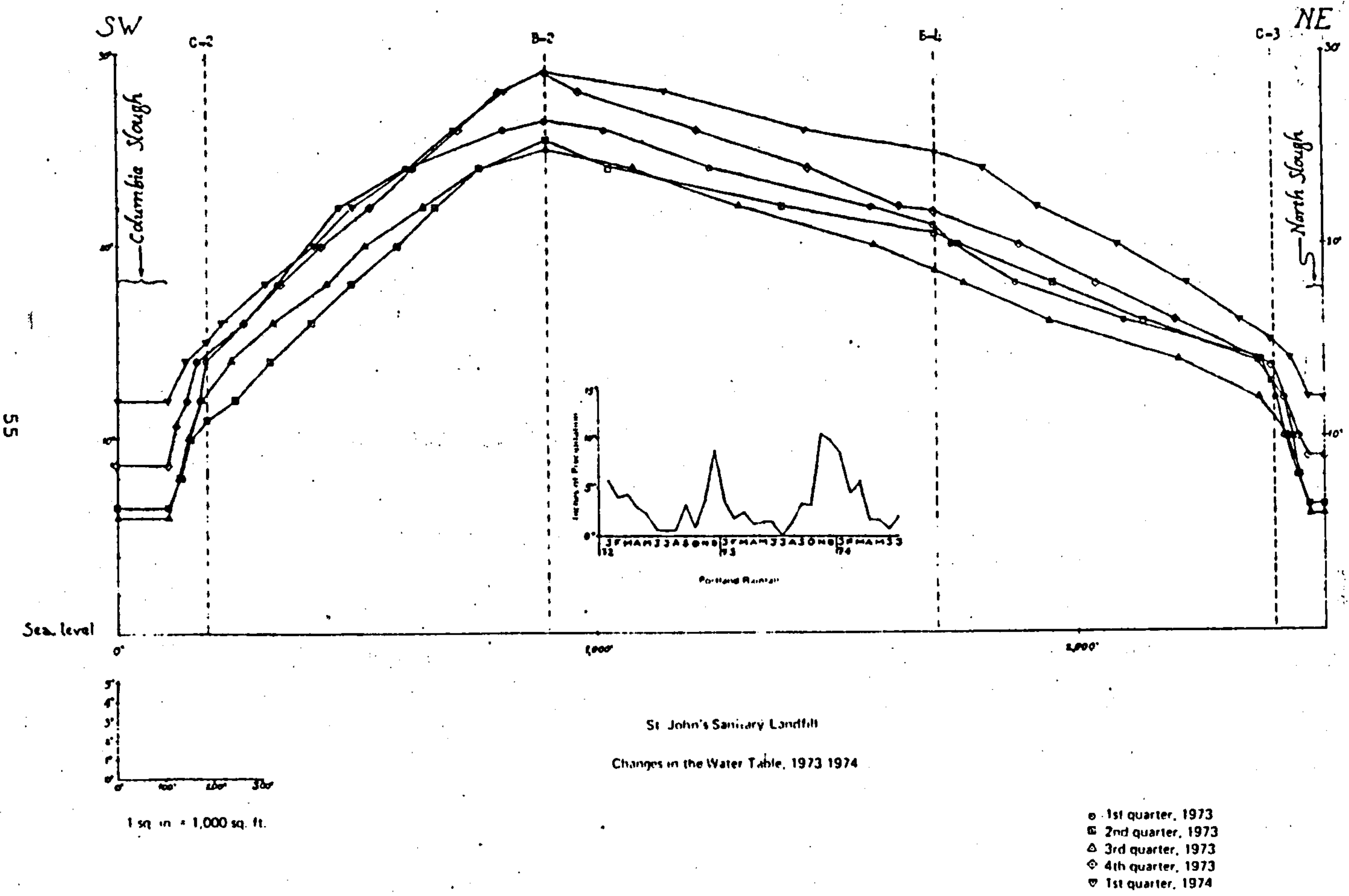
Section 3: **GROUND-WATER HYDROLOGY** (cont'd)

3.3 Leachate Mounding At St. Johns Landfill: (cont'd)

the basis of evidence, nor is it likely to occur in this situation. A slight mound in the "piezometric" surface is shown to be present entirely within the Recent Alluvium, with the bottom of "Refuse" perched well above ground-water saturation levels. Original wetlands topography, (1905 USGS maps), and drilling evidence shows that most of the garbage mass extends approximately to sea level and that the garbage was saturated with leachate to significant levels as early as 1972 (Stevens, Thompson & Runyan, 1974). In general, the recently published cross-sections and descriptions fail to provide a fair representation of the groundwater flow system and how the leachate mound functions as a driving force for deep penetration of contaminants.

The leachate mound at St. Johns Landfill has gradually accumulated over a period of perhaps 30 to 50 years. Few measurement records are available to show long term trends in growth of the leachate mound, or whether fluid production has stabilized. The earliest known and most comprehensive definition of leachate mounding and contamination at St. Johns Landfill was conducted by Stevens, Thompson & Runyan, Inc. (1974). A grid of 15 monitoring wells drilled in 1971 were used to produce maps and profiles of leachate mounding (Fig. B-6 and B-7). The maps and profiles show that leachate mounding had reached elevations of about 20 to 28 feet at a time when Landfill surface elevations were 50 to 60 feet in the area of cross-section. The same wells now show (1986) that the leachate mound has reached elevations of 40 to 50 feet near the line of section (Fig. B-4), with final fill elevations of 60 to 70 feet. Therefore, the leachate has risen about 20 feet in 12 years and now saturates about 66 to 71 percent of the vertical garbage section above sea level. In 1974, about 50 percent of the vertical section was saturated with leachate, during a period of active fill operations along the line of section.

Active filling could account for the smaller percentage of saturated thickness in 1974 as compared to current levels because some time would be

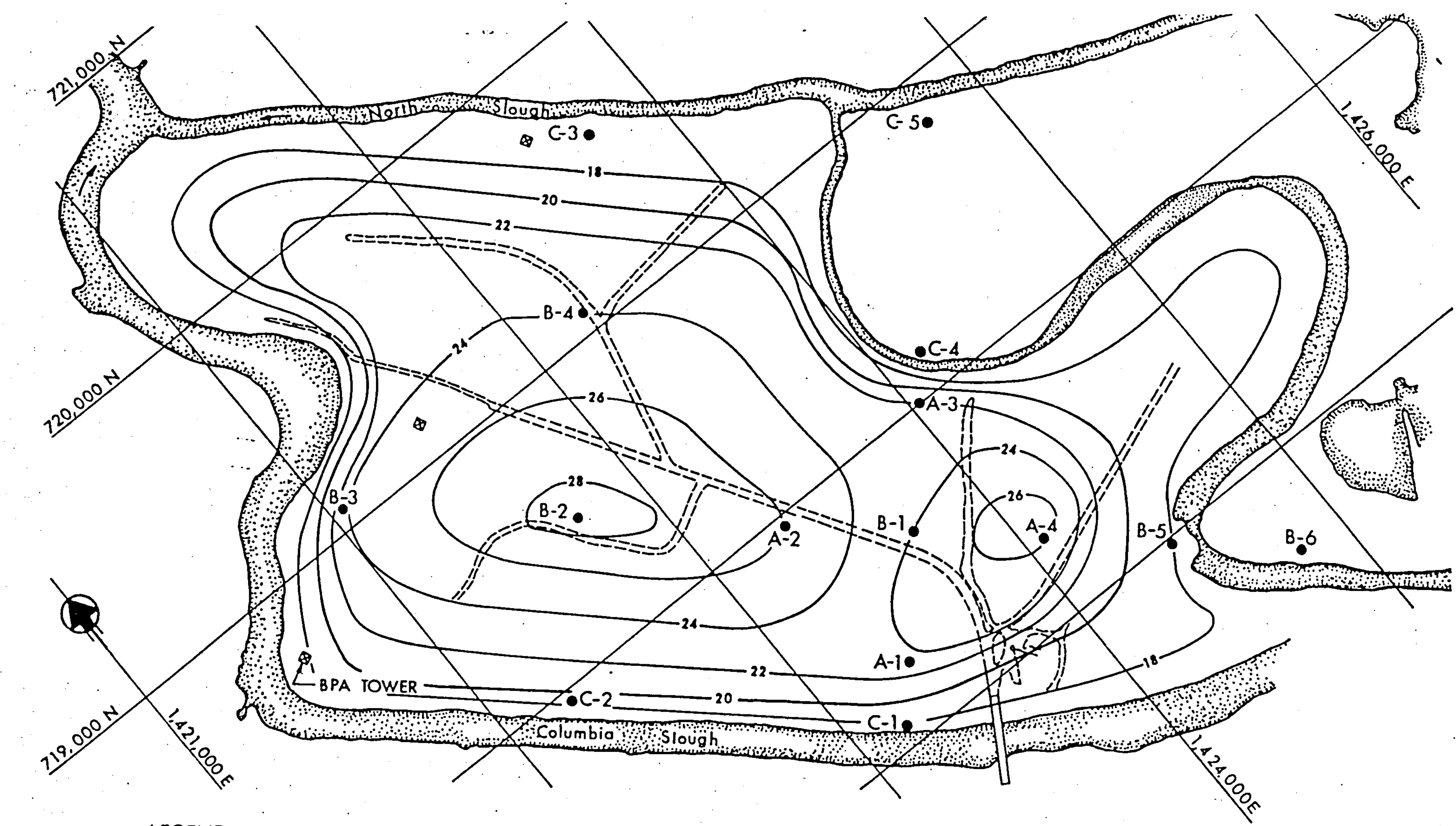


FROM: STEVENS, THOMPSON & RUNYAN, INC. 1974

SMITH AND BYBEE LAKES
MANAGEMENT PLAN
ENVIRONMENTAL STUDIES

FIGURE B-6

PROFILES OF LEACHATE FLUCTUATIONS
AT ST. JOHNS LANDFILL, 1973-74



LEGEND

- ●A-1 TYPE A OBSERVATION WELL (4)
- ●B-1 TYPE B OBSERVATION WELL (6)
- ●C-1 TYPE C OBSERVATION WELL (5)

LOCATION OF OBSERVATION WELLS AND GENERAL CONTOURS OF UNDERLYING WATERTABLE

FROM: STEVENS, THOMPSON & RUNYAN, INC. 1972

SMITH AND BYBEE LAKES MANAGEMENT PLAN ENVIRONMENTAL STUDIES

FIGURE B-7

ELEVATION CONTOURS ON LEACHATE MOUND AT ST. JOHNS LANDFILL, 1972

Section 3: **GROUND-WATER HYDROLOGY** (cont'd)

3.3 Leachate Mounding At St. Johns Landfill: (cont'd)

required for leachate levels to respond and stabilize to the newly formed landfill surface. By the same account, it is uncertain as to whether the present mounded leachate surface is nearing stabilization. Improved monitoring of internal landfill wells (i.e., B2 and B4, with the addition to the network of the new EPA wells), would provide better long term data to determine whether leachate generation and leakage losses have stabilized.

In general, a sound technical analysis of the ground-water flow system is an essential element in evaluating the distribution of existing contaminants and predicting routes of contaminant transport and possible release mechanisms.

3.4 Ground-water Contamination: The most obvious source of ground-water contaminants to the Smith-Bybee Lakes Region is the St. Johns Landfill. Other ground-water sources that could contaminate the Lakes and wetlands include any existing or future spills on the interior half of the Rivergate sand fill bordering the wetlands. Spills or releases in the sand fill would have a short travel path to the wetlands and little chance for dilution. Therefore, potential spills in the adjacent sand areas pose added risk if spill containment is not expeditous.

Several sources of ground-water contamination have been identified previously by the EPA and DEQ in the old industrial fill area along North Suttle Road, adjacent to the northeast corner of Smith Lake. An investigative report by Ecology and Environment, Inc. (1984), shows that pesticide (DDT) contaminated acid alum wastes and other products have been disposed of onsite, in unlined ponds and pits, and in the Portland Harbor from 1954 to 1973 by the Stauffer Chemical Company. Specific contaminants identified both in soils and groundwater include DDT, chlordane, and herbicides.

An investigative report by Stauffer Chemical Company (1981), found volatile organics in each of eight onsite monitoring wells, but generally concluded

Section 3: GROUND-WATER HYDROLOGY (cont'd)

3.4 Ground-water Contamination: (Cont'd)

that there was "no indication of what would be considered a ground water problem", but that studies would continue. The later study for the EPA by Ecology and Environment, Inc. (1984), concluded (1) "The alum deposits contain pesticides in relatively high concentrations. The impact of the pesticides on the North Portland Harbor water quality is not clear since the desorption of the compounds from the alum waste cannot be predicted". (2) "Based on RCRA EP Toxicity Criteria for pesticides, the soil, alum sludge and groundwater samples are not classed as hazardous waste". These conclusions were made despite findings of significant concentrations of chlordane, DDT, and DDD in groundwater, and a suggestion "that the alum waste deposit still releases pesticides into the groundwater".

Neither study recognized the possibility of ground-water flow towards the wetlands, despite the installation of at least 20 monitoring wells, eight of which are known to be completed onsite in 15 to 28 feet of sand. Several wells near unlined lagoons had water-levels only 9 to 11 feet below the top of casing in early December, 1980 (Stauffer Chemical Company, 1981). Although elevation data was not provided, the ground-water surface must have been close to 20 feet elevation, well above nearby Lake levels and the Columbia River stage. Ground-water contaminants therefore, can probably be found along a flowpath to the wetlands and Smith Lake, as well as to the Portland Harbor.

In 1985, an oil spill nearby at the Merit Oil Company (client files), apparently entered the wetlands and Smith Lake via a 3-foot storm culvert draining the North Suttle Road Industrial area. Clean-up operations resulted in damage to several acres of wetland and included the removal of vegetation. During a site visit and inspection of the spill area on December 5, 1986 (during a rainy period), members of the project team noted discolored ground-water seeps and springs issuing from the sand fill, and a strong flow of amber colored water with slight oil traces, discharging from the 3-foot culvert.

Section 3: GROUND-WATER HYDROLOGY (cont'd)

3.4 Ground-water Contamination: (Cont'd)

Initial field measurements showed that specific conductance of most ground-water seeps and springs ranged from about 1,200 to 12,000 micromhos-/cm, and the culvert discharge was about 1,600 micromhos/cm. During a return visit in dry weather to confirm the initial findings on December 8, the following measurements were made:

	Specific Conductance	pH	Temp°C
Culvert Discharge	1,589	8.70	6.7
Brown Seep (midway to Lake)	41,800	10.10	5.0
Discharge into Smith Lake	3,300	9.40	5.3

Preliminary laboratory tests by MEI-Charlton, Inc. on a composite sample revealed approximately the following concentrations in mg/l:

Chloride	6,400.	Sulfate	>5.
Sodium	3,000.	Alkalinity	4,200.
Ammonia-N	1,400.	Volatile Solids	4,800.
Potassium	1,140.	Total Solids	12,400.
Calcium	27.	Specific Conductivity	16,000. micromhos/cm
Magnesium	2.		

The chemistry of this water may be described as a brackish, ammonium-rich alkaline solution. The depleted concentrations of calcium, magnesium, and sulfate are more characteristic of oil field waters than of seawater. Testing for other ground-water contaminants is desirable, but further tests are outside the scope of this project. The ammonium-rich fluid is completely water soluble, and because of dissolved salts, it has high specific gravity. The very high pH in all samples suggests that the contamination is related to a common source upgradient, and it is probably not directly related to the acid alum wastes at Stauffer Chemical Company. Contaminated ground water at that site has been shown in both the investigative reports (1981 and 1984), to have an acidic pH range of 3.9 to 6.8, and specific conductivity of about 360 to 3,700 micromhos/cm. The ammonium-rich ground-water seepage has been observed to sink and stratify along the

Section 3: GROUND-WATER HYDROLOGY (cont'd)

3.4 Ground-water Contamination: (Cont'd)

stream course into Smith Lake, and it is likely that sinking has also occurred along the ground-water flowpath in the source area. Since ammonia-nitrogen is equivalent to "liquid fertilizer", it is a detrimental nutrient contaminant source to Smith Lake.

At St. Johns Landfill the large leachate mound discussed previously (Fig. B-4), is maintained largely by (1) the passage of rainfall and snowmelt through the soil cap and open garbage areas, (2) additions of moist garbage and waste fluids, and (3) reduction of pore space during decomposition and compaction of the garbage mass. Leachate fluids move continuously through pore space in the garbage, slowly leaching and redepositing chemical substances and biological organisms along any particular ground-water flowpath. Both the fluid and garbage become charged with gas and reach elevated temperatures because of biological decomposition and heat producing chemical reactions. Leachate thus formed, is often readily differentiated from native ground water by fairly simple field measurements of specific electrical conductance (an excellent indicator of total dissolved substances), temperature, and sometimes observed odor and color. Native ground water, unlike leachate, passes through a comparatively unreactive and cool porous matrix composed of rock and mineral grains. Therefore, the dissolved solids content and electrical conductivity of native ground water remain fairly low and uniform, with barely detectable increases in dissolved solids even after many miles of migration. Examples of typical specific electrical conductivity measurements in the Portland region are as follows:

Rainfall and snowmelt	10	micromhos/cm	@ 25°C
Fresh springs, mountain streams	50	"	"
Willamette River	70	"	"
Columbia River	160	"	"
Fresh ground-water	300	"	"
St. Johns leachate	1,000 to 12,000	"	"

Section 3: GROUND-WATER HYDROLOGY (cont'd)

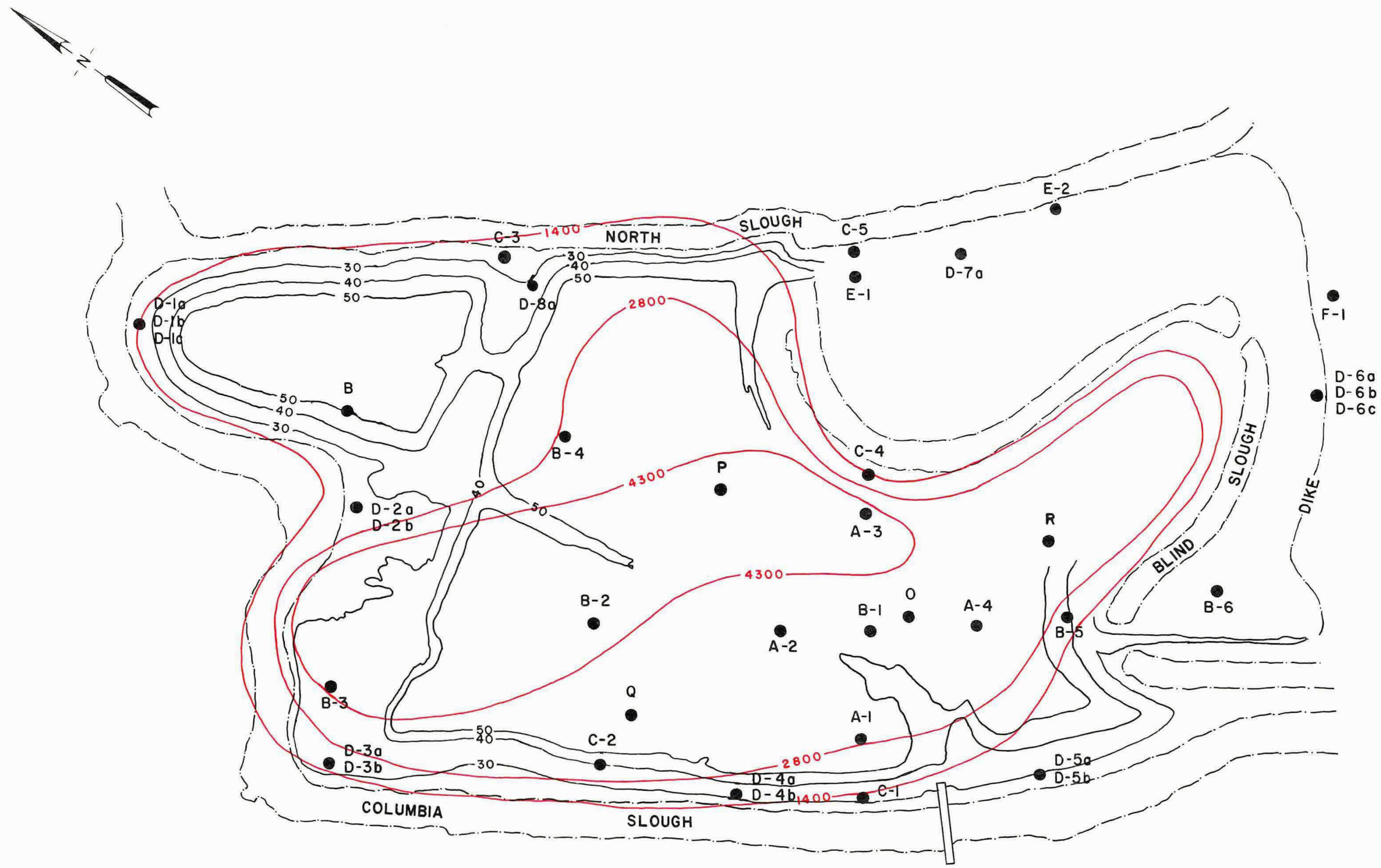
3.4 Ground-water Contamination: (cont'd)

The earliest measurements of total dissolved solids in the leachate mound at St. John's Landfill were made in 1972-74 by Stevens, Thompson & Runyan (1974). Although specific electrical conductance was not measured, we have converted the 1972-74 total dissolved solids data to electrical conductance by dividing by an estimated 0.7 conversion factor. Figure B-8 is a generalized map of calculated electrical conductance for the period 1972-74, and the map is roughly comparable to the 1985-86 map of measured electrical conductance (Fig. B-9).

A comparison of the two maps suggests leachate has generally become more concentrated during the past 12 years, coincidental with landfilling to higher elevations and increased leachate mounding (Fig. B-4). Generally, conductivities near the base of the landfill (+6 to -11 feet elevation), were in the range of 1,400 to 4,300 micromhos/cm in 1972-74, compared to 4,000 to 12,000 micromhos/cm by 1985-86.

Recent mapping (Fig. B-9), suggests that leachate contamination may extend off-site beyond the solid waste boundary and beyond the sloughs. However, no off-site ground-water monitoring has been conducted to provide the necessary information to properly evaluate the possibility.

One way to examine the potential for off-site migration is to examine the evidence for vertical penetration of leachate (i.e., fluid movement against the grain of horizontal sedimentary layers beneath the landfill). Figure B-10 shows contours of fluid electrical conductivity in wells screened at elevations of -17 to -44 feet. At this elevation range, only the perimeter wells remain as control points because monitoring wells have not been drilled more than several feet below sea level in the landfill interior. The inferred positions of the 4,000 and 7,000 conductivity contours are based partly on (1) the presence of highly concentrated leachate overlying this zone near sea level (Fig. B-9), (2) the ground-water flow directions as



PREPARED BY: SHANNON & WILSON, INC.

SOURCE: CALCULATED FROM DATA IN STEVENS, THOMPSON & RUNYAN, 1974.

CONTOURS OF CALCULATED FLUID ELECTRICAL CONDUCTIVITY OF LEACHATE NEAR THE BOTTOM OF ST. JOHNS LANDFILL, 1972-74.

LEGEND

—50— CONTOUR LINES

● MONITORING WELL SITE

—4300— CALCULATED ELECTRICAL CONDUCTIVITY NEAR THE LANDFILL BOTTOM, Micromhos/cm.

Port of Portland

GRAPHIC SCALE IN FEET

500 0 500 1000 1500 2000 2500

DECEMBER, 1986

SMITH AND BYBEE LAKES
MANAGEMENT PLAN
ENVIRONMENTAL STUDIES

LEACHATE CONDUCTIVITY CONTOURS, 1972-74

SENIOR PLANNER, LAND DEVELOPMENT

RG 86-511 5/23 (C-5)

FIGURE B-8

PREPARED BY: SHANNON & WILSON, INC.

CONTOURS OF FLUID ELECTRICAL CONDUCTIVITY OF LEACHATE NEAR THE BOTTOM OF ST. JOHNS LANDFILL, 1985 - 86.

LEGEND

—50— CONTOUR LINES

● MONITORING WELL SITE

— — — INFERRED CONTOURS

—1000— ELECTRICAL CONDUCTIVITY NEAR THE LANDFILL BOTTOM, Micromhos/cm.

Port of Portland

GRAPHIC SCALE IN FEET

500 0 500 1000 1500 2000 2500

DECEMBER, 1986

SMITH AND BYBEE LAKES

MANAGEMENT PLAN

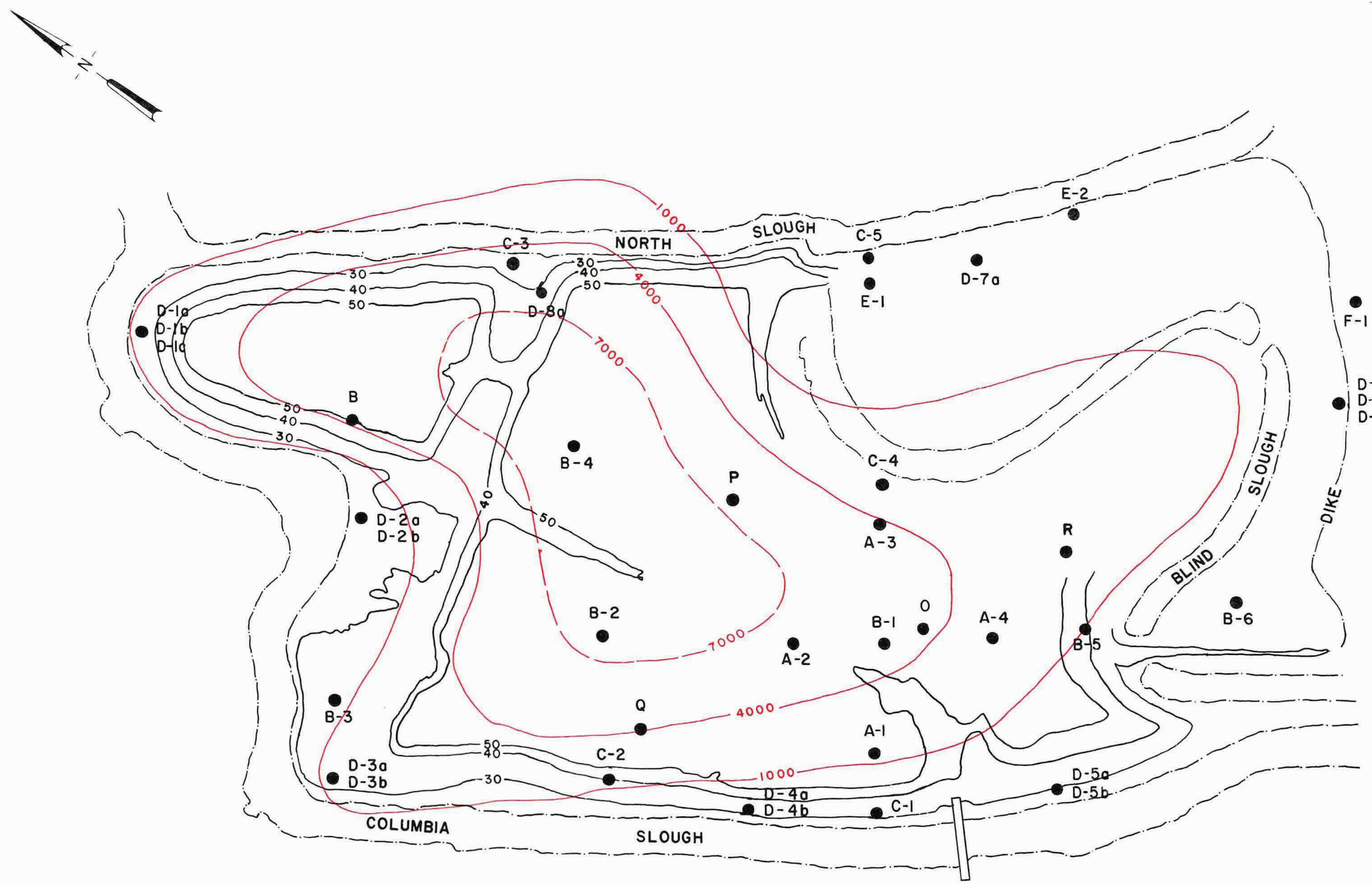
ENVIRONMENTAL STUDIES

LEACHATE CONDUCTIVITY CONTOURS, 1985-86

SENIOR PLANNER, LAND DEVELOPMENT

RG 86-511 6/23 (C-6)

FIGURE B - 9



PREPARED BY: SHANNON & WILSON, INC.

CONTOURS OF FLUID ELECTRICAL CONDUCTIVITY IN SEDIMENTS AND GRAVEL BENEATH ST. JOHNS LANDFILL, ELEVATION RANGE FROM -17 TO -44 FEET, 1985-86.

LEGEND

—50— CONTOUR LINES

● MONITORING WELL SITE

— — — INFERRED CONTOURS

—1000— FLUID ELECTRICAL CONDUCTIVITY, Micromhos/cm.

Port of Portland

GRAPHIC SCALE IN FEET

500 0 500 1000 1500 2000 2500

DECEMBER, 1986

SMITH AND BYBEE LAKES

MANAGEMENT PLAN

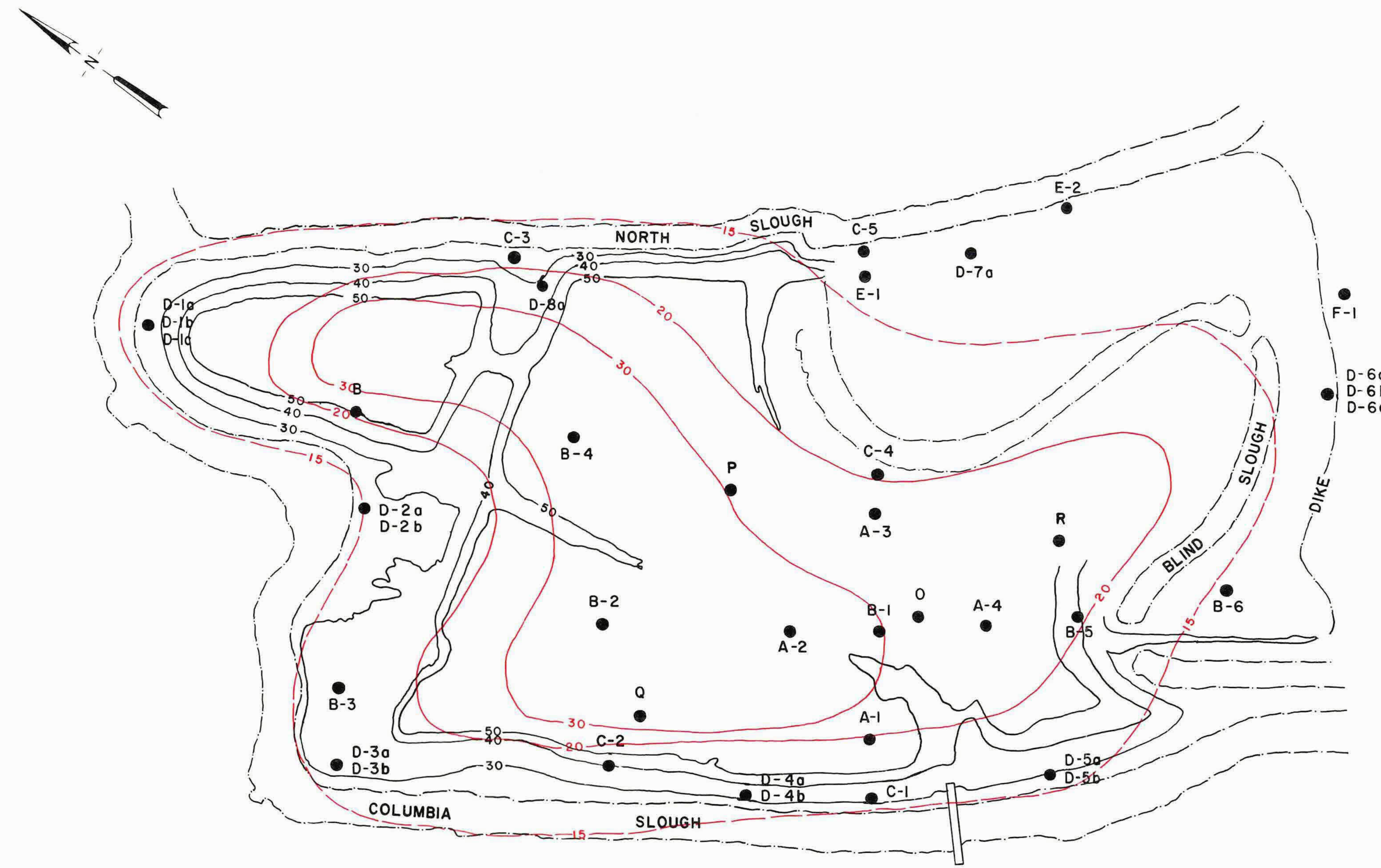
ENVIRONMENTAL STUDIES

MID-DEPTH CONDUCTIVITY CONTOURS

SENIOR PLANNER, LAND DEVELOPMENT

RG 86-511 7/23 (C-7)

FIGURE B-10



PREPARED BY: SHANNON & WILSON, INC.

CONTOURS OF FLUID TEMPERATURE IN GARBAGE AND SEDIMENTS AT ST. JOHNS LANDFILL, ELEVATION RANGE FROM +22 TO -44 FEET, 1985-86.

LEGEND

—50— CONTOUR LINES

● MONITORING WELL SITE

—30— FLUID TEMPERATURES, °C

Port of Portland

GRAPHIC SCALE IN FEET

500 0 500 1000 1500 2000 2500

DECEMBER, 1986

SMITH AND BYBEE LAKES

MANAGEMENT PLAN

ENVIRONMENTAL STUDIES

FLUID TEMPERATURE CONTOURS, 1985-86

SENIOR PLANNER, LAND DEVELOPMENT

RG 86-511 8/23 (C-8)

FIGURE B-11

3.4 Ground-water Contamination: (cont'd)

shown in plan view and in cross-section (Fig. B-4 and Plate B-4), (4) the position of maximum mounding and long term driving force for deep leachate penetration, and (5) the position of maximum fluid temperatures (lower fluid viscosity) shown in Figure B-11.

The above factors must be considered in explaining leachate penetration with depth, and particularly the presence of leachate contamination in the gravel aquifer at the northeast side of the landfill (Plate B-5). This cross-section shows that leachate contaminated groundwater has penetrated to more than 40 feet below sea level on each side of the landfill (wells D4B and D8A). In each case, a considerable thickness (45 and 32 feet) of low permeability overbank sediment failed to provide protection. These wells and other wells in the -17 to -44 elevation range, exhibit elevated temperatures, ammonia-nitrogen, chloride, hardness, and nuisance metals typical of leachate, and in some instances, priority pollutant organic compounds.

Average data values for selected indicators from all monitoring wells in the DEQ data base (Table B-3, Appendix), have been summarized in Table B-1 and plotted versus elevation of screen bottom to show variations with depth. The parameters include electrical conductance (Fig. B-12), ammonia-nitrogen [NH_3-N] (Fig. B-13), chloride [Cl^-] (Fig. B-14), and temperature (Fig. B-15).

A general trend can be observed in each figure showing high concentrations of dissolved ions and leachate contamination within the saturated garbage mass down to within plus or minus a few feet of sea level. The magnitude of contamination gradually decreases with depth but is still above background levels in several wells penetrating as deep as -80 feet elevation. All plots show that along the Landfill perimeter, leachate has penetrated into the underlying clayey silts to more than 40 feet below sea level. At several sites, the leachate contaminated ground water has penetrated the fine-grained overbank deposits and entered the Pleistocene gravel aquifer

TABLE 1. ST. JOHN'S LANDFILL MONITORING WELL CONSTRUCTION SPECIFICATIONS AND AVERAGE GEOCHEMICAL DATA FOR SELECTED CONSTITUENT!

UPDATED 12/08/86 COMPILED BY DAVID G. LIVERMORE, 1986, SHANNON & WILSON, INC.

WELL OR PIEZ. NUMBER	REF PT ELEV. (FEET)	DIAM & DEPTH (IN*FT)	SCREEN INTERVAL DEPTH (FEET)	SCREEN PACK (FEET)	SCREEN LENGTH (FEET)	ELEV OF SCREEN BOTTOM	MATERIAL AT SCREEN	<---2/13/86--- S.W.L. (FEET)	---> S.W.L. ELEV. (FEET)	<------AVERAGE TEMP (C)	(1977-86) LAB COND (umhos/ cm)	NH3-N TOTAL (mg/L)	-------> CL (mg/L)
A1H SHAL	66.23	2*	--	3.5	~2.5	+20.6	GARBAGE	16.60	49.63	--	3745	141.00	339
A1L DEEP	66.23	2*	--	3.5	2.5	+6.6	GARBAGE	--	--	--	5760	290.00	272
A2H SHAL	63.28	2*	--	3.5	~2.5	+20.7	GARBAGE	--	--	--	4723	297.33	469
A2L DEEP	63.28	2*	--	3.5	2.5	+6.7	GARBAGE	--	--	--	4324	215.90	545
A3H SHAL	59.80	2*	--	3.5	~2.5	+18.8	GARBAGE	--	--	--	5984	306.50	598
A3L DEEP	59.80	2*	--	3.5	2.5	+4.8	GARBAGE	--	--	--	6710	792.00	717
A4	62.26	2*	--	3.5	--	+20.6	OIL SUMP	19.70	42.56	--	--	--	--
B1	56.53	3*	--	21	19	+0.50	GARBAGE	7.90	48.63	--	7256	360.98	1040
B2	69.33	3*	--	21	19	+6.00	GARBAGE\CLAY	19.30	50.03	--	8621	460.64	1531
B3	36.73	3*	--	21	19	-1.20	GARBAGE\CLAY	--	--	20.5	5275	335.57	516
B4	60.73	3*	--	21	19	+0.30	GARBAGE\CLAY	14.60	46.13	--	8320	539.17	1244
B5	31.70	3*	--	21	19	-10.70	SILTY CLAY	--	--	18.7	4351	132.00	543
B6	15.75	3*	--	21	19	-9.80	CLAY\SAND	7.20	8.55	11.8	504	22.42	13
C1	39.88	2*	--	--	3	+3.30	?	30.46	9.42	16.7	3700	196.33	389
C2	25.63	2*	--	--	3	+1.80	?	13.15	12.48	16.3	5374	152.93	969
C3	21.30	2*	--	--	3	+1.50	?	8.70	12.60	11.6	1970	11.59	193
C4	--	2*	--	--	3	-0.9	?	--	--	--	918	20.00	8
C5	18.71	2*	--	--	3	-5.30	?	9.30	9.41	13.3	420	3.67	12
D-1A	27.02	3*38	28-38	12	10	-10.98	CLAY	19.60	7.42	14.6	1545	6.38	164
D-1B	27.54	3*68	58-68	12	10	-40.46	CLAY	17.20	10.34	14.5	1038	12.92	41
D-1C	27.22	3*109	88-108	23	20	-80.78	CLAY\SILT	17.00	10.22	14.3	625	9.48	11
D-2A	26.82	3*41	31-41	12	10	-14.18	CLAY	10.50	16.32	12.2	845	16.47	32
D-2B	27.43	3*71	61-71	12	10	-43.57	SILT	15.40	12.03	10.8	844	15.58	16
D-3A	37.46	3*49	39-49	12	10	-11.54	CLAY	25.60	11.86	18.7	3467	141.61	289
D-3B	37.96	3*88	70-80	12	10	-42.04	SILTY CLAY	26.55	11.41	18.5	1340	41.03	161
D-4A	23.15	3*31	21-31	10	10	-7.85	SILTY CLAY	11.80	11.35	16.8	1077	18.47	39
D-4B	22.92	3*61	51-61	12	10	-38.08	SILTY CLAY	10.11	12.81	17.4	669	12.20	11
D-5A	31.27	3*41	31-41	12	10	-9.73	CLAY	18.20	13.07	16.7	2532	8.78	309
D-5B	31.58	3*71	61-71	12	10	-39.42	SILTY CLAY	21.80	9.78	17.4	796	7.37	4
D-6A	30.04	3*40	30-40	12	10	-9.96	CLAY	19.40	10.64	12.4	688	4.22	4
D-6B	30.44	3*61	51-61	11	10	-30.56	CLAY	20.20	10.24	12.6	335	4.79	3
D-6C	30.36	3*110	90-110	22	20	-79.64	SAND & GRAVEL	21.20	9.16	12.4	315	0.07	8
D-7A	29.50	3*57	47-57	12	10	-27.50	SILT & SAND	20.10	9.40	13.3	320	0.27	8
D-8A	33.79	3*71	66-71	6	5	-37.21	SAND & GRAVEL	23.50	10.29	16.2	4254	281.58	425
E1L SHAL	--	2*31	29.5-31	9	1.5	-14.80	SANDY SILT	--	--	14.0	525	10.32	19
E1H DEEP	--	2*45	43.5-45	7	1.5	-28.80	SANDY SILT	--	--	14.7	515	1.32	13
E2L SHAL	31.01	2*31	29.5-31	7	1.5	-14.43	SANDY SILT	21.00	10.01	13.9	569	1.09	13
E2H DEEP	31.27	2*98	96.5-98	50	1.5	-81.43	GRAVEL	21.40	9.87	13.4	620	3.95	11
F1	16.36	3*27	25.5-27	5	1.5	-14.92	SANDY SILT	6.10	10.26	13.4	221	2.22	6
EPA-B	56.08	2*50	40-50	21.5	10	+6.08	GARBAGE	30.72	25.36	36.0	9500	--	--
EPA-O	59.27	2*58	48-58	22	10	+1.27	GARBAGE	37.17	22.10	26.0	5500	--	--
EPA-P	60.27	2*58	48-58	22	10	+2.27	GARBAGE	17.00	43.27	--	--	--	--
EPA-Q	67.63	2*60	53-63	22	10	+4.63	GARBAGE	19.33	48.30	35.0	1200	--	--
EPA-R	45.74	2*48	38-48	22	10	-2.26	CLAYEY SILT	29.31	16.43	23.0	4300	--	--

NOTES: Elevations of EPA well casings are from Pg. 46 of EPA dioxin study (1986;TDD R10-8410-13).
Well EPA-O elevation from R E Meyer Consulatants Survey (11/11/85).
Groundwater samples and static water levels of EPA wells measured on 8-15-85.
Reported depths of E & F wells were measured from the original ground surface. Current well depths may differ.
Measuring point elevations referenced to City of Portland Datum.

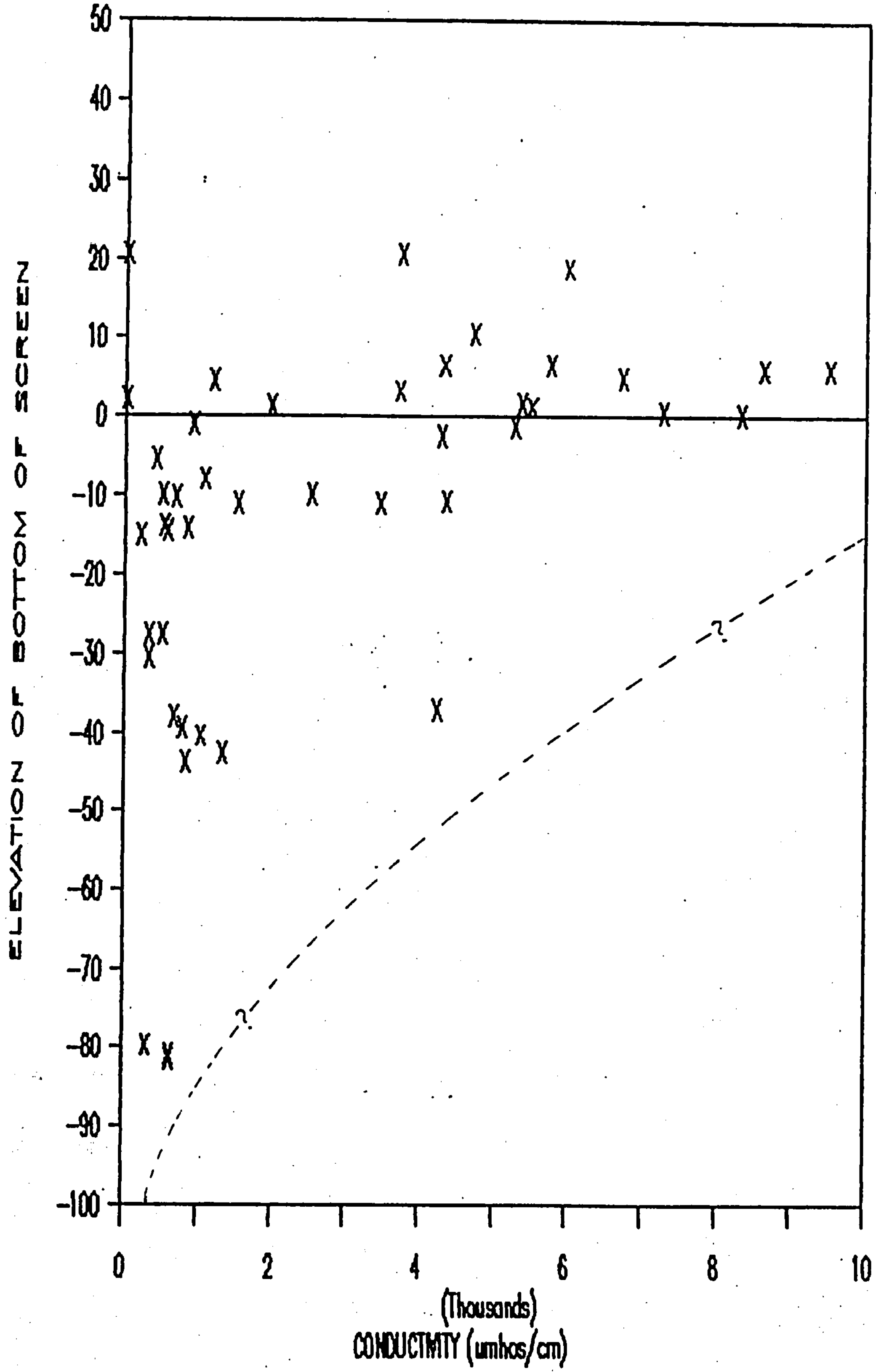


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FIGURE B-12

SCREEN ELEVATION VS FLUID ELECTRICAL
CONDUCTIVITY AT ST. JOHNS LANDFILL

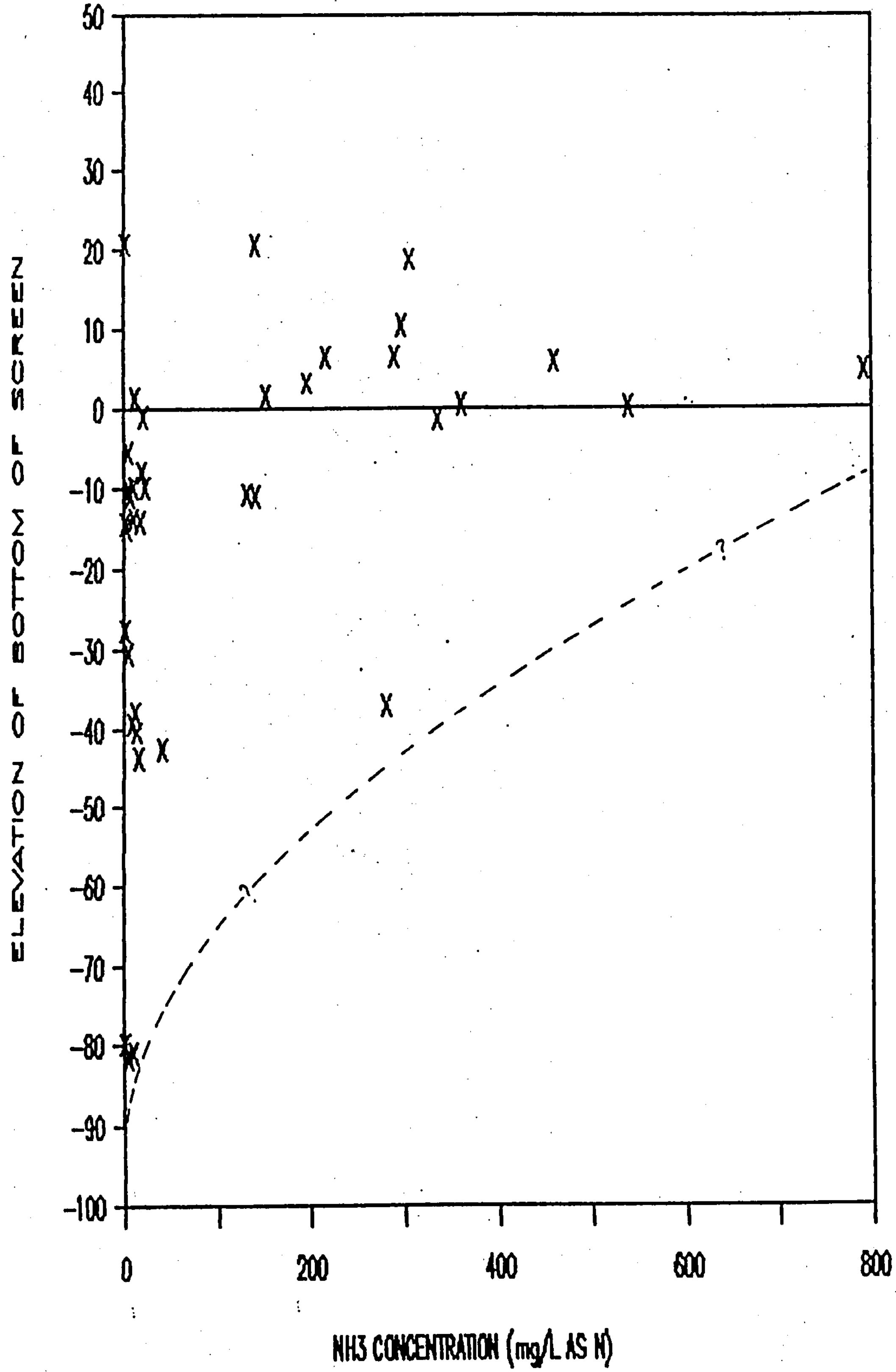

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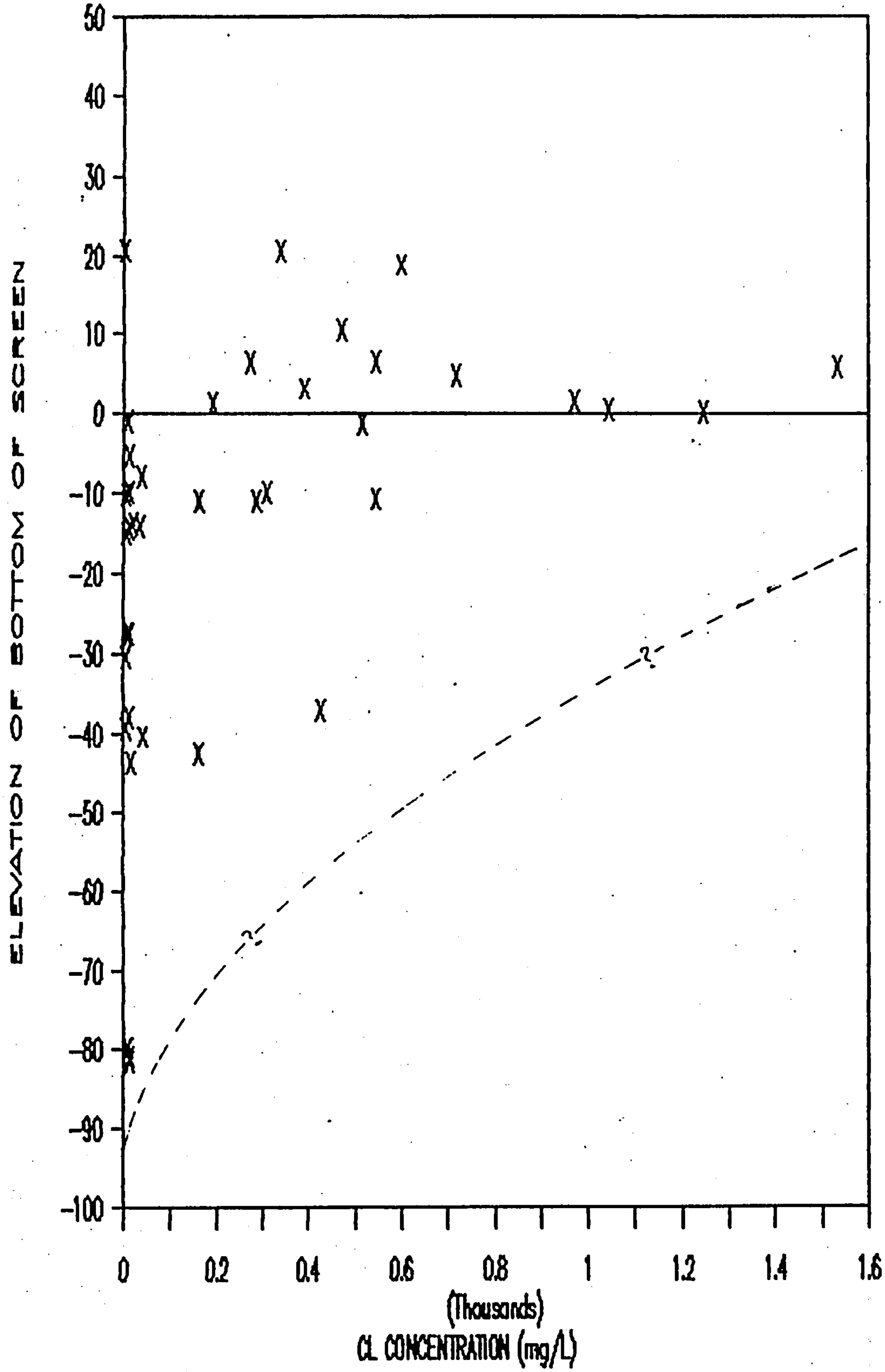
FIGURE B-13

SCREEN ELEVATION VS AMMONIA-NITROGEN
CONCENTRATION AT ST. JOHNS LANDFILL



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ENVIRONMENTAL STUDIES

FIGURE B-14

SCREEN ELEVATION VS CHLORIDE
CONCENTRATION AT ST. JOHNS LANDFILL

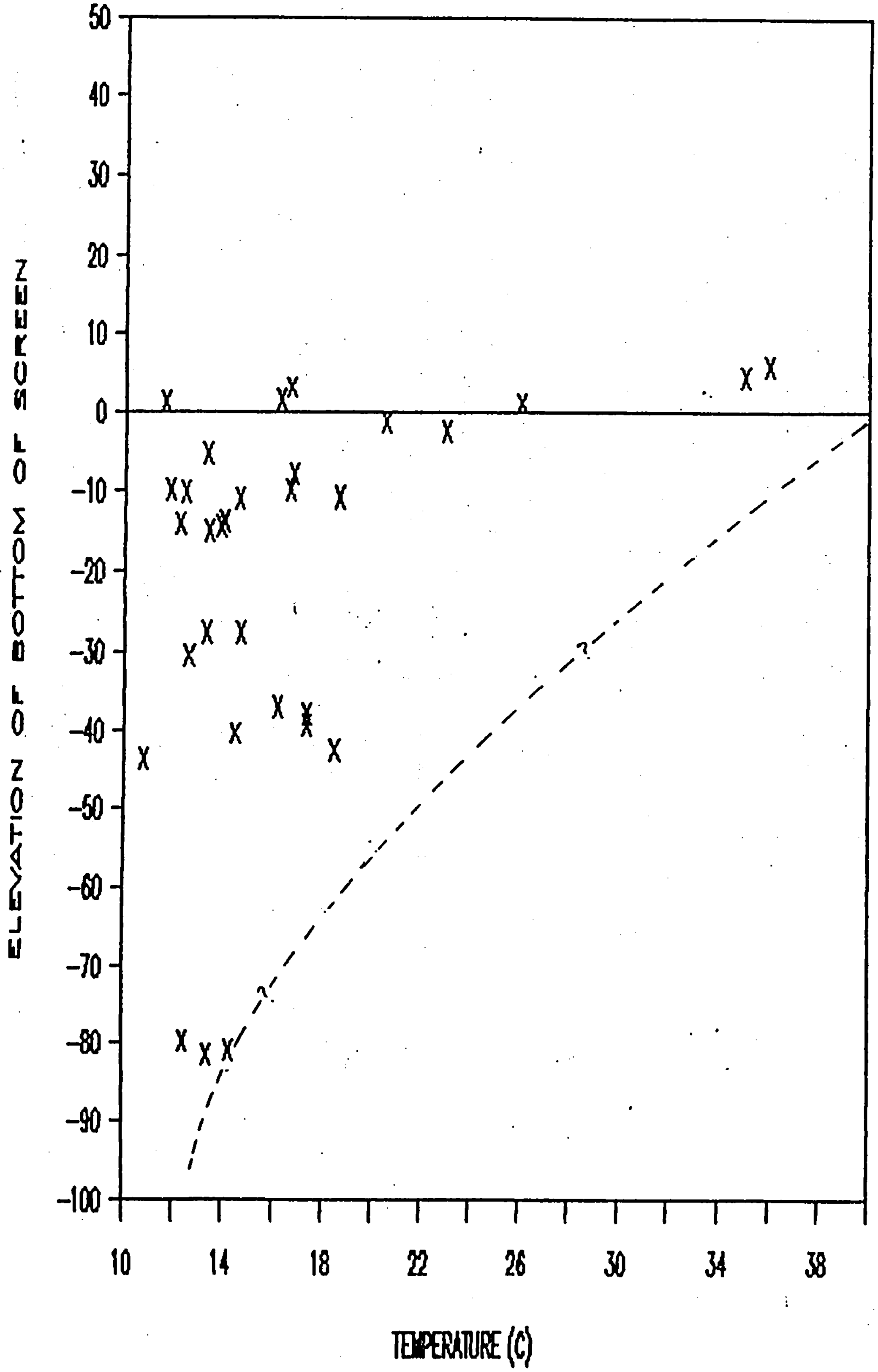

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FIGURE B-15

SCREEN ELEVATION VS FLUID TEMPERATURE
AT ST. JOHNS LANDFILL

3.4 Ground-water Contamination: (cont'd)

(wells D8A and E2H deep). Well D8A (Table B-1), which is screened in the gravel along the northeast side of the landfill (-32 to -37 feet elevation), has an average conductivity of 4,300 micromhos/cm, ammonia-nitrogen 282 mg/1, chloride 425 mg/1, and temperature 17°C. Well E2H-deep, also located on the northeast side of the landfill about 1500 feet upstream from D8A, shows only a marginal degree of leachate contamination; however, the short screen on this piezometer is implanted about 50 feet below the top of the gravel aquifer (-81 feet elevation), and very close to uncontaminated fresh ground water. Therefore, higher levels of contamination would be expected closer to the top of the gravel aquifer near E2H-deep.

The lack of any deep monitoring wells (screens deeper than -2 elevation) in the interior of the landfill, shows that the vertical data profiles are strongly biased by data from perimeter wells. It can be assumed, however, that interior deep monitoring wells would show even stronger evidence of leachate penetration than equivalent depth perimeter wells. If an unlimited number of data points were available for all depths within and below the landfill, the boundary of the data envelope using non-averged data, might appear as shown by the dashed line on each profile plot (Figs. B-12 through B-15). In other words, if deep monitoring wells were drilled centrally located within the landfill interior, one might expect from the data envelope to find significant zones of leachate contamination to depths of more than 60 feet below sea level.

Analyses for priority pollutant organic compounds in ground water have been made at 10 onsite perimeter monitoring wells by DEQ in 1985; numerous organic compounds within the garbage and leachate were identified also by Ecology and Environment, Inc. (1986), to which the reader is referred for a detailed discussion. The DEQ results are summarized in Table B-2. This table shows that organic compounds have penetrated to depths of about 40 feet below sea level in two wells, one of which is in the Pleistocene gravel aquifer (well D8A, Plate B-5).

Section 3: GROUND-WATER HYDROLOGY (cont'd)

3.4 Ground-water Contamination: (cont'd)

TABLE B-2 Summary of GC/MS analyses for Organic Priority Pollutant Extractables in ground-water at St. Johns Landfill, 1985.

Well No. (Bottom Screen Elevation)	Priority Pollutants		Other Organic Compounds Identified Micrograms/liter	Most Persistent Priority Pollutant
	No.of Organic Compounds	Total Micrograms/liter		
C 3 (+1.5)	2	2	ND	Dichlorobenzene
D1A (-11)	ND	ND	ND	--------
D1B (-40)	ND	ND	ND	-------
D1C (-81)	ND	ND	ND	--------
D8A (-37)	1	7	ND	Dichlorobenzene
B3 (-1)	5	61	140	Dichlorobenzene
D2A (-14)	3	24	ND	Naphthalene
D2B (-44)	4	27	ND	Naphthalene
D3A (-11)	3	38	70	Dichlorobenzene
D3B (-43)	ND	ND	ND	-------

It is noteworthy that dichlorobenzene and naphthalene were detected so frequently. These compounds are highly soluble and persistent under anerobic conditions, however, and might be good indicators of offsite leachate contamination of ground water.

The leachate penetration of about 40 feet of fine grained overbank sediments in 30 to 50 years, clearly demonstrates that given enough time and inducement to move, contaminants can migrate considerable distances through low permeability soils. Pathways of least resistance will be followed

Section 3: GROUND-WATER HYDROLOGY (cont'd)

3.4 Ground-water Contamination: (cont'd)

also, resulting in springs and seeps at the edges of the landfill, or subsurface escape through buried sand channels.

Contaminant escape routes from St. Johns Landfill are not restricted only to the sloughs as shown by several lines of evidence presented in this report. These conclusions differ from those of the National Dioxin Study by Ecology and Environment, Inc. (1986). That study concluded generally that downward migration of contaminants to water supplies of the "Troutdale Formation" is prevented and exposure mechanisms are not present. The dioxin study was aimed at locating 5,000 55-gallon drums of chemical residues (possibly contaminated by dioxin), from the Rhone-Poulenc Chemical Plant (formerly Rhodia, Inc.). The drums were buried at the Landfill between 1958 and 1962. The target zone for ground-water sampling apparently was a narrow zone at the base of the garbage near sea level (Table B-1 and Well EPA-P, Plate B-5). This zone is a suitable search horizon but the dioxin study did not account for the possibility that the 1958-62 leachate fluids would have penetrated to much deeper levels by 1985. Perhaps the upwelling concept of ground-water flow previously discussed, influenced the selection of fluid sampling zones for the dioxin study. While it is possible that dioxin contaminated wastes at St. Johns Landfill may not escape, the basis for that conclusion cannot be supported by our findings nor those of the dioxin study. The search for dioxins should encompass a much broader depth range and bracket a 30 year ground-water transport zone.

Section 4: GROUND-WATER MITIGATION MEASURES

Existing and potential ground-water contamination sources pose an environmental threat to the Smith-Bybee Lakes Region. These include (1) long term leachate migration from St. Johns Landfill via the sloughs, the sand and gravel aquifer, and/or buried sand channels within the overbank sediments, and (2) existing chemical wastes or future spills in the Rivergate sand fill. Over long periods of time, even small sources of contamination from a variety of sources including surface water, may become additive and build-up to unacceptable levels in the lakes and wetlands.

In the case of St. Johns Landfill, only limited measures can be taken now to limit offsite migration of leachate contaminated ground water. Mitigation measures would almost certainly require the long term use of leachate extraction wells. These could be placed at key locations in the main Pleistocene aquifer along the northeast edge of the Landfill near North Slough (Plate B-1). A properly designed extraction system in this area could intercept leachate at a shallow depth with the lowest pumping costs. Some attempt should also be made to extract leachate from sand channels buried within the overbank sediments below the garbage (Boring 9, Plate B-1, for example). Sand beds below the garbage mass could be used as a natural leachate collecting system if low fluid pressures are maintained in the sand by pumping. Possible escape routes for leachate migration via sand channels would also be eliminated.

Before instituting ground-water control measures, an effective network of offsite monitoring wells in the wetlands should be installed to map the extent of leachate contamination from St. Johns Landfill into the Pleistocene gravel aquifer. At least 30 to 50 years have passed without checking for contaminant migration offsite. We have presented evidence (Plate B-5), which suggests that migration of leachate contamination offsite has probably occurred.

A ground-water monitoring network should also be established within the Rivergate sand fill areas bordering the wetlands to establish background water quality data. This network could help protect the client's interests in establishing future liability claims.

Strict controls on waste disposal and spill prevention are essential throughout the wetlands area particularily in the North Suttle Road

Section 4: GROUND-WATER MITIGATION MEASURES (cont'd)

industrial area, where the project team identified active contaminant flow into the wetlands on December 5 and 8, 1986. Special control measures and a more complete investigation of that area will be needed to restrict the migration of contaminants.

Fresh ground water in the Pleistocene gravel aquifer could be used as a supplemental supply for maintaining stage, and for flushing Smith and Bybee Lakes during low flow periods. The prolific nature of the Pleistocene gravel aquifer would allow economical pumping at almost any desired pumping rate. One or two wells could be located at the upstream end of Smith Lake where the top of gravel is about 60 to 80 feet below sea level (Plate B-3). Water sources here could provide very effective flushing of both Lakes. Perhaps the present stage control structure at North Slough, near the Landfill, could be complimented with another control downstream on Bybee Lake at Columbia Slough. Leachate access to the wetlands via North Slough would be reduced during rising flood stage, by allowing floodwaters to pass only through the Bybee Lake control. Both control structures could then be used for outflow adjustments during flushing.

Section 5: FINDINGS AND RECOMMENDATIONS

5.1 Findings

1. The wetlands containing Smith-Bybee Lakes and St. Johns Landfill are underlain by fine-grained overbank sediments that thin out against an elongate mound of Pleistocene gravel that rises to the floor of Bybee Lake.

2. The northwest part of Bybee Lake appears to be separated from the underlying Pleistocene gravel aquifer by less than 5 to 30 feet of overbank sediments, whereas Smith Lake is separated from the gravel aquifer by 50 to 70 feet of overbank sediments.

Section 5: FINDINGS AND RECOMMENDATIONS (cont'd)

5.1 Findings (cont'd)

3. Along the northeast one-third of St. Johns Landfill, overbank deposits are less than 40 feet thick, and are too thin to provide long term containment of leachate. Overbank deposits range from 40 feet to more than 80 feet thick beneath the remaining two-thirds of the landfill.

4. The Pleistocene gravel aquifer beneath the Smith-Bybee wetlands and St. Johns Landfill originated as a catastrophic flood deposit 18,000 to 20,000 years ago, and it occupies parts of a buried canyon of the Columbia River, 300 to 600 feet deep between the Columbia River Gorge and the Trojan Nuclear Power Plant.

5. The Columbia River channel is the main outflow boundary for ground water in the Pleistocene gravels and sands underlying the wetlands and the intervening overbank sediments. Changes in River stage are quickly transmitted throughout the permeable deposits beneath the wetlands, causing complex changes in pressure gradients and flow directions, particularly during major flood events each year.

6. During typical years in which a major flood event occurs on the Columbia River in summer, elevated ground-water pressures in the permeable deposits lag behind the faster falling River stage and provide upward leakage into the wetlands during July and August. Apparently little exchange of water occurs during other times of the year because of minor head differences.

7. Leachate mounding within St. Johns Landfill to elevations of 40 to 50 feet, acts as a continuous driving force for seeps and springs at lower elevation, and deep penetration of leachate contaminated ground water into overbank sediments and the Pleistocene gravel aquifer.

Section 5: **FINDINGS AND RECOMMENDATIONS** (cont'd)

5.1 Findings (cont'd)

8. Perimeter monitoring wells at St. Johns Landfill show that leachate has penetrated about 40 feet of fine-grained overbank sediments in 30 to 50 years, a clear demonstration that given enough time and inducement to move, contaminants can migrate considerable distances through low permeability soils.

9. Leachate has penetrated the overbank deposits and entered the Pleistocene gravel aquifer at the northeast side of St. Johns Landfill. Monitoring wells are not available to evaluate the extent of offsite plume development beneath the adjacent wetlands. Wetland water quality, however, is unlikely to be affected significantly in the event of leachate plume development within the gravel aquifer beneath Bybee Lake.

10. Recent dioxin investigators at St. Johns Landfill did not recognize the extent of deep leachate penetration and escape routes for offsite migration of contaminants. Dioxin and leachate contaminated ground water would have penetrated to much deeper levels over a 26 year period (1960-85) than the targeted search horizon at the base of the garbage. The general conclusions of the National Dioxin study that downward migration of contaminants is prevented, and exposure mechanisms are not present, therefore cannot be supported by our findings.

11. Slight ground-water mounding has occurred in the dredged sand fill riming the wetlands. At the North Suttle Road industrial area, chemical contaminants previously identified in ground water (DDT, chlordane, herbicides, and volatile organics), appear to have access to Smith-Bybee Lakes in addition to North Portland Harbor because of ground-water mounding.

12. The project team has apparently identified a new source of ground-water and surface-water contamination near a culvert draining the North

Section 5: FINDINGS AND RECOMMENDATIONS (cont'd)

5.1 Findings (cont'd)

Suttle Road industrial area. Analysis of springs and seeps discharging from the sand fill into the wetlands shows the contaminant is a brackish, ammonia-nitrogen based alkaline solution with a high specific gravity.

13. Existing and potential ground-water contamination sources from St. Johns Landfill and the industrial fill areas could pose a long term environmental threat to the Smith-Bybee Lakes Region.

14. Ground-water protection measures might require the use of leachate extraction wells at St. Johns Landfill, imposition of strict controls on waste disposal and spill prevention, and a more complete investigation of the North Suttle Road industrial area.

15. Fresh ground water in the highly productive Pleistocene gravel aquifer could be tapped by one or two wells at the upstream end of Smith Lake, for use in maintaining stage and flushing both Lakes during low flow periods. In conjunction with a control structure on Bybee Lake, leachate access to the wetlands via North Slough could be reduced substantially.

5.2 Recommendations

1. Measures should be taken to contain contaminants now entering Smith Lake from the North Suttle Road industrial area. A long term ground water and surface water monitoring network should be established in this area.

2. Additional monitoring wells should be installed in the wetlands between St. Johns Landfill and Bybee Lake in order to map leachate contamination of ground water in the Pleistocene gravel aquifer.

Section 5: FINDINGS AND RECOMMENDATIONS (cont'd)

5.1 Recommendations (cont's)

3. Deeper monitoring wells located in the interior of St. Johns Landfill would be beneficial in measuring depth of penetration of leachate directly beneath the landfill.

4. All monitoring well casings at St. Johns Landfill should be checked periodically for casing integrity down to the top of screen, and necessary repairs accomplished to prevent possible short-circuiting of contaminants to deeper aquifers.

5. Several key monitoring sites should be checked comprehensively on a long term basis at least every 2 years for various contaminants, including dioxin near St. Johns Landfill, and DDT near the North Suttle Road industrial area.

6. Some effort should be made to restrict the entrance of degraded water in Columbia and North Sloughs from entering the wetlands during rising flood stage. This could be accomplished by adding a stage control structure in Bybee Lake, along with a supplemental source of groundwater for flushing at the upstream end of Smith Lake.

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Section 6: REFERENCES CITED

Bretz, J.H., 1925. The Spokane flood beyond the channeled scablands; pt. 2. Journal of Geology, v.33, no. 3, p. 236-259.

CH2M Hill, 1979, St. Johns Landfill Expansion Conceptual Design and Operational plan, Phase I, 102 p.

Dames & Moore, 1962, Report of Foundation Investigation and Land Development Consultation, Rivergate Area, Portland, Oregon, 14 p.

Dames & Moore, 1969, Soils Investigation and Settlement Study Northerly portion of the Rivergate Area, Portland, Oregon, 13 p.

Ecology & Environment, Inc., 1984, Field Investigations of Groundwater and Sediments Adjacent to the Stauffer Chemical Company, Portland, Oregon. TDD R10-8308-03; TDD R10-8308-03A, 16 p.

Ecology & Environment, Inc., 1986, Final Report St. John's Landfill National Dioxin Study, Portland, Oregon. TDD R10-8410-13.

Fishman Environmental Services, 1985. Smith and Bybee Lakes Baseline Data Report. [for the Port of Portland], 52 p.

Fishman Environmental Services, 1986, Smith and Bybee Lakes Environmental Studies, Preliminary Data [for the Port of Portland].

Luzier Hydrosciences, 1985, Environmental Consequences of Ground-water Contamination near the Portland Well Field: A Preliminary Evaluation, December 1984, 24 p.

Luzier and Willis, In Review, Hydrogeology and Computer Modeling of Pliocene Bedrock Aquifers in the vicinity of the Portland Oregon Wellfield, 28 p.

Section 6: REFERENCES CITED (cont'd)

McFarland, W.D., Luzier, J.E. and Willis, R.F., 1982, Hydrogeology and simulation modeling of the Portland Well Field, Portland, Oregon: American Geophysical Union poster session, San Francisco, CA, December 10, 1982.

Scientific Resources, Inc., 1986, Smith and Bybee Lake Area fall-winter Data Collection. Fishman Environmental Services for Port of Portland, 17 p.

Stauffer Chemical Company, 1981, Letter Report to Mr. Bob Stamnes of U.S. EPA from J.Y. Wiseman, Environmental Control-West, dated March 11, 1981.

Stevens, Thompson & Runyan, Inc., 1972, Final Report; Portland Sanitary Landfill Hydrogeological Studies, 14 p.

Stevens, Thompson & Runyan, Inc., 1974, Leachate Monitoring Report For the St. John's Landfill, 1972-74, 86p.

Sweet, Edwards and Associates, Inc., 1983, METRO/St. John's Sanitary Landfill Water Quality Study. 42 p.

Willis, R.F., 1977, A report on the Ground Water Exploratory Program for the Bureau of Water Works, Portland, Oregon: in-house document, 287 p.

Willis, R.F., 1978, A report on the Ground Water Development Program - Pilot Well Study for the Bureau of Water Works, Portland, Oregon: in-house document, 150 p.

Section 7: APPENDIX

CONTENTS:

LOTUS FILE: STJOHN.WK1 UPDATED 12/11/86

COMPILED BY DAVID G. LIVERMORE, SHANNON & WILSON, 1986.

WELL ID	DATE OF SAMPLE	SAMPLER	M.P. ELEV. (1,4) Feet	S.W.L. (2) Feet	ELEV. S.W.L. (3) Feet	TEMP C	pH FIELD	pH LAB	COND. FIELD umhos /cm	COND. LAB umhos /cm	CALC. HARD. mg/l	LAB ALK as CaCO3 mg/l	DISSOLVED CL- mg/l	SO4-2 mg/l	Fe mg/l	Ca mg/l	Mg mg/l	Na mg/l	K mg/l	Zn mg/l	Mn mg/l	COD mg/l	TOC as C mg/l	NH3-N TOTAL mg/l	NO3+ NO2-N mg/l
A1H	09/24/74	DEQ	--	23.50	42.73			7.6		4080	359.5	1270	219.0	10.0		44.4	54.4	200	0.12	0.04	<0.03	324		180.00	
(SH)	03/05/80	METRO	--	--	--			7.8		3410		1160	459.0									316		182.00	
	02/13/86	CH2M	66.23	16.60	49.63																				
	08/05/86	CH2M	66.23	--	--																				
A1L	09/24/74	DEQ	66.23	22.00	44.23			7.7		5760	425.6	1920	271.9	36.6		76.0	50.4	284	240	0.17	0.10	2290		290.00	
A2H	09/24/74	DEQ	--	21.00	42.28			8.2		6240	272.7	2090	456.1	26.9		34.4	47.0	420	305	0.11	<0.03	399		350.00	
	11/07/79	METRO	--	--	--			7.8		3250	220	1487.	430.0									241		230.00	
	03/05/80	METRO	63.28	--	--			8.1		4680		1710	520.0									514		312.00	
A2L	09/24/74	DEQ	--	19.00	44.28			8.0		4320	343	1450	228.1	16.0		48.8	47.6	210	204	0.09	<0.03	326		225.00	
	11/07/79	METRO	--	--	--			7.8		3320	253	741	535.0									201		62.50	
	03/05/80	METRO	--	--	--			7.8		4980		1610	800.0									473		184.00	
	04/16/80	METRO	--	--	--			7.6		4000		1650	560.0									380		274.00	
	05/28/80	METRO	63.28	36.00	27.28			7.6		5800		1620	600.0									334		334.00	
A3H	09/24/74	DEQ	--	18.00	41.80			8.3		7920	450.4	2100	631.6	32.1		22.0	78.8	494	414	0.4	0.05	600		240.00	
	02/10/77	DEQ	59.80	--	--			7.5		4048	434	1590	565.0	<1.0		75.0	60.0	407	145			335		373.00	1.60
A3L	02/10/77	DEQ	59.80	--	--			7.7		6710	343	3020	717.0	100.0		47.0	55.0	337	340			310		792.00	40.00
A4	02/13/86	CH2M	62.26	19.7	42.56																				
	08/05/86	CH2M	62.26	--	--																				
B1	09/24/74	DEQ	--	19.50	37.03			7.9		10320	487.6	2980	1052.6	31.3		40.0	92.0	840	455	0.05	<0.03	666		480.00	
	11/07/79	METRO	--	--	--			7.9		3020	876	1057	394.0									275		81.80	
	03/05/80	METRO	--	--	--			8.3		6400		1670	1240.0									356		292.00	
	04/16/80	METRO	--	--	--			8.3		6500		1650	970.0									454		372.00	
	05/28/80	METRO	--	30.00	26.53			8.2		7000		1800	1200.0									418		435.00	
	10/07/80	METRO	--	31.00	25.53			8.1		7900		2432	1260.0									565		467.00	
	11/18/80	METRO	--	31.00	25.53			7.9		8200		2470	1120.0									680		415.00	
	01/06/81	METRO	--	29.00	27.53			8.0		7800		2430	1140.0									475		420.00	
	02/03/81	METRO	--	--	--			7.9		8200		2410	1120.0									460		362.00	
	03/03/81	METRO	--	--	--			8.0		7800		2344	880.0									512		390.00	
	05/05/81	METRO	--	30.30	26.23			8.0		6600		2150	1040.0									480		256.00	
	02/13/86	CH2M	56.53	7.9	48.63																				
	08/05/86	CH2M	56.53	8.76	47.77																				
B2	09/24/74	DEQ	--	16.00	53.33			7.2		4200	851.2	1450	302.6	16.0		78.4	142.0	226	112	0.03	<0.03	532		135.00	
	10/10/79	METRO	--	--	--			7.1		1800	1896	2240	1680.0									575		191.00	
	11/07/79	METRO	--	--	--			7.2		8070	1790	2380	1630.0									578		242.00	
	03/05/80	METRO	--	--	--			7.4		6800		1930	1460.0									730		411.00	
	04/16/80	METRO	--	--	--			7.4		8550		2470	1440.0									944		384.00	
	05/28/80	METRO	--	29.50	39.83			7.4		9910		2940	1790.0									850		408.00	
	11/18/80	METRO	--	29.00	40.33			7.3		11000		3170	1800.0									930		600.00	
	01/06/81	METRO	--	27.00	42.33			7.3		10000		3340	1660.0									1010		580.00	
	02/03/81	METRO	--	--	--			7.3		11500		3320	1860.0									950		640.00	
	03/03/81	METRO	--	--	--			7.6		10200		3471	1484.0									980		692.00	
	05/05/81	METRO	--	31.00	38.33			8.0		12000		4040	1720.0									1350		784.00	
	02/13/86	CH2M	69.33	19.30	50.03																				
	08/05/86	CH2M	69.33	33.90	35.43																				

DATA BASE HAS NOT BEEN CHECKED FOR ACCURACY WITH ORIGINAL DATA FORMS.

TABLE B-3. ST JOHNS LANDFILL GROUNDWATER QUALITY DATA BASE, 9/74 THROUGH 8/86, MONITORING WELLS A1H THROUGH F1 (STORET NOS. STJOHN15 THROUGH STJOHN52); FROM DEQ WELL DATA BASE (THROUGH 5/85) AND RECENT ANALYSES.

LOTUS FILE: STJOHN.WK1 UPDATED 12/11/86

COMPILED BY DAVID G. LIVERMORE, SHANNON & WILSON, 1986.

WELL ID	DATE OF SAMPLE	SAMPLER	M.P. ELEV. (1,4) Feet	S.W.L. (2) Feet	ELEV. S.W.L. (3) Feet	TEMP C	pH FIELD	pH LAB	COND. FIELD umhos /cm	COND. LAB umhos /cm	CALC. HARD. mg/l	LAB ALK as CaCO3 mg/l	DISSOLVED CL- mg/l	SO4-2 mg/l	Fe mg/l	Ca mg/l	Mg mg/l	Na mg/l	K mg/l	Zn mg/l	Mn mg/l	COD mg/l	TOC as C mg/l	NH3-N TOTAL mg/l	NO3+ NO2-N mg/l
B3	09/24/74	DEQ	--	20.00	16.73			7.7		10320	479.3	3190	824.5	42.5		30.0	88.0	665	584	0.06	<0.03	820		480.00	
	02/10/77	DEQ	--	25.30	11.43			7.2		5500	467	2400	696.0	<1.0		77.0	67.0	357	275			570		512.00	0.42
	01/25/78	DEQ	--	13.90	22.83	22.0		7.6		5940	775	3020	860.0	20.0	3.8	34.0	166.0	620	440	0.12	0.14	601	320	590.00	4.80
	12/13/78	DEQ	--	24.00	12.73	19.5		7.6	7200	8200	300	2850	854.0	57.0	2.9	32.0	54.0	624	520	0.1	0.10	566	475	545.00	0.74
	01/09/79	DEQ	--	22.40	14.33	18.0		7.5	7000	8000		2954										453			
	05/02/79	DEQ	--	--	--	20.5		7.6		7150		2750	740.0									428			
	06/19/79	DEQ	--	22.90	13.83	21.5		7.6		6490	382	2080	670.0	11.0	6.4	36.2	68.0	574	426	0.1	0.10	421	110	450.00	
	07/17/79	DEQ	--	23.00	13.73	24.0		7.5	6000	6120		2800	650.0									438			
	08/21/79	DEQ	--	23.80	12.93	23.0		7.5	6000	6240		2525	675.0									445			
	08/26/80	DEQ	--	23.60	13.13			7.8		6000	327	2558	590.0	8.1	2.8							770		393.00	
	07/08/81	METRO	--	17.00	19.73			7.6		5200		2040	589.0									298		375.00	
	10/13/81	METRO	--	18.00	18.73			7.0		2800		1030	288.0									228		160.00	
	02/02/82	METRO	--	14.00	22.73			7.6		5200		1934	559.0											300.00	
	04/06/82	METRO	--	15.00	21.73			7.6		4450		1990	444.0											338.00	
	07/13/82	METRO	--	20.20	16.53			7.3		4600		1890	428.0											250.00	
	10/06/82	METRO	--	--	--			7.4		4500		1920	437.0											342.00	
	01/12/83	METRO	--	--	--			7.2		4600		1790	430.0											4.60	
	04/13/83	DEQ	--	--	--	22.0	7.3	7.7	4770	4990	260	1765	640.0	9.3	1.1	27.0	47.0					240	129	330.00	0.43
	04/13/83	METRO	--	--	--			7.6		4580		1820	396.0											294.00	
	07/14/83	METRO	--	--	--			7.9		4100		1810	336.0											200.00	
	10/06/83	METRO	--	--	--			7.6		4600		1900	500.0											370.00	
	01/27/84	METRO	--	--	--			7.2		3400		1760	385.0											365.00	
	05/15/84	DEQ	--	15.00	21.73	20.0	7.1	7.4	4368	4400	260	1768	370.0	6.5	4.5	25.0	48.0					230	100	380.00	0.04
	06/22/84		--	--	--			7.5		4200		1680	438.0											325.00	
	11/19/84	DEQ	--	13.60	23.13	19.0	7.2	7.4	4026	4200	240	1612	332.0	0.4	8.5	20.0	46.0							290.00	0.11
	QA 11/19		--	--	--	19.0	7.1	7.4	4000	4200	270	1568	326.0	0.4	8.3	20.0	54.0							290.00	0.04
	05/14/85	DEQ	--	16.80	19.93	18.5	7.3	7.3	3538	3700	210	1478	290.0	0.8	9.2	22.0	37.0							260.00	0.44
	09/26/85	DEQ	36.73	18.50	18.23	20.0	7.2	7.4	4001	4100	220	1600	343.0	0.4	6.8	22.0	41.0				0.07	190	93	290.00	0.36
B4	10/07/80	METRO	--	29.00	31.73			7.9		8000		2320	1210.0									572		565.00	
	11/18/80	METRO	--	29.00	31.73			7.8		8400		2120	1300.0									620		565.00	
	01/06/81	METRO	--	27.00	33.73			7.8		8150		2180	1240.0									520		415.00	
	02/03/81	METRO	--	--	--			7.9		8470		2160	1280.0									535		495.00	
	03/03/81	METRO	--	--	--			7.9		8400		2236	1052.0									496		573.00	
	05/05/81	METRO	--	29.00	31.73			8.0		8500		2216	1300.0									501		622.00	
	02/13/86	CH2M	60.73	14.60	46.13																				
	08/05/86	CH2M	60.73	--	--																				
B5	02/10/77	DEQ	--	21.00	10.70			6.8		3685	1000	1610	511.0	<1.0		260.0	86.0	330	130			300		163.00	0.03
	01/25/78	DEQ	--	17.90	13.80			7.0		2730	1083	1400	198.0	6.5	35.0	263.0	85.0	200	90	0.08	8.00	170	80	92.00	4.50
	12/13/78	DEQ	--	19.90	11.80	17.0		7.0	3550	4300	1176	1760	427.0	7.0	12.9	274.0	110.0	326	147	0.1	8.60	240	170	99.00	0.29
	01/09/79	DEQ	--	20.40	11.30	15.0		7.5	3400	4150		1170										215			
	05/02/79	DEQ	--	--	--			7.2		4071		1600	440.0									252			
	07/17/79	DEQ	--	20.00	11.70	19.0		7.0	3750	4230		1600	490.0									304			
	08/21/79	DEQ	--	20.20	11.50	18.5		7.1	3650	4161		1690	550.0									311			
	10/10/79	METRO	--	--	--			7.3		3830	1082	1660	800.0									292		111.00	
	11/07/79	METRO	--	--	--			7.6		4110	1010	1590	520.0									236		80.00	
	03/05/80	METRO	--	--	--			7.7		4250		1660	544.0									330		137.00	
	04/16/80	METRO	--	--	--			7.3		4550		1630	590.0									340		111.00	
	05/28/80	METRO	--	19.00	12.70			7.1		4950		1680	600.0									320		116.00	
	10/07/80	METRO	--	20.00	11.70			7.5		4900		1690	602.0									357		164.00	
	11/18/80	METRO	--	20.00	11.70			7.2		4550		1600	523.0									290		152.00	
	01/06/81	METRO	--	17.00	14.70			7.3		4650		1500	512.0									295		133.00	

TABLE B-3. ST JOHNS LANDFILL GROUNDWATER QUALITY DATA BASE, 9/74 THROUGH 8/86, MONITORING WELLS A1H THROUGH F1 (STORET NOS. STJOHN15 THROUGH STJOHN52); FROM DEQ WELL DATA BASE (THROUGH 5/85) AND RECENT ANALYSES.

LOTUS FILE: STJOHN.WK1 UPDATED 12/11/86

COMPILED BY DAVID G. LIVERMORE, SHANNON & WILSON, 1986.

WELL ID	DATE OF SAMPLE	SAMPLER	M.P. ELEV. (1,4) Feet	S.W.L. (2) Feet	ELEV. S.W.L. (3) Feet	TEMP C	pH FIELD	pH LAB	COND. FIELD umhos /cm	COND. LAB umhos /cm	CALC. HARD. mg/l	LAB ALK as CaCO3 mg/l	DISSOLVED CL- mg/l	DISSOLVED SO4-2 mg/l	DISSOLVED Fe mg/l	DISSOLVED Ca mg/l	DISSOLVED Mg mg/l	DISSOLVED Na mg/l	DISSOLVED K mg/l	DISSOLVED Zn mg/l	DISSOLVED Mn mg/l	COD mg/l	TOC as C mg/l	NH3-N TOTAL mg/l	NO3+ NO2-N mg/l
	02/03/81	METRO	—	19.00	12.70			7.2		4800		1540	560.0									313		164.00	
	11/19/84	DEQ	—	19.60	12.10	18.7	6.9	7.0	5840	5150	750	1750	690.0	1.4	38.0	160.0	85.0					180	145	180.00	<0.02
	05/14/85	DEQ	—	20.10	11.60	20.0	6.8	7.0	4403	4300	790	1564	580.0	1.3	41.0	170.0	88.0					220	121	130.00	<0.02
	09/24/85	DEQ	—	20.42	11.28	23.0	6.8	7.0	4900	5300	770	1760	620.0	0.4	40.0	170.0	83.0				7.50	750	141	140.00	0.02
	08/05/86	CH2M	31.70	—	—																				
B6	02/10/77	DEQ	—	16.50	-0.75			7.1		259	132	164	3.2	6.4		30.0	14.0	7.7	1.4			7		4.00	<0.01
	01/25/78	DEQ	—	13.60	2.15	10.0		6.5		235	119	103	5.0	15.7	13.5	22.0	9.5	7.3	1.5	0.07	0.72	7	11	1.30	1.60
	12/13/78	DEQ	—	14.60	1.15	10.0		6.5	150	210	88	83	5.7	14.0	3.0	10.0	9.0	7.2	1.6	0.1	0.40	8	10	1.96	0.71
	01/09/79	DEQ	—	15.60	0.15	8.5		6.9	170	243		115										<5			
	05/02/79	DEQ	—	—	—	10.0		6.9		255		110	4.0									6			
	06/19/79	DEQ	—	15.90	-0.15	12.0		6.8	230	313	156	149	5.0	11.0	14.0	30.9	12.0	8.7	2.3	<0.05	0.08	9	<1	2.03	0.04
	07/17/79	DEQ	—	16.50	-0.75	14.0		7.0	220	277		126	3.0									11			
	08/21/79	DEQ	—	16.90	-1.15	12.0		7.2	410	537		260	4.0									14			
	10/10/79	METRO	—	—	—			7.7		400	218	260	32.8									10		6.00	
	11/07/79	METRO	—	—	—			7.2		610	231	276	24.0									6		4.30	
	02/06/80	DEQ	—	—	—			7.2		163		83	2.8	3.7	4.7							7		0.35	
	03/05/80	METRO	—	—	—			7.7		275		100	1.0									110		0.30	
	04/16/80	METRO	—	—	—			7.2		190		95	10.6									4		1.00	
	05/28/80	METRO	—	14.00	1.75			7.0		349		110	6.2									15		1.50	
	06/03/81	METRO	—	—	—			7.3		465		240	4.0									16		3.60	
	07/08/81	METRO	—	8.00	7.75			7.0		792		332	21.6									4		7.00	
	08/11/81	METRO	—	7.50	8.25			7.3		590		300	6.7									80		1.60	
	09/15/81	METRO	—	8.00	7.75			7.3		615		300	4.2									20		4.10	
	10/13/81	METRO	—	6.50	9.25			7.2		250		93	11.6									13		26.00	
	11/03/81	METRO	—	7.00	8.75			6.9		505		252	5.4									5		3.40	
	02/02/82	METRO	—	7.50	8.25			7.6		660		330	320.0											120.00	
	03/02/82	METRO	—	7.00	8.75			6.8		630		365	2.4											0.50	
	04/06/82	METRO	—	7.50	8.25			7.3		609		406	10.2											4.60	
	05/04/82	METRO	—	8.20	7.55			6.7		655		420	2.8											6.80	
	06/02/82	METRO	—	8.20	7.55			7.9		690		396	3.4											7.30	
	07/13/82	METRO	—	8.40	7.35			7.1		760		420	5.6											675.00	
	08/04/82	METRO	—	—	—			6.8		750		417	4.6											7.40	
	08/30/82	METRO	—	7.70	8.05			6.6		765		430	3.2											8.20	
	10/06/82	METRO	—	8.70	7.05			6.8		750		362	4.6											4.60	
	11/03/82	METRO	—	—	—			7.1		220		126	4.0											2.00	
	12/10/82	METRO	—	—	—			7.9		515		326	4.4											6.10	
	01/12/83	METRO	—	—	—			6.9		830		420	8.2											8.10	
	02/16/83	METRO	—	—	—			7.3		780		440	3.2											6.80	
	03/18/83	METRO	—	—	—			6.6		820		480	4.3											9.20	
	04/13/83	DEQ	—	—	—	18.5	6.9	7.0	454	440	280	236	4.2	3.6	11.0	44.0	22.0					<5	11	3.40	0.13
	04/13/83	METRO	—	—	—			6.8		800		435	6.1											11.00	
	05/04/83	METRO	—	—	—			7.3		610		433	5.9											7.90	
	06/02/83	METRO	—	—	—			8.2		600		374	3.6											4.30	
	07/14/83	METRO	—	—	—			7.3		610		417	6.8											44.00	
	08/11/83	METRO	—	—	—			7.0		800		450	3.2											7.50	
	09/08/83	METRO	—	—	—			7.2		710		420	9.0											5.80	
	10/06/83	METRO	—	—	—			7.6		350		356	15.0											11.70	
	11/03/83	METRO	—	—	—			6.9		220		110	9.4											1.20	
	12/08/83	METRO	—	—	—			7.2		320		175	13.8											0.10	
	01/27/84	METRO	—	—	—			7.1		410		280	6.8											4.30	
	05/15/84	DEQ	—	6.90	8.85	12.0	6.8	6.8	826	780	390	465	4.3	0.7	31.0	87.0	41.0					22	12	8.30	<0.02
	06/22/84	METRO	—	—	—			7.0		600		350	1.6											1.00	

DATA BASE HAS NOT BEEN CHECKED FOR ACCURACY WITH ORIGINAL DATA FORMS.

TABLE B-3. ST JOHNS LANDFILL GROUNDWATER QUALITY DATA BASE, 9/74 THROUGH 8/86, MONITORING WELLS A1H THROUGH F1 (STORET NOS. STJOHN15 THROUGH STJOHN52); FROM DEQ WELL DATA BASE (THROUGH 5/85) AND RECENT ANALYSES.

LOTUS FILE: STJOHN.WK1 UPDATED 12/11/86

COMPILED BY DAVID G. LIVERMORE, SHANNON & WILSON, 1986.

WELL ID	DATE OF SAMPLE	SAMPLER	M.P. ELEV. (1,4) Feet	S.W.L. (2) Feet	ELEV. S.W.L. (3) Feet	TEMP C	pH FIELD	pH LAB	COND. FIELD umhos /cm	COND. LAB umhos /cm	CALC. HARD. mg/l	LAB ALK as CaCO3 mg/l	DISSOLVED CL- mg/l	SO4-2 mg/l	Fe mg/l	Ca mg/l	Mg mg/l	Na mg/l	K mg/l	Zn mg/l	Mn mg/l	COD mg/l	TOC as C mg/l	NH3-N TOTAL mg/l	NO3+ NO2-N mg/l
	11/19/84	DEQ	—	6.90	8.85	12.0	6.6	6.9	683	611	350	342	4.4	1.0	28.0	76.0	38.0							3.00	<0.02
	05/14/85	DEQ	—	7.10	8.65	11.5	6.8	6.8	139	400	260	186	5.0	0.7	32.0	56.0	28.0							1.69	0.02
	09/26/85	DEQ	15.75	10.83	4.92	16.0	6.3	6.5	179	175	61	55	12.0	11.0	3.9	14.0	6.3				0.49	18	5	0.85	2.70
	02/13/86	CH2M	15.75	7.2	8.55	6.7	6.9	6.8	180	220	97.1	99.5	7.5	2.7	13.6	19.7	9					14	5.62	1.29	<0.01
C1	09/24/74	DEQ	—	26.00	13.88			8.6		4200	545.5	1450	342.1	8.1		20.0	125.0	334	76	0.02	<0.03	318		155.00	
	02/10/77	DEQ	—	28.90	10.98			7.6		2332	402	980	421.0	<1.0		21.0	85.0	222	45			290		115.00	0.10
	01/25/78	DEQ	—	24.70	15.18			7.0		3270	443	1300	508.0	9.6	65.0	116.0	8.2	260	90	0.15	1.72	288	200	220.00	5.20
	12/13/78	DEQ	—	26.00	13.88	14.5		7.4	3350	4300	633	1270	568.0	12.0	47.5	80.0	84.0	295	156	0.1	1.00	260	175	177.00	0.58
	01/09/79	DEQ	—	26.90	12.98	18.0		7.3	3350	3850		1760										302			
	05/02/79	DEQ	—	—	—			7.3		4757		1506	520.0									422			
	06/19/79	DEQ	—	29.40	10.48	16.0		7.3	3150	3900	776	1550	430.0	<1.0	21.0	140.0	94.0	334	174	0.1	1.20	450	115	180.00	1.28
	07/17/79	DEQ	—	26.90	12.98	18.5		7.2	3710	4229		1580	460.0									301			
	08/21/79	DEQ	—	27.00	12.88	16.5		7.3	3600	4284		1620	500.0									259			
	10/10/79	METRO	—	—	—			7.3		3520	615	1480	500.0									155		211.00	
	11/07/79	METRO	—	—	—			7.5		3200	527	1287	352.0									111		156.00	
	02/06/80	DEQ	—	—	—			7.7		2560		456	250.0	1.0	3.6							128		104.00	
	03/05/80	METRO	—	—	—			7.5		2710		931	332.0									164		141.00	
	04/16/80	METRO	—	—	—			7.5		3650		1270	433.0									166		197.00	
	05/28/80	METRO	—	—	—			7.7		2950		940	320.0									18		140.00	
	10/07/80	METRO	—	—	—			7.5		4480		1620	454.0									190		242.00	
	11/18/80	METRO	—	—	—			7.3		4290		1510	534.0									195		248.00	
	01/06/81	METRO	—	—	—			7.3		3150		1230	204.0									135		142.00	
	02/03/81	METRO	—	—	—			7.2		3600		1400	272.0									168		163.00	
	03/03/81	METRO	—	—	—			7.8		3900		1470	243.0									163		205.00	
	05/05/81	METRO	—	—	—			8.1		4100		1460	400.0									169		189.00	
	07/08/81	METRO	—	—	—			7.5		3800		1840	411.0									202		233.00	
	10/13/81	METRO	—	—	—			7.4		4800		1470	360.0									250		200.00	
	02/02/82	METRO	—	—	—			7.7		3750		1490	576.0											172.00	
	04/06/82	METRO	—	—	—			7.7		3400		1520	390.0											192.00	
	07/13/82	METRO	—	—	—			7.6		3800		1470	376.0											285.00	
	10/06/82	METRO	—	—	—			7.4		3700		1410	385.0											220.00	
	01/12/83	METRO	—	—	—			7.5		1200		500	110.0											1.30	
	04/13/83	METRO	—	—	—			7.4		2400		968	340.0											180.00	
	07/14/83	METRO	—	—	—			7.5		3100		1440	360.0											210.00	
	01/27/84	METRO	—	—	—			6.8		2800		1370												222.00	
	05/15/84	DEQ	—	26.40	13.48	18.0	6.8	7.2	3481	3400	500	1224	430.0	2.9	32.0	46.0	92.0					250	99	170.00	0.04
	06/22/84	METRO	—	—	—			7.1		3600		650	480.0											205.00	
	09/26/85	DEQ	—	29.67	10.21	19.5	7.5	7.8	10712	11100		4610			14.0						0.20	2280	569	700.00	0.05
	02/13/86	CH2M	39.88	30.46	9.42	10.2	7.35	7.7	2800	2500	333	1430	196	482	1.2	33.5	42.5					797	163	111	0.02
	05/28/86	DEQ	—	29.60	10.28																				
	08/05/86	CH2M	39.88	29.12	10.76	19.0	7.4		5800																
C2	10/10/79	METRO	—	—	—			7.9		3900	700	1090	1340.0									262		95.00	
	11/07/79	METRO	—	—	—			7.8		5020	760	2439	1220.0									253		80.00	
	03/05/80	METRO	—	—	—			7.9		5240		1550	1112.0									369		130.00	
	04/16/80	METRO	—	—	—			7.8		5150		1510	1040.0									475		137.00	
	07/08/81	METRO	—	—	—			7.5		5580		1610	1070.0									550		162.00	
	10/13/81	METRO	—	12.00	13.63			7.5		5700		1460	1040.0									13		164.00	
	02/02/82	METRO	—	11.00	14.63			7.9		5900		1860	880.0											20.00	
	04/06/82	METRO	—	11.00	14.63			7.5		5100		1880	1040.0											200.00	
	07/13/82	METRO	—	—	—			7.3		4800		2050	840.0											300.00	
	10/06/82	METRO	—	11.80	13.83			6.8		4600		1970	1020.0											152.00	

DATA BASE HAS NOT BEEN CHECKED FOR ACCURACY WITH ORIGINAL DATA FORMS.

TABLE B-3. ST JOHNS LANDFILL GROUNDWATER QUALITY DATA BASE, 9/74 THROUGH 6/86, MONITORING WELLS A1H THROUGH F1 (STORET NOS. STJOHN15 THROUGH STJOHN52); FROM DEQ WELL DATA BASE (THROUGH 5/85) AND RECENT ANALYSES.

LOTUS FILE: STJOHN.WK1 UPDATED 12/11/86

COMPILED BY DAVID G. LIVERMORE, SHANNON & WILSON, 1986.

WELL ID	DATE OF SAMPLE	SAMPLER	M.P. ELEV. (1,4) Feet	S.W.L. (2) Feet	ELEV. S.W.L. (3) Feet	TEMP C	pH FIELD	pH LAB	COND. FIELD umhos /cm	COND. LAB umhos /cm	CALC. HARD. mg/l	LAB ALK as CaCO3 mg/l	DISSOLVED CL- mg/l	SO4-2 mg/l	Fe mg/l	Ca mg/l	Mg mg/l	Na mg/l	K mg/l	Zn mg/l	Mn mg/l	COD mg/l	TOC as C mg/l	NH3-N TOTAL mg/l	NO3+ NO2-N mg/l
	01/12/83	METRO	--	--	--			7.1		5800		1070	980.0											4.00	
	04/13/83	METRO	--	--	--			6.9		5800		2070	1120.0											210.00	
	05/14/85	DEQ	--	13.60	12.03	16.5	7.0	7.2	5307	6000	980	2180	890.0	1.1	28.0	210.0	110.0							280.00	<0.02
	09/26/85	DEQ	--	--	--	19.0	6.9	7.0	5500	6200	760	2130	850.0	0.4	42.0	190.0	92.0				3.00	520	160	270.00	0.02
	02/13/86	CH2M	25.63	13.15	12.48	9.7	5.6	6.7	5400	5700	1030	2100	945.0	1.1	35.6	206.0	64.7					459	126	230.00	0.03
	08/05/86	CH2M	25.63	14.20	11.43	20.0	6.8	6.9	5720	5500	1040	2160	119.0	<1.0	37.0	206.0	1.9					558	150	12.80	<0.50
C3	10/10/79	METRO	--	--	--			7.7		2050	645	860	380.0									121		4.90	
	11/07/79	METRO	--	--	--			7.7		2320	690	887	354.0									110		5.00	
	03/05/80	METRO	--	--	--			7.8		2400		1040	316.0									150		4.00	
	04/16/80	METRO	--	--	--			7.9		2400		1020	233.0									130		4.50	
	05/28/80	METRO	--	9.00	12.30			7.6		2420		990	207.0									119		5.00	
	10/07/80	METRO	--	11.00	10.30			8.3		2280		912	240.0									130		10.00	
	11/18/80	METRO	--	13.00	8.30			7.3		2300		916	184.0									120		0.20	
	01/06/81	METRO	--	8.00	13.30			7.7		2390		1040	208.0									100		5.30	
	02/03/81	METRO	--	12.00	9.30			7.6		2400		1410	179.0									115		5.60	
	03/03/81	METRO	--	--	--			8.1		1800		1007	140.0									131		5.50	
	05/05/81	METRO	--	10.00	11.30			8.1		2400		998	171.0									112		0.40	
	07/08/81	METRO	--	--	--			7.7		2220		990	512.0									120		2.50	
	10/13/81	METRO	--	10.00	11.30			7.8		1900		876	224.0									170		20.00	
	02/02/82	METRO	--	7.00	14.30			8.2		2100		914	46.0											7.70	
	04/06/82	METRO	--	7.00	14.30			7.9		1600		910	150.0											5.60	
	07/13/82	METRO	--	14.50	6.80			7.6		1800		860	152.0											90.00	
	10/06/82	METRO	--	11.20	10.10			7.4		1850		849	146.0											6.00	
	01/12/83	METRO	--	--	--			7.1		1900		860	140.0											2.20	
	04/13/83	METRO	--	--	--			7.9		1850		834	131.0											6.00	
	07/14/83	METRO	--	--	--			7.9		1500		824	128.0											60.00	
	05/15/84	DEQ	--	9.60	11.70	12.0	7.7	8.0	1476	1350	380	910	110.0	1.2	0.2	58.0	58.0					110	34	5.70	0.04
	06/22/84	METRO	--	--	--			7.6		1700		810	126.0											8.00	
	11/19/84	DEQ	--	8.20	13.10	11.5	7.2	7.6	1548	1510	570	734	113.0	1.7	8.6	120.0	65.0							5.50	0.02
	05/14/85	DEQ	--	9.60	11.70	12.0	7.7	8.0	1476	1350	380	910	110.0	1.2	0.2	58.0	58.0							5.70	0.04
	09/26/85	DEQ	--	11.17	10.13	14.0	7.3		1464																
	02/13/86	CH2M	21.30	8.70	12.60	8.4	7.6	7.6	1540	1470	571	734	133.0	5.2	0.3	53.8	39.9					158	75.3	6.46	0.03
	05/28/86	DEQ	--	9.10	12.20																				
	08/05/86	CH2M	21.30	10.43	10.87																				
C4	02/10/77	DEQ	--	8.90	--			7.2		918	546	628	7.6	1.1		105.0	69.0	25.2	4.2			16		20.00	<0.01
C5	01/25/78	DEQ	--	8.60	10.11	10.0		7.0		340	177	172	19.0	6.5	6.6	36.0	18.0	11	1.7	<0.05	1.05	8	14	2.60	1.10
	12/13/78	DEQ	--	10.20	8.51	10.0		7.2	255	360	159	166	12.0	4.0	1.9	29.0	20.0	13.5	3.2	<0.05	0.70	8	19	2.03	0.63
	01/09/79	DEQ	--	10.60	8.11	10.0		7.7	255	352		180										10			
	05/02/79	DEQ	--	--	--	10.0		7.5		380		186	14.0									15			
	06/19/79	DEQ	--	10.60	8.11	12.0		7.9	275	374	181	182	22.0	<1.0	2.9	39.8	18.2	14.4	2.2	<0.05	0.70	13	<1	3.50	0.75
	07/17/79	DEQ	--	11.30	7.41	13.0		7.4	260	358		182	14.0									15			
	08/21/79	DEQ	--	12.50	6.21	12.0		7.7	280	367		191	14.0									14			
	10/10/79	METRO	--	--	--			7.7		318	154	194	32.0									6		2.80	
	11/07/79	METRO	--	--	--			7.7		392	159	177	14.4									4		2.60	
	03/05/80	METRO	--	--	--			8.0		445		185	15.5									57		2.20	
	04/16/80	METRO	--	--	--			8.0		390		180	14.9									12		2.10	
	05/28/80	METRO	--	9.00	9.71			8.0		375		166	14.2									15		2.20	
	10/07/80	METRO	--	11.00	7.71			8.1		380		170	14.1									8		2.00	
	11/18/80	METRO	--	12.00	6.71			8.1		390		162	14.4									8		2.80	
	01/06/81	METRO	--	6.00	12.71			8.0		475		302	10.4									6		2.80	

DATA BASE HAS NOT BEEN CHECKED FOR ACCURACY WITH ORIGINAL DATA FORMS.

TABLE 8-3. ST JOHNS LANDFILL GROUNDWATER QUALITY DATA BASE, 9/74 THROUGH 8/86, MONITORING WELLS A1H THROUGH F1 (STORET NOS. STJOHN15 THROUGH STJOHN52); FROM DEQ WELL DATA BASE (THROUGH 5/85) AND RECENT ANALYSES.

LOTUS FILE: STJOHN.WK1 UPDATED 12/11/86

COMPILED BY DAVID G. LIVERMORE, SHANNON & WILSON, 1986.

WELL ID	DATE OF SAMPLE	SAMPLER	M.P. ELEV. (1,4) Feet	S.W.L. (2) Feet	ELEV. S.W.L. (3) Feet	TEMP C	pH FIELD	pH LAB	COND. FIELD umhos /cm	COND. LAB umhos /cm	CALC. HARD. mg/l	LAB ALK as CaCO3 mg/l	DISSOLVED CL- mg/l	SO4-2 mg/l	Fe mg/l	Ca mg/l	Mg mg/l	Na mg/l	K mg/l	Zn mg/l	Mn mg/l	COD mg/l	TOC as C mg/l	NH3-N TOTAL mg/l	NO3+ NO2-N mg/l
	02/03/81	METRO	--	12.00	6.71			8.0		460		200	11.2									6		3.20	
	03/03/81	METRO	--	--	--			8.2		410		214	8.6									8		3.00	
	05/05/81	METRO	--	10.00	8.71			8.3		490		217	8.4									4		3.50	
	06/03/81	METRO	--	--	--			8.2		430		220	8.0									10		3.30	
	07/08/81	METRO	--	--	--			8.3		400		215	9.2									8		3.20	
	08/11/81	METRO	--	10.00	8.71			8.3		430		202	9.0									21		2.90	
	09/15/81	METRO	--	11.00	7.71			8.0		440		210	10.2									10		2.90	
	10/13/81	METRO	--	11.00	7.71			7.8		470		212	18.0									10		4.30	
	11/03/81	METRO	--	11.00	7.71			8.0		445		223	11.6									5		2.80	
	12/08/81	METRO	--	8.50	10.21			7.5		380		210	10.2											2.60	
	02/02/82	METRO	--	7.00	11.71			8.0		490		210	18.4											3.10	
	03/02/82	METRO	--	2.00	16.71			7.7		430		235	2.4											0.50	
	04/06/82	METRO	--	7.00	11.71			8.1		372		220	11.0											2.60	
	05/04/82	METRO	--	11.40	7.31			7.8		410		200	9.8											3.20	
	06/02/82	METRO	--	14.00	4.71			8.1		400		217	9.8											2.90	
	07/13/82	METRO	--	12.00	6.71			7.8		470		237	16.0											<0.10	
	08/04/82	METRO	--	--	--			7.9		410		214	10.2											3.30	
	08/30/82	METRO	--	7.70	11.01			7.7		420		220	10.9											3.50	
	10/06/82	METRO	--	--	--			7.8		520		225	10.8											3.60	
	11/03/82	METRO	--	--	--			8.1		370		221	11.3											3.30	
	12/10/82	METRO	--	--	--			8.1		410		232	11.4											3.80	
	01/12/83	METRO	--	--	--			8.0		450		300	11.6											3.70	
	02/16/83	METRO	--	--	--			8.2		455		214	11.0											3.20	
	04/13/83	DEQ	--	--	--			8.0		405	200	340	4.6	1.3	0.1	48.0	19.0					<5	6	3.40	
	04/13/83	METRO	--	--	--	10.5	8.2	8.0	404	450		216	11.1											4.10	
	05/04/83	METRO	--	--	--			8.0		410		217	18.1											3.60	
	06/02/83	METRO	--	--	--			8.4		405		218	11.3											4.00	
	07/14/83	METRO	--	--	--			8.3		390		210	14.4											5.00	
	08/11/83	METRO	--	--	--			8.1		450		230	11.2											3.90	
	09/08/83	METRO	--	--	--			8.3		430		230	16.2											3.50	
	10/06/83	METRO	--	--	--			8.2		440		242	11.4											4.30	
	11/03/83	METRO	--	--	--			8.1		445		235	10.2											3.10	
	12/08/83	METRO	--	--	--			8.2		445		235	16.2											0.20	
	01/27/84	METRO	--	--	--			7.9		420		240	10.2											3.00	
	05/15/84	DEQ	--	6.00	12.71	12.0	8.0	8.2	407	420	190	225	12.0	2.3	0.1	44.0	19.0					<5	3	4.30	<0.02
	06/22/84	METRO	--	--	--			7.8		470		230	18.3											3.70	
	11/19/84	DEQ	--	8.60	10.11	12.5	7.6	7.7	409	440	200	220	11.0	1.1	3.5	48.0	20.0							3.20	<0.02
	05/14/85	DEQ	--	8.60	10.11	12.0	8.1	8.1	399	410	180	220	9.4	0.3	0.2	42.0	19.0							3.20	<0.02
	09/26/85	DEQ	--	10.83	7.88	13.5	7.4	7.5	429	420	160	230	9.0	<0.2	1.8	34.0	18.0				1.60	<5	2	3.40	<0.02
	02/13/86	CH2M	18.71	9.3	9.41	8	7.79	7.8	410	440	214	240	7.2	<1.0	0.23	41.1	21					14	4.34	3.17	0.03
	05/28/86	DEQ	--	8.20	10.51	14.0	8.2	8.2	407	460	200	238	10.0	<0.2	0.2	42.0	22.0				0.39	17	4	4.00	0.02
	08/05/86	CH2M	18.71	10.52	8.19	16.0	7.8	7.8	396	420	223	324	8.7	<1.0	<0.05	43.4	0.8					49	4.6	36.00	<0.50
D1A	11/19/84	DEQ	--	16.00	11.02	15.0	6.8	6.9	1418	1400	640	554	133.0	49.0	2.1	140.0	71.0							3.20	<0.02
	05/14/85	DEQ	--	16.60	10.42	17.0	6.7	6.8	1785	1590	780	731	180.0	2.7	16.0	180.0	81.0							5.50	<0.02
	09/26/85	DEQ	--	19.33	7.69	16.0	6.7	6.9	1519	1470	670	646	190.0	1.3	5.8	150.0	7.3				7.10	32	17	7.40	0.02
	02/13/86	CH2M	27.02	19.60	7.42	9.8	6.8	6.6	1530	1590	887	734	186.0	<1.0	26.9	189.0	59.8					59	20.2	6.29	<0.01
	05/28/86	DEQ	--	15.00	12.02	16.0	6.8	7.0	1852	1670	840	796	180.0	0.4	19.0	180.0	94.0				8.00	65	28	7.70	0.02
	08/05/86	CH2M	27.02	17.68	9.34	14.0	6.1	6.5	1940	1550	895	865	113.0	1.1	23.8	188.0	4.4					529	514	8.20	<0.50
D1B	11/19/84	DEQ	--	16.90	10.64	15.0	7.0	7.4	750	757	400	370	7.6	14.0	3.5	93.0	40.0							7.70	0.02
	05/14/85	DEQ	--	17.10	10.44	16.0	7.0	7.1	1164	1090	490	613	23.0	6.4	4.9	120.0	47.0							13.70	<0.02
	09/26/85	DEQ	--	20.83	6.71	16.0	7.0	7.2	1079	1060	450	628	8.0	1.2	4.6	110.0	42.0				2.40	7	8	14.60	0.02

DATA BASE HAS NOT BEEN CHECKED FOR ACCURACY WITH ORIGINAL DATA FORMS.

TABLE 8-3. ST JOHNS LANDFILL GROUNDWATER QUALITY DATA BASE, 9/74 THROUGH 8/86, MONITORING WELLS A1H THROUGH F1 (STORET NOS. STJOHN15 THROUGH STJOHN52); FROM DEQ WELL DATA BASE (THROUGH 5/85) AND RECENT ANALYSES.

LOTUS FILE: STJOHN.WK1 UPDATED 12/11/86

COMPILED BY DAVID G. LIVERMORE, SHANNON & WILSON, 1986.

WELL ID	DATE OF SAMPLE	SAMPLER	M.P. ELEV. (1,4) Feet	S.W.L. (2) Feet	ELEV. S.W.L. (3) Feet	TEMP C	pH FIELD	pH LAB	COND. FIELD umhos /cm	COND. LAB umhos /cm	CALC. HARD. mg/l	LAB ALK as CaCO3 mg/l	DISSOLVED CL- mg/l	SO4-2 mg/l	Fe mg/l	Ca mg/l	Mg mg/l	Na mg/l	K mg/l	Zn mg/l	Mn mg/l	COD mg/l	TOC as C mg/l	NH3-N TOTAL mg/l	NO3+ NO2-N mg/l
	02/13/86	CH2M	27.54	19.60	7.94	9.8	6.8	6.6	1530	1140	538	734	186.0	<1.0	7.7	119.0	43.1					36	17.3	6.29	<0.01
	05/28/86	DEQ	--	16.00	11.54	16.0	7.1	7.4	1135	1100	450	632	14.0	0.7	6.9	110.0	42.0				2.00	21	11	17.00	0.02
	08/05/86	CH2M	27.54	18.33	9.21	14.5	6.2	6.8	1205	1080	506	712	7.0	<1.0	8.6	104.0	1.8					380	104	18.20	<0.50
D1C	11/19/84	DEQ	--	16.80	10.42	15.0	7.2	7.4	499	544	240	273	7.1	3.3	6.0	63.0	20.0							8.00	<0.02
	05/14/85	DEQ	--	19.90	7.32	16.0	7.2	7.4	828	730	310	379	33.0	1.8	12.0	81.0	27.0							9.40	<0.02
	09/26/85	DEQ	--	19.17	8.05	16.5	7.0	7.2	650	650	260	358	17.0	0.3	10.0	66.0	22.0				2.00	26	13	8.70	<0.02
	02/13/86	CH2M	27.22	17.00	10.22	8.4	7.0	7.1	550	575	332	347	3.7	<1.0	4.0	59.6	22.3					23	7.46	7.80	<0.01
	05/28/86	DEQ	--	15.60	11.62	16.0	7.3	7.4	661	630	250	355	3.0	0.2	6.2	65.0	22.0					28	5	11.20	0.02
	08/05/86	CH2M	27.22	17.88	9.34	14.0	6.3	6.4	743	620	326	490	2.2	<1.0	6.6	68.4	1.7					429	164	11.80	<0.50
D2A	11/19/84	DEQ	--	6.90	19.92	11.5	6.7	6.7	704	680	240	288	23.0	7.5	42.0	65.0	19.0							11.00	0.02
	05/14/85	DEQ	--	12.30	14.52	11.5	6.6	6.6	1220	940	350	568	34.0	1.1	100.0	94.0	29.0							19.00	<0.02
	09/26/85	DEQ	--	14.42	12.40	13.5	6.8	6.7	1143	1040	340	546	42.0	0.6	66.0	87.0	29.0				1.40	48	26	26.00	<0.02
	02/13/86	CH2M	26.82	10.50	16.32	3.9	6.7	6.2	540	590	264	372	17.1	<1.0	56.8	62.8	19.6					98	22.1	8.61	<0.01
	05/28/86	DEQ	--	12.60	14.22	11.5	6.7	6.6	1056	900	340	476	27.0	0.6	83.0	92.0	27.0				1.70	84	29	16.00	0.02
	08/05/86	CH2M	26.82	14.32	12.50	21.0	6.7	6.5	918	920	396	469	51.3	1.3	34.5	101.0	1.4					96	27.1	18.20	<0.50
D2B	11/19/84	DEQ	--	3.90	23.53	11.0	6.6	6.7	750	713	200	298	24.0	7.9	49.0	71.0	5.1							14.00	0.02
	05/14/85	DEQ	--	13.20	14.23	11.5	6.6	6.6	1009	860	340	482	31.0	0.6	48.0	89.0	28.0							18.00	0.02
	09/26/85	DEQ	--	17.50	9.93	13.0	6.6	7.0	889	850	300	462	19.0	0.3	52.0	77.0	25.0				1.10	40	18	16.10	<0.02
	02/13/86	CH2M	27.43	15.40	12.03	3.7	6.1	6.4	870	850	362	530	7.7	<1.0	45.3	88.7	25.6					63	14.6	14.30	<0.01
	05/28/86	DEQ	--	14.90	12.53	10.5	6.9	7.0	984	900	360	510	9.0	0.2	35.0	89.0	34.0				1.00	39	13	17.00	0.02
	08/05/86	CH2M	27.43	16.63	10.80	15.0	6.7	6.7	996	890	456	615	5.5	<1.0	79.0	108.0	1.0					65	20.7	14.10	<0.50
D3A	11/19/84	DEQ	--	25.50	11.96	18.5	7.0	7.2	3260	3400	780	1240	348.0	3.1	11.0	180.0	80.0							130.00	0.02
	05/14/85	DEQ	--	27.20	10.26	19.0	7.0	7.0	2988	3300	590	1325	320.0	0.3	25.0	130.0	64.0							150.00	0.04
	09/26/85	DEQ	--	28.00	9.46	19.0	6.9	7.1	3671	3700	560	1370	410.0	0.5	26.0	130.0	56.0				7.60	200	94	190.00	0.03
	02/13/86	CH2M	37.46	25.60	11.86	14.5	6.8	6.7	3350	3700	598	1480	334.0	<1.0	19.8	111.0	49.8					232	69.6	3.63	<0.01
	05/28/86	DEQ	--	26.40	11.06	19.0	7.0	7.3	3221	3300	460	1460	200.0	0.4	23.0	99.0	52.0				3.10	210	72	200.00	0.04
	08/05/86	CH2M	37.46	27.43	10.03	22.0	6.9	7	3098	3400	511	1380	119.0	<1.0	19.2	99.6	2.9					208	77.8	176.00	<0.50
D3B	11/19/84	DEQ	--	25.40	12.56	18.5	7.0	6.9	1320	1330	640	458	168.0	1.4	23.0	150.0	65.0							3.70	<0.02
	05/14/85	DEQ	--	26.00	11.96	18.5	6.8	6.8	1260	1280	590	486	170.0	0.4	19.0	150.0	53.0							3.70	<0.02
	09/26/85	DEQ	--	27.92	10.04	19.0	6.8	6.8	1368	1340	590	506	170.0	0.3	22.0	150.0	53.0				3.10	32	11	4.00	0.03
	02/13/86	CH2M	37.96	26.55	11.41	14.8	6.6	6.4	1410	1380	687	515	169.0	<1.0	23.4	162.0	49.0					27	8.81	225.00	<0.01
	05/28/86	DEQ	--	25.30	12.66	19.0	6.9	7.2	1438	1360	600	516	170.0	0.6	23.0	150.0	55.0				1.70	36	12	6.50	0.02
	08/05/86	CH2M	37.96	26.81	11.15	21.0	6.2	6.5	1372	1350	728	536	118.0	<1.0	31.4	172.0	1.7					29	8.71	3.25	<0.50
D4A	11/19/84	DEQ	--	10.90	11.25	17.5	7.1	7.2	1140	1130	500	519	56.0	0.2	7.4	120.0	50.0							15.00	0.02
	05/14/85	DEQ	--	12.10	10.05	16.5	7.1	7.1	976	980	420	544	23.0	0.8	6.0	100.0	41.0							15.90	<0.02
	09/26/85	DEQ	--	13.17	8.98	18.0	7.0	7.0	1004	1050	440	538	41.0	0.3	5.3	110.0	41.0				6.50	25	11	16.30	0.02
	02/13/86	CH2M	22.15	11.80	10.35	14.8	6.5	6.9	1150	1200	483	536	26.4	<1.0	3.7	104.0	39.9					36	15.3	14.50	<0.01
	05/28/86	DEQ	--	11.90	10.25	16.0	7.1	7.5	1164	1180	460	610	56.0	0.4	5.5	110.0	46.0				4.10	59	24	20.00	0.05
	08/05/86	CH2M	22.15	13.17	8.98	18.0	6.7	6.7	1024	920	494	681	32.6	<1.0	15.4	104.0	3.8					4956	637	29.10	<0.50
D4B	11/19/84	DEQ	--	10.10	12.82	17.0	7.1	7.2	677	653	260	316	6.0	32.0	7.4	63.0	24.0							10.00	0.02
	05/14/85	DEQ	--	11.00	11.92	17.0	7.2	7.2	696	670	250	371	38.0	12.0	5.6	60.0	25.0							11.40	<0.02
	09/26/85	DEQ	--	12.83	10.09	17.5	7.1	7.1	670	670	250	402	14.0	19.3	8.1	62.0	23.0				2.70	12	4	13.30	<0.02
	02/13/86	CH2M	22.92	10.11	12.81	14.6	6.8	7.0	550	680	297	398	3.6	3.3	4.8	58.6	22.6					32	9.65	12.10	0.01
	05/28/86	DEQ	--	10.90	12.02	17.0	7.2	7.5	788	780	260	404	4.0	1.7	6.9	62.0	25.0				3.30	35	12	12.90	0.03
	08/05/86	CH2M	22.92	12.14	10.78	21.0	6.9	6.7	659	640	302	445	1.5	1.0	7.0	68.0	3.7					65	18	13.50	<0.50

DATA BASE HAS NOT BEEN CHECKED FOR ACCURACY WITH ORIGINAL DATA FORMS.

TABLE B-3. ST JOHNS LANDFILL GROUNDWATER QUALITY DATA BASE, 9/74 THROUGH 8/86, MONITORING WELLS A1H THROUGH F1 (STORET NOS. STJOHN15 THROUGH STJOHN52); FROM DEQ WELL DATA BASE (THROUGH 5/85) AND RECENT ANALYSES.

LOTUS FILE: STJOHN.WK1 UPDATED 12/11/86

COMPILED BY DAVID G. LIVERMORE, SHANNON & WILSON, 1986.

WELL ID	DATE OF SAMPLE	SAMPLER	M.P. ELEV. (1,4) Feet	S.W.L. (2) Feet	ELEV. S.W.L. (3) Feet	TEMP C	pH FIELD	pH LAB	COND. FIELD umhos /cm	COND. LAB umhos /cm	CALC. HARD. mg/l	LAB ALK as CaCO3 mg/l	DISSOLVED CL- mg/l	SO4-2 mg/l	Fe mg/l	Ca mg/l	Mg mg/l	Na mg/l	K mg/l	Zn mg/l	Mn mg/l	COD mg/l	TOC as C mg/l	NH3-N TOTAL mg/l	NO3+ NO2-N mg/l
D5A	11/19/84	DEQ	—	18.40	12.87	17.0	6.7	6.9	1823	1790	740	620	252.0	81.0	8.1	170.0	76.0							12.00	0.02
	05/14/85	DEQ	—	19.70	11.57	17.5	6.5	6.6	2570	2500	1100	778	410.0	78.0	35.0	250.0	110.0							5.70	0.02
	09/26/85	DEQ	—	20.25	11.02	13.0	6.7	6.6	2714	2700	1000	862	390.0	76.0	37.0	240.0	100.0				14.00	36	18	7.60	<0.02
	02/13/86	CH2M	31.27	18.20	13.07	13.7	6.3	6.4	2820	2900	360	1060	343.0	117.0	52.4	266.0	67.3					25	17.5	7.30	<0.01
	05/28/86	DEQ	—	19.08	12.19	18.0	6.5	6.9	2645	2700	1100	944	340.0	110.0	62.0	260.0	110.0				13.00	60	21	9.10	0.03
	08/05/86	CH2M	31.27	20.07	11.20	21.0	6.1	6.4	2592	2600	1250	912	119.0	90.7	66.5	253.0	12.3					101	28.3	11.00	<0.50
D5B	11/19/84	DEQ	—	21.50	10.00	17.5	7.1	7.2	620	674	320	357	3.8	2.3	5.3	77.0	32.0							3.60	0.04
	05/14/85	DEQ	—	20.90	10.60	17.5	7.0	7.0	842	760	380	450	2.2	0.5	8.8	94.0	35.0							6.30	<0.02
	09/26/85	DEQ	—	23.67	7.91	19.0	7.0	7.0	795	810	370	469	6.3	0.5	6.3	89.0	35.0				1.30	8	4	7.30	<0.02
	02/13/86	CH2M	31.58	21.80	9.78	13.5	6.8	6.8	740	840	424	490	3.8	<1.0	6.7	93.1	36.9					16	8.97	10.00	<0.01
	05/28/86	DEQ	—	19.92	11.66	18.0	6.9	7.2	828	858	410	503	6.0	1.0	10.0	98.0	40.0				1.50	27	7	9.90	0.04
	08/05/86	CH2M	31.58	21.79	9.79	19.0	6.3	6.9	851	840	438	551	2.9	<1.0	9.9	102.0	1.1					87	24.8	7.14	<0.50
D6A	11/19/84	DEQ	—	18.40	11.64	13.0	6.7	6.9	726	646	280	348	3.3	2.8	0.2	63.0	30.0							6.30	<0.02
	05/14/85	DEQ	—	18.10	11.94	12.0	6.7	6.9	715	660	330	381	3.9	1.7	1.6	75.0	34.0							4.30	0.02
	09/26/85	DEQ	—	21.33	8.71	12.5	6.8	6.9	644	690	310	402	4.8	1.0	0.2	72.0	32.0				3.30	10	4	4.90	0.03
	02/13/86	CH2M	30.04	19.40	10.64	9.1	6.1	6.4	680	700	362	377	4.5	2.6	1.4	75.2	26.5					33	9.35	2.50	0.01
	05/28/86	DEQ	—	18.42	11.62	14.0	6.6	6.8	706	720	340	413	4.0	1.6	4.7	78.0	36.0				4.40	21	7	3.90	0.02
	08/05/86	CH2M	30.04	18.82	11.22	14.0	6	6.3	731	710	384	435	5.8	2.6	4.7	82.6	6.0					63	7.19	3.43	<0.50
D6B	11/19/84	DEQ	—	18.90	11.54	12.5	7.0	7.2	288	308	130	156	3.3	2.8	2.4	29.0	14.0							2.30	<0.02
	05/14/85	DEQ	—	17.80	12.64	12.0	6.9	7.0	343	310	130	168	2.2	6.5	2.8	29.0	14.0							4.90	0.02
	09/26/85	DEQ	—	21.00	9.44	14.0	6.8	7.0	344	340	120	180	3.7	9.8	0.3	30.0	12.0				0.59	10	3	5.20	0.05
	02/13/86	CH2M	30.44	20.20	10.24	9.2	6.5	6.8	320	340	168	196	2.8	6.9	3.4	32.3	14.0					11	5.54	5.11	<0.01
	05/28/86	DEQ	—	18.17	12.27	14.0	6.9	7.0	355	350	130	188	2.5	4.5	4.7	30.0	13.0				1.20	<5	3	5.40	0.02
	08/05/86	CH2M	30.44	19.08	11.36	14.0	6.1	6.7	296	360	168	233	2.7	4.7	3.9	31.2	1.3					95	50.5	5.80	<0.50
D6C	11/19/84	DEQ	—	20.60	9.76	12.0	6.7	6.7	306	329	140	100	8.7	29.0	<0.0	35.0	14.0							0.05	5.00
	05/14/85	DEQ	—	20.00	10.36	12.5	6.4	6.5	306	300	370	90	8.3	20.0	0.1	130.0	12.0							0.06	1.30
	09/26/85	DEQ	—	23.00	7.36	13.0	6.5	6.7	299	310	130	117	9.0	15.0	0.1	32.0	12.0				0.05	74	- 20	0.03	0.02
	02/13/86	CH2M	30.36	21.20	9.16	10.0	6.1	6.4	320	330	149	111	7.0	28.3	<0.0	32.6	13.1					8	1.16	0.15	<0.01
	05/28/86	DEQ	—	19.33	11.03	13.0	6.9	7.1	310	320	130	105	7.5	29.0	0.1	31.0	13.0				<0.05	<5	<1	0.03	4.90
	08/05/86	CH2M	30.36	21.28	9.08	14.0	6.2	6.7	290	300	155	119	6.7	30.4	<0.0	33.9	<0.05					3	1.61	0.08	<0.50
D7A	11/19/84	DEQ	--	20.00	9.50	12.0	6.8	7.1	312	337	150	139	8.2	17.0	<0.0	35.0	16.0							0.29	0.78
	05/14/85	DEQ	—	19.80	9.70	13.0	6.9	6.9	302	280	120	103	9.4	19.0	0.8	29.0	12.0							0.05	3.50
	09/26/85	DEQ	--	22.17	7.33	13.0	6.6	6.9	266	270	110	110	10.0	21.0	0.1	28.0	9.8				<0.05	<5	<1	0.04	0.30
	02/13/86	CH2M	29.50	20.10	9.40	9.1	6.8	6.8	310	340	187	203	3.9	7.1	0.1	39.7	16.7					10	3.58	0.48	<0.01
	05/28/86	DEQ	--	18.67	10.83	14.5	6.8	7.0	306	320	130	118	9.5	18.0	0.4	31.0	12.0				0.36	10	2	0.52	3.60
	08/05/86	CH2M	29.50	20.43	9.07	18.0	6.1	6.6	322	370	212	254	4.9	3.9	0.9	41.0	0.3					9	5.89	0.21	<0.50
D8A	11/19/84	DEQ	--	23.90	9.89	18.0	7.3	7.4	419	426	90	123	38.0	17.0	0.6	23.0	7.8							9.50	0.02
	05/14/85	DEQ	--	23.00	10.79	21.0	7.6	7.8	3397	3300	190	1150	410.0	1.0	5.3	27.0	30.0							200.00	1.10
	09/26/85	DEQ	—	26.17	7.62	21.0	7.5	7.6	6148	6300	200	2020	900.0	0.4	5.2	22.0	36.0				0.22	500	197	440.00	0.02
	02/13/86	CH2M	33.79	23.50	10.29	14.0	7.5	7.5	3890	4000	20.8	357	403.0	<1.0	1.0	20.8	23.2					261	91.3	248.00	0.03
	05/28/86	DEQ	—	22.40	11.39	21.0	7.5	7.7	5832	5800	210	1790	680.0	1.4	4.4	26.0	35.0				0.28	430	193	390.00	0.05
	08/05/86	CH2M	33.79	23.65	10.14	22.0	6.8	7.5	5775	5700	294	1950	119.0	<1.0	6.1	23.2	0.1					542	143	402.00	<0.50
E1L	10/10/79	METRO	--	—	—			7.9		362	119	163	7.4									22		4.10	
(SH)	11/07/79	METRO	--	—	—			7.4		142	49	50	4.8									5		0.40	
	02/06/80	DEQ	--	6.10	--			7.1		437		228	3.8	2.9	2.5							21		5.90	
	03/05/80	METRO	—	—	—			7.5		142		54	6.1									18		<0.10	

DATA BASE HAS NOT BEEN CHECKED FOR ACCURACY WITH ORIGINAL DATA FORMS.

LOTUS FILE: STJOHN.WK1 UPDATED 12/11/86

COMPILED BY DAVID G. LIVERMORE, SHANNON & WILSON, 1986.

WELL ID	DATE OF SAMPLE	SAMPLER	M.P. ELEV. (1,4) Feet	S.W.L. (2) Feet	ELEV. S.W.L. (3) Feet	TEMP C	pH FIELD	pH LAB	COND. FIELD umhos /cm	COND. LAB umhos /cm	CALC. HARD. mg/l	LAB ALK as CaCO3 mg/l	DISSOLVED CL- mg/l	SO4-2 mg/l	Fe mg/l	Ca mg/l	Mg mg/l	Na mg/l	K mg/l	Zn mg/l	Mn mg/l	COD mg/l	TOC as C mg/l	NH3-N TOTAL mg/l	NO3+ NO2-N mg/l
	04/16/80	METRO	--	--	--			7.9		250		105	4.2									4.2		0.20	
	05/28/80	METRO	--	6.00	--			7.2		492		242	3.8									21		7.40	
	08/26/80	DEQ	--	5.40	--			7.3		488	193	246	3.6	1.6	3.3									7.64	
	06/03/81	METRO	--	--	--			8.4		790		285	92.0									48		2.80	
	07/08/81	METRO	--	--	--			7.5		1060		403	113.0									65		125.00	
	08/11/81	METRO	--	5.00	--			7.5		1050		386	39.0									69		18.00	
	09/15/81	METRO	--	6.50	--			7.6		840		360	50.0									20		16.00	
	10/13/81	METRO	--	6.00	--			7.2		760		357	45.2									35		18.00	
	11/03/81	METRO	--	6.00	--			7.3		740		344	36.4									13		15.80	
	12/08/81	METRO	--	4.50	--			7.5		750		310	92.8											7.80	
	02/02/82	METRO	--	4.00	--			7.7		870		320	86.4											0.60	
	03/02/82	METRO	--	3.10	--			6.9		680		330	37.0											4.90	
	04/06/82	METRO	--	3.50	--			7.7		465		274	8.4											9.20	
	05/04/82	METRO	--	10.70	--			6.7		485		280	7.0											9.20	
	06/02/82	METRO	--	10.90	--			7.8		485		264	6.1											8.30	
	07/13/82	METRO	--	10.90	--			7.4		510		262	5.0											<0.10	
	08/04/82	METRO	--	--	--			7.0		500		256	7.2											8.50	
	08/30/82	METRO	--	8.40	--			6.7		490		260	6.0											8.00	
	10/06/82	METRO	--	8.50	--			7.0		390		251	6.4											9.10	
	11/03/82	METRO	--	--	--			8.1		410		250	5.6											8.00	
	12/10/82	METRO	--	--	--			7.9		450		255	5.8											8.40	
	01/12/83	METRO	--	--	--			7.0		440		200	14.6											1.30	
	02/16/83	METRO	--	--	--			8.2		440		224	9.2											3.40	
	03/18/83	METRO	--	--	--			6.7		955		260	6.1											8.50	
	04/13/83	DEQ	--	--	--	10.0	7.0	7.2	505	494	200	260	4.0	2.1	9.4	52.0	18.0					6	11	8.30	0.12
	04/13/83	METRO	--	--	--			7.5		480		236	5.0											11.10	
	05/04/83	METRO	--	--	--			7.0		420		384	8.0											9.40	
	06/02/83	METRO	--	--	--			7.5		460		262	10.9											9.90	
	07/14/83	METRO	--	--	--			7.4		420		238	4.8											7.90	
	08/11/83	METRO	--	--	--			7.7		450		150	5.6											8.50	
	09/08/83	METRO	--	--	--			8.2		450		240	10.0											7.80	
	10/06/83	METRO	--	--	--			8.2		440		245	5.4											8.80	
	11/03/83	METRO	--	--	--			7.1		440		285	5.0											7.00	
	12/08/83	METRO	--	--	--			7.6		455		248	9.8											7.00	
	01/27/84	METRO	--	--	--			7.0		380		260	4.5											8.40	
	05/15/84	DEQ	--	3.10	--	12.0	6.9	7.1	488	460	190	256	4.3	0.5	12.0	47.0	17.0					6	4	7.10	0.02
	06/22/84	METRO	--	--	--			6.9		375		245	5.7											8.80	
	11/19/84	DEQ	--	4.80	--	12.8	7.0	7.1	396	441	180	220	4.4	0.9	0.4	46.0	15.0							6.90	<0.02
E1H	10/10/79	METRO	--	--	--			8.0		282	99.2999	95	8.1									6		0.80	
(DP)	11/07/79	METRO	--	--	--			7.7		360	131	171	2.6									21		3.90	
	02/06/80	DEQ	--	6.30	--			6.5		115		12	5.5	10.1	0.6							14		0.22	
	03/05/80	METRO	--	--	--			7.5		468		241	5.2									21		7.20	
	04/16/80	METRO	--	--	--			7.8		460		242	4.6									18		7.50	
	05/28/80	METRO	--	6.00	--			7.2		265		112	4.4									19		0.40	
	08/26/80	DEQ	--	8.00	--			7.8		259	98	170	4.7	4.2	0.4							34		0.56	
	06/03/81	METRO	--	--	--			12.4		5200		1310	130.0									180		3.40	
	07/08/81	METRO	--	--	--			9.2		544		215	46.8									174		10.20	
	08/11/81	METRO	--	5.00	--			11.7		1000		270	37.8									70		4.50	
	09/15/81	METRO	--	6.00	--			11.7		1140		310	18.8									8		2.50	
	10/13/81	METRO	--	6.00	--			11.1		1200		265	16.8									20		2.80	
	11/03/81	METRO	--	6.50	--			11.4		840		221	17.6									8		2.60	
	12/08/81	METRO	--	4.50	--			10.6		435		125	16.4											2.30	

DATA BASE HAS NOT BEEN CHECKED FOR ACCURACY WITH ORIGINAL DATA FORMS.

TABLE B-3. ST JOHNS LANDFILL GROUNDWATER QUALITY DATA BASE, 9/74 THROUGH 8/86, MONITORING WELLS A1H THROUGH F1 (STORET NOS. STJOHN15 THROUGH STJOHN52); FROM DEQ WELL DATA BASE (THROUGH 5/85) AND RECENT ANALYSES.

LOTUS FILE: STJOHN.WK1 UPDATED 12/11/86

COMPILED BY DAVID G. LIVERMORE, SHANNON & WILSON, 1986.

WELL ID	DATE OF SAMPLE	SAMPLER	M.P. ELEV. (1,4) Feet	S.W.L. (2) Feet	ELEV. S.W.L. (3) Feet	TEMP C	pH FIELD	pH LAB	COND. FIELD umhos /cm	COND. LAB umhos /cm	CALC. HARD. mg/l	LAB ALK as CaCO3 mg/l	DISSOLVED CL- mg/l	SO4-2 mg/l	Fe mg/l	Ca mg/l	Mg mg/l	Na mg/l	K mg/l	Zn mg/l	Mn mg/l	COD mg/l	TOC as C mg/l	NH3-N TOTAL mg/l	NO3+ NO2-N mg/l
	02/02/82	METRO	--	3.00	--			10.7		330		147	21.6											1.90	
	03/02/82	METRO	--	8.00	--			7.9		340		150	2.4											0.50	
	04/06/82	METRO	--	--	--			8.0		325		158	8.5											0.10	
	05/04/82	METRO	--	--	--			7.5		350		150	8.2											0.20	
	06/02/82	METRO	--	--	--			7.7		310		133	7.9											<0.10	
	07/13/82	METRO	--	12.90	--			7.3		330		136	1.0											<0.10	
	08/04/82	METRO	--	--	--			7.4		310		127	9.0											<0.10	
	08/30/82	METRO	--	9.40	--			7.2		330		134	9.0											0.10	
	10/06/82	METRO	--	8.70	--			7.4		330		129	9.0											0.10	
	11/03/82	METRO	--	--	--			8.0		280		129	8.8											<0.10	
	12/10/82	METRO	--	--	--			7.9		300		132	8.6											<0.10	
	01/12/83	METRO	--	--	--			7.4		350		200	8.6											0.20	
	02/16/83	METRO	--	--	--			8.2		350		156	8.0											0.10	
	03/18/83	METRO	--	--	--			6.8		495		160	8.0											0.10	
	04/13/83	DEQ	--	--	--	19.0	7.3	7.4	327	336	140	154	6.8	8.7	0.4	35.0	14.0					5	5	0.21	1.30
	04/13/83	METRO	--	--	--			7.7		320		124	7.9											0.10	
	05/04/83	METRO	--	--	--			7.1		270		129	13.5											0.10	
	06/02/83	METRO	--	--	--			8.5		310		146	6.8											0.10	
	07/14/83	METRO	--	--	--			7.8		285		130	8.4											0.70	
	08/11/83	METRO	--	--	--			7.7		330		240	8.1											0.20	
	09/08/83	METRO	--	--	--			7.7		310		140	13.4											<0.10	
	10/06/83	METRO	--	--	--			8.0		330		148	7.7											0.20	
	11/03/83	METRO	--	--	--			7.3		335		150	7.4											<1.00	
	12/08/83	METRO	--	--	--			7.5		340		163	12.5											<0.10	
	01/27/84	METRO	--	--	--			7.3		320		170	8.0												
	05/15/84	DEQ	--	1.50	--	13.0	7.0	7.5	321	320	140	141	6.4	15.0	0.2	34.0	13.0					<5	<1	0.15	1.50
	06/22/84	METRO	--	--	--			7.0		280		150	7.2											<0.10	
	11/19/84	DEQ	--	4.10	--	12.0	7.0	7.3	304	329		137	8.2	15.0	<0.0	35.0	13.0							0.13	1.60
E2L	10/10/79	METRO	--	--	--			6.8		411	228	100	9.0									286		2.80	
(SH)	11/07/79	METRO	--	--	--			6.8		505	217	213	7.0									190		1.60	
	02/06/80	DEQ	--	7.20	23.81			6.8		398		186	2.8	4.4	12.4							96		2.00	
	03/05/80	METRO	--	--	--			7.1		409		203	4.2									33		1.80	
	04/16/80	METRO	--	--	--			7.2		420		205	3.2									32		1.50	
	05/28/80	METRO	--	10.00	21.01			6.8		408		200	3.3									30		2.30	
	08/26/80	DEQ	--	16.60	14.41			7.1		450	199	246	4.3	2.0	6.9							650		2.72	
	11/18/80	METRO	--	23.00	8.01			7.0		440		205	6.7									24		0.30	
	01/06/81	METRO	--	18.00	13.01			6.9		475		201	6.2									11		0.60	
	02/03/81	METRO	--	19.00	12.01			6.7		490		234	8.8									24		0.80	
	03/03/81	METRO	--	--	--			8.1		480		231	2.8									23		0.40	
	05/05/81	METRO	--	22.00	9.01			8.2		480		240	4.5									21		0.30	
	06/03/81	METRO	--	--	--			6.7		510		250	5.4									28		8.00	
	07/08/81	METRO	--	--	--			6.9		580		298	9.8									16		0.50	
	08/11/81	METRO	--	23.00	8.01			7.1		560		254	7.6									26		0.20	
	12/08/81	METRO	--	20.00	11.01			6.6		495		270	13.6											0.50	
	02/02/82	METRO	--	19.50	11.51			7.0		545		268	15.6											0.20	
	03/02/82	METRO	--	14.00	17.01			6.6		1110		470	46.0											7.40	
	04/06/82	METRO	--	19.50	11.51			8.1		700		421	26.2											0.20	
	05/04/82	METRO	--	11.10	19.91			6.3		570		285	16.8											0.50	
	06/02/82	METRO	--	13.00	18.01			7.9		670		342	23.0											<0.10	
	07/13/82	METRO	--	11.10	19.91			7.3		730		437	33.6											8.20	
	08/04/82	METRO	--	--	--			7.1		720		368	28.8											0.80	
	08/30/82	METRO	--	7.90	23.11								23.1											8.10	

DATA BASE HAS NOT BEEN CHECKED FOR ACCURACY WITH ORIGINAL DATA FORMS.

TABLE B-3. ST JOHNS LANDFILL GROUNDWATER QUALITY DATA BASE, 9/74 THROUGH 8/86, MONITORING WELLS A1H THROUGH F1 (STORET NOS. STJOHN15 THROUGH STJOHN52); FROM DEQ WELL DATA BASE (THROUGH 5/85) AND RECENT ANALYSES.

LOTUS FILE: STJOHN.WK1 UPDATED 12/11/86

COMPILED BY DAVID G. LIVERMORE, SHANNON & WILSON, 1986.

WELL ID	DATE OF SAMPLE	SAMPLER	M.P. ELEV. (1,4) Feet	S.W.L. (2) Feet	ELEV. S.W.L. (3) Feet	TEMP C	pH FIELD	pH LAB	COND. FIELD umhos /cm	COND. LAB umhos /cm	CALC. HARD. mg/l	LAB ALK as CaCO3 mg/l	DISSOLVED CL- mg/l	SO4-2 mg/l	Fe mg/l	Ca mg/l	Mg mg/l	Na mg/l	K mg/l	Zn mg/l	Mn mg/l	COD mg/l	TOC as C mg/l	NH3-N TOTAL mg/l	NO3+ NO2-N mg/l
	10/06/82	METRO	--	7.60	23.41			7.0		610		362	26.3											0.40	
	11/03/82	METRO	--	--	--			8.3		620		356	24.2											<0.10	
	12/10/82	METRO	--	--	--			8.0		590		306	14.5											0.90	
	01/12/83	METRO	--	--	--			7.2		960		450	32.4											0.20	
	02/16/83	METRO	--	--	--			7.7		765		378	18.2											0.20	
	03/18/83	METRO	--	--	--			6.2				995	18.2											0.10	
	04/13/83	DEQ	--	--	--	17.5	6.6	6.7	690	690	330	368	14.0	18.0	0.3	90.0	26.0					<5	26	0.10	0.10
	04/13/83	METRO	--	--	--			7.1		860		469	13.4											0.20	
	05/04/83	METRO	--	--	--			7.8		660		354	16.4											0.10	
	06/02/83	METRO	--	--	--			8.1		420		214	4.9											1.00	
	07/14/83	METRO	--	--	--			7.0		530		302	8.8											0.30	
	12/08/83	METRO	--	--	--			6.7		630		358	11.5											0.40	
	01/27/84	METRO	--	--	--			6.6		460		270	6.5											0.60	
	05/15/84	DEQ	--	18.80	12.21	12.5	6.2	6.5	413	410	210	213	6.4	11.0	7.6	54.0	18.0					<5	3	0.44	<0.02
	06/22/84	METRO	--	--	--			6.3		380		210	9.0											1.30	
	11/19/84	DEQ	--	21.00	10.01	11.5	6.3	6.5	549	579	230	292	7.6	9.6	5.5	63.0	19.0							2.10	0.06
	05/14/85	DEQ	--	21.80	9.21	15.5	6.6	6.6	617	530	270	312	5.6	7.5	23.0	69.0	23.0							2.10	0.02
	02/13/86	CH2M	--	21	10.01	8.6	6.15	5.8	540	530	313	326	5.9	5.6	14.2	60.9	22.3					109	24.8	1	<0.01
	05/28/86	DEQ	--	20.92	10.09	14.0	6.2	6.6	567	630	290	337	6.0	11.0	2.9	80.0	21.0				0.77	12	5	0.42	0.05
	08/05/86	CH2M	31.01	22.28	8.73	18.0	5.6	5.5	437	490	294	305	7.7	9.9	3.7	72.0	0.8					25	11.1	0.44	<0.50
E2H	10/10/79	METRO	--	--	--			8.2		230	94	92	12.1									4		0.10	
(DP)	11/07/79	METRO	--	--	--			7.4		188	111	94	9.1									4		<0.10	
	02/06/80	DEQ	--	7.80	23.47			6.9		326		131	2.1	23.3	0.1							11		0.11	
	03/05/80	METRO	--	--	--			7.3		341		140	3.9									17		0.10	
	04/16/80	METRO	--	--	--			6.7		365		151	3.8									13		0.20	
	05/28/80	METRO	--	9.00	22.27			6.8		376		155	3.3									17		0.20	
	08/26/80	DEQ	--	18.10	13.17			7.5		400	187	194	4.9	20.7	0.8							320		0.07	
	10/07/80	METRO	--	21.00	10.27			8.0		510		254	5.2									221		4.20	
	11/18/80	METRO	--	23.00	8.27			6.7		535		253	8.4									160		5.30	
	01/06/81	METRO	--	17.00	14.27			6.5		540		98	5.4									25		0.90	
	02/03/81	METRO	--	19.00	12.27			6.7		520		254	8.4									106		4.80	
	03/03/81	METRO	--	--	--			7.2		590		305	5.8									88		5.10	
	05/05/81	METRO	--	23.00	8.27			8.2		720		343	5.0									44		5.40	
	06/03/81	METRO	--	--	--			7.0		735		375	6.4									46		6.20	
	07/08/81	METRO	--	--	--			6.8		585		295	9.0									21		1.20	
	08/11/81	METRO	--	23.00	8.27			7.0		688		376	7.2									38		4.80	
	09/15/81	METRO	--	23.50	7.77			7.0		785		395	8.8									38		8.10	
	10/13/81	METRO	--	23.00	8.27			7.6		740		385	6.4									23		8.10	
	11/03/81	METRO	--	23.00	8.27			6.8		815		437	9.4									12		6.80	
	12/08/81	METRO	--	22.00	9.27			8.0		685		410	8.2											7.40	
	02/02/82	METRO	--	20.00	11.27			6.9		770		428	9.6											6.90	
	03/02/82	METRO	--	14.20	17.07			6.6		1110		470	40.0											3.00	
	04/06/82	METRO	--	20.00	11.27			7.0		620		325	21.3											0.20	
	05/04/82	METRO	--	11.30	19.97			6.1		390		195	9.6											0.30	
	06/02/82	METRO	--	13.20	18.07			7.8		385		190	9.6											<0.10	
	07/13/82	METRO	--	12.00	19.27			6.5		350		187	9.8											80.00	
	08/04/82	METRO	--	--	--			6.3		430		189	10.8											0.20	
	08/30/82	METRO	--	8.20	23.07			5.9		420		185	10.8											0.20	
	10/06/82	METRO	--	7.80	23.47			6.1		430		194	11.1											0.40	
	11/03/82	METRO	--	--	--			8.8		370		205	11.2											0.50	
	12/10/82	METRO	--	--	--			6.8		540		318	12.1											1.40	
	01/12/83	METRO	--	--	--			6.9		960		650	35.2											0.10	

TABLE 8-3. ST JOHNS LANDFILL GROUNDWATER QUALITY DATA BASE, 9/74 THROUGH 8/86, MONITORING WELLS A1H THROUGH F1 (STORET NOS. STJOHN15 THROUGH STJOHN52); FROM DEQ WELL DATA BASE (THROUGH 5/85) AND RECENT ANALYSES.

LOTUS FILE: STJOHN.WK1 UPDATED 12/11/86

COMPILED BY DAVID G. LIVERMORE, SHANNON & WILSON, 1986.

WELL ID	DATE OF SAMPLE	SAMPLER	M.P. ELEV. (1,4) Feet	S.W.L. (2) Feet	ELEV. S.W.L. (3) Feet	TEMP C	pH FIELD	pH LAB	COND. FIELD umhos /cm	COND. LAB umhos /cm	CALC. HARD. mg/l	LAB ALK as CaCO3 mg/l	DISSOLVED CL- mg/l	SO4-2 mg/l	Fe mg/l	Ca mg/l	Mg mg/l	Na mg/l	K mg/l	Zn mg/l	Mn mg/l	COD mg/l	TOC as C mg/l	NH3-N TOTAL mg/l	NO3+NO2-N mg/l
	02/16/83	METRO	--	--	--			7.5		900		424	27.4											0.60	
	03/18/83	METRO	--	--	--			6.1		965		500	20.6											0.40	
	04/13/83	DEQ	--	--	--	18.0	6.7	6.7	759	698	330	368	14.0	18.0	0.3	90.0	26.0					<5	26	0.10	0.10
	04/13/83	METRO	--	--	--			7.9		710		441	12.3											0.20	
	05/04/83	METRO	--	--	--			7.5		680		432	16.6											1.20	
	06/02/83	METRO	--	--	--			7.3		738		428	7.8											1.40	
	07/14/83	METRO	--	--	--			7.0		725		446	11.2											2.00	
	08/11/83	METRO	--	--	--			7.8		720		420	11.2											2.00	
	09/08/83	METRO	--	--	--			7.8		720		440	16.7											2.00	
	10/06/83	METRO	--	--	--			8.5		810		446	10.6											1.90	
	11/03/83	METRO	--	--	--			6.6		780		405	11.4											1.50	
	12/08/83	METRO	--	--	--			6.8		810		482	16.7											1.90	
	01/27/84	METRO	--	--	--			6.8		720		680	9.5											3.10	
	05/15/84	DEQ	--	19.30	11.97	12.0	6.6	6.8	791	740	340	424	9.6	0.6	22.0	91.0	28.0					11	5	3.90	<0.02
	06/22/84	METRO	--	--	--			6.7		680		410	7.8											5.40	
	11/19/84	DEQ	--	21.80	9.47	12.0	6.6	6.7		744	370	416	5.0	0.7	24.0	92.0	34.0							4.00	<0.02
	05/14/85	DEQ	--	21.90	9.37	12.5	6.7	6.8	756	680	320	395	5.6	0.3	21.0	85.0	25.0							3.60	<0.02
	09/26/85	DEQ	--	24.58	6.69	13.0	6.7	6.8	666	660	290	390	6.4	0.3	22.0	80.0	22.0				2.00	4	5	4.60	<0.02
	02/13/86	CH2M	--	21.4	9.87	8.7	6.47	6.6	610	670	326	408	4.6	<1.0	22.7	79.8	22.9					30	7.53	3.7	<0.01
	05/28/86	DEQ	--	20.67	10.60	15.0	6.4	6.6	664	610	300	338	5.0	6.3	13.0	84.0	22.0				0.94	14	4	0.08	0.05
	08/05/86	CH2M	31.27	22.57	8.70	16.0	5.6	6.2	588	680	363	401	5.7	1.5	20.8	86.7	1.6					47	20.7	3.34	<0.50
F1	10/10/79	METRO	--	--	--			8.2		203	246	124	5.2									20		3.50	
	11/07/79	METRO	--	--	--			7.2		272	96	126	3.4									15		3.30	
	02/06/80	DEQ	--	7.60	8.76			7.3		262		137	2.4	1.4	3.9							45		3.52	
	03/05/80	METRO	--	--	--			7.9		292		142	4.2									29		4.10	
	04/16/80	METRO	--	--	--			7.6		305		148	3.8									27		4.20	
	05/28/80	METRO	--	4.00	12.36			7.1		305		148	3.0									26		4.50	
	08/26/80	DEQ	--	8.90	7.46			7.7		288	122	150	3.6	2.6	3.2							49		2.87	
	10/07/80	METRO	--	10.00	6.36			7.7		320		150	4.4									12		4.80	
	11/18/80	METRO	--	9.00	7.36			7.2		338		151	4.8									15		4.30	
	01/06/81	METRO	--	3.50	12.86			7.1		84		24	3.8									6		1.90	
	02/03/81	METRO	--	7.00	9.36			6.6		89		29	3.9									10		0.10	
	03/03/81	METRO	--	--	--			7.6		110		30	2.5									10		0.10	
	05/05/81	METRO	--	7.00	9.36			7.5		145		46	4.6									8		0.10	
	07/08/81	METRO	--	--	--			7.5		178		63	6.0									7		0.30	
	08/11/81	METRO	--	8.00	8.36			7.5		188		66	7.7									18		0.10	
	09/15/81	METRO	--	10.00	6.36			7.3		200		115	7.2									24		1.20	
	10/13/81	METRO	--	9.50	6.86			7.4		195		73	7.2									13		1.40	
	11/03/81	METRO	--	8.00	8.36			7.2		210		96	9.6									7		1.20	
	02/02/82	METRO	--	4.50	11.86			8.2		288		130	9.6											3.10	
	04/06/82	METRO	--	4.00	12.36			8.1		127		86	7.7											<0.10	
	05/04/82	METRO	--	11.40	4.96			6.5		158		60	7.8											0.50	
	06/02/82	METRO	--	13.60	2.76			7.8		160		60	8.1											<0.10	
	08/04/82	METRO	--	--	--			7.1		190		74	9.0											0.20	
	08/30/82	METRO	--	7.90	8.46			6.7		200		100	8.2											0.50	
	10/06/82	METRO	--	7.90	8.46			7.1		165		86	8.0											1.10	
	11/03/82	METRO	--	--	--			7.8		150		80	7.7											0.40	
	12/10/82	METRO	--	--	--			8.1		185		81	5.4											0.40	
	02/16/83	METRO	--	--	--			7.6		110		43	4.5											0.10	
	04/13/83	DEQ	--	--	--	18.0	7.2	7.4	164	183	61	74	9.4	5.9	0.4	15.0	5.7					7	4	1.73	0.44
	04/13/83	METRO	--	--	--			7.8		150		60	7.0											0.40	
	05/04/83	METRO	--	--	--			7.8		-190		98	10.1											2.50	

DATA BASE HAS NOT BEEN CHECKED FOR ACCURACY WITH ORIGINAL DATA FORMS.

TABLE B-3. ST JOHNS LANDFILL GROUNDWATER QUALITY DATA BASE, 9/74 THROUGH 8/86, MONITORING WELLS A1H THROUGH F1 (STORET NOS. STJOHN15 THROUGH STJOHN52); FROM DEQ WELL DATA BASE (THROUGH 5/85) AND RECENT ANALYSES.

LOTUS FILE: STJOHN.WK1 UPDATED 12/11/86

COMPILED BY DAVID G. LIVERMORE, SHANNON & WILSON, 1986.

WELL ID	DATE OF SAMPLE	SAMPLER	M.P. ELEV. (1,4) Feet	S.W.L. (2) Feet	ELEV. S.W.L. (3) Feet	TEMP C	pH FIELD	pH LAB	COND. FIELD umhos /cm	COND. LAB umhos /cm	CALC. HARD. mg/l	LAB ALK as CaCO3 mg/l	DISSOLVED CL- mg/l	SO4-2 mg/l	Fe mg/l	Ca mg/l	Mg mg/l	Na mg/l	K mg/l	Zn mg/l	Mn mg/l	COD mg/l	TOC as C mg/l	NH3-N TOTAL mg/l	NO3+ NO2-N mg/l
	07/14/83	METRO	—	—	—			7.5		215		104	7.2											2.40	
	08/11/83	METRO	—	—	—			7.3		210		230	5.0											3.40	
	09/08/83	METRO	—	—	—			8.0		260		130	7.2											3.50	
	10/06/83	METRO	—	—	—			8.1		280		140	4.1											3.10	
	11/03/83	METRO	—	—	—			7.1		290		145	4.4											3.00	
	12/08/83	METRO	—	—	—			7.5		280		147	6.4											<0.10	
	01/27/84	METRO	—	—	—			7.2		270		140	3.6											4.00	
	05/15/84	DEQ	—	3.10	13.26	12.0	6.9	7.3	273	270	110	146	6.4	0.6	2.3	26.0	11.0					<5	2	3.90	<0.02
	11/19/84	DEQ	—	4.60	11.76	12.0	6.8	7.1	264	285	110	139	3.3	0.4	2.0	28.0	10.0							3.90	<0.02
	05/14/85	DEQ	—	4.20	12.16	11.5	7.1	7.2	295	280	110	148	3.3	0.6	2.5	27.0	11.0							4.60	0.02
	09/26/85	DEQ	—	7.50	8.86	11.5	6.9	7.0	309	290	110	160	4.3	0.5	4.0	27.0	11.0				0.59	13	3	4.10	<0.02
	02/13/86	CH2M	16.36	6.1	10.26	7.6	6.69	6.9	330	320	130	186	3.3	<1.0	3.84	28.8	11.7					45	3.41	4.23	<0.01
	05/28/86	DEQ	—	5.42	10.94	17.5	7.0	7.1	269	200	110	100	3.5	0.3	4.4	26.0	11.0				0.77	13	3	3.70	0.12
	08/05/86	CH2M	16.36	5.77	10.59	17.0	7.0	7.0	260	270	136	172	3.1	<1.0	3.8	25.7	0.5					29	8.52	3.84	<0.50

NOTES: (1) MEASURING POINT ELEVATION
(2) STATIC WATER LEVEL
(3) ELEVATION OF STATIC WATER LEVEL
(4) MEASURING POINT ELEVATIONS OF WELLS A1H, A1L, A2H, A2L, A3H, A3L, AND B3 ARE APPROXIMATE (+ OR - 1 FOOT).
[—] OR [BLANK SPACE] INDICATES PARAMETER WAS NOT MEASURED OR DATA WAS NOT AVAILABLE.

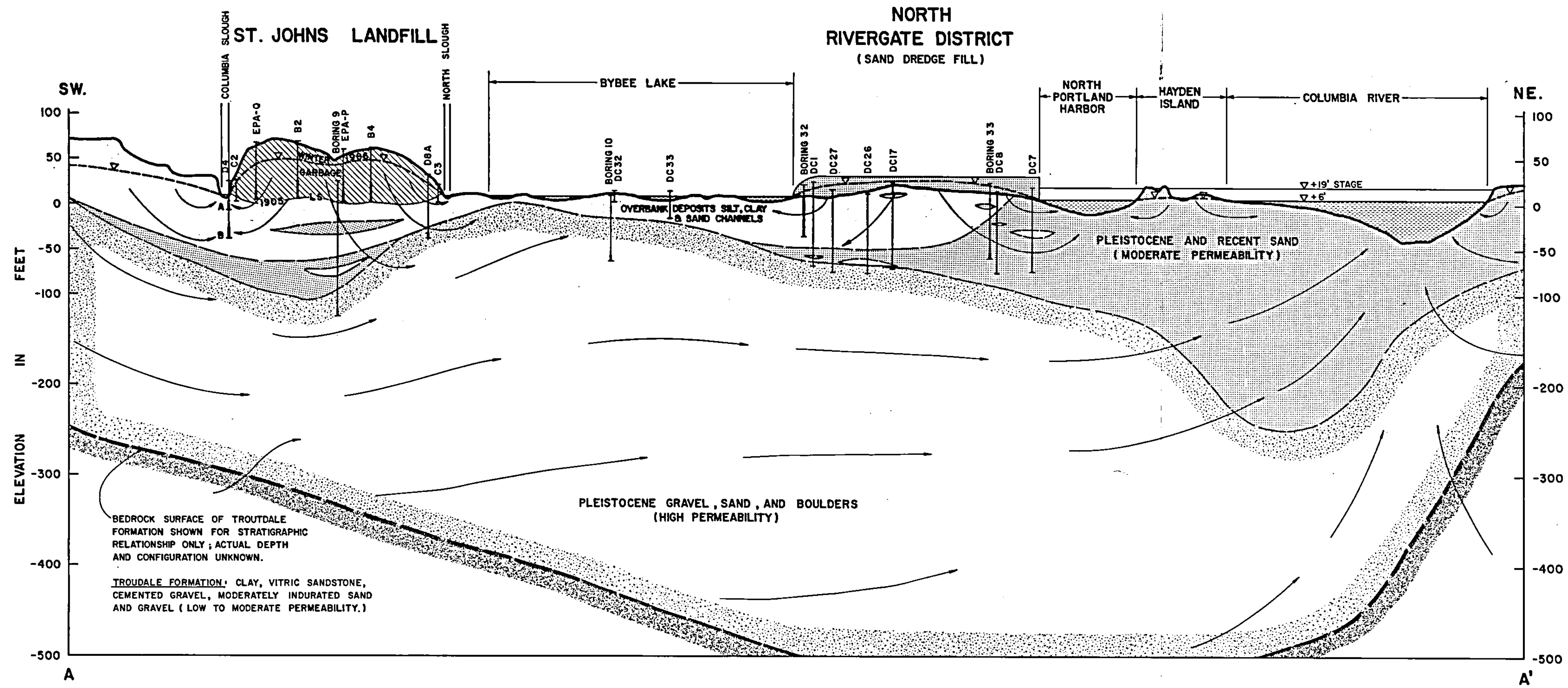
TABLE B-4

GROUNDWATER ELEVATIONS IN SELECTED WELLS,
ST. JOHNS LANDFILL, 1986

GROUNDWATER ELEVATIONS (FT,MSL)

		WELL LOCATION									LAKE	SLOUGH
DAY NO.	DATE	D1A	D1B	D1C	D4A.	D4B	D6A	D6B	D6C	PA-6	LEVEL	LEVEL
108	13FEB86	7.42	7.94	10.22	10.35	12.81	10.64	10.24	9.16	N/A	17.9	17.9
210	28MAY86	12.02	11.54	11.62	10.25	12.02	11.62	12.27	11.03	N/A	10.64	9.8
218	5JUN86	12.35	11.54	9.91	12.76	11.47	10.34	9.99	10.41	9.84	9.93	14.8
226	13JUN86	11.14	10.54	10.08	10.17	11.09	10.38	10.07	9.82	9.96	10.42	8.1
230	17JUN86	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	10.26	7.6
233	20JUN86	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	10.22	8.81
239	26JUN86	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	10.09	6.46
247	4JUL86	8.69	8.77	8.96	8.94	10.13	10.17	9.55	8.53	10	10.05	5.13
267	24JUL86	8.35	8.17	8.16	8.73	9.72	9.92	9.15	8.16	N/A	9.71	7
276	2AUG86	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	9.44	N/A
289	15AUG86	7.64	7.25	7.04	7.57	7.76	9.59	8.65	7.16	N/A	9.3	4.8
302	28AUG86	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	9.05	N/A
315	10SEP86	6.85	6.75	6.79	8.73	8.53	8.36	7.86	6.64	N/A	8.86	4.4
335	30SEP86	6.6	6.54	6.5	8.51	8.3	8.71	7.9	6.24	N/A	9.03	3.5
357	22OCT86	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	9.17	8.83	3.5

* DAY NO. = Number of days from 1NOV85



PREPARED BY: SHANNON & WILSON, INC.

REGIONAL GEOHYDROLOGY CROSS-SECTION THROUGH THE SMITH-BYBEE WETLANDS

NOTE:
GEOLOGIC CONTACTS ARE ASSUMED OR EXTRAPOLATED IN AREAS WITHOUT WELLS AND BORINGS; CITY OF PORTLAND DATUM.

Port of Portland

GRAPHIC SCALE IN FEET

500 0 500 1000 1500 2000 2500

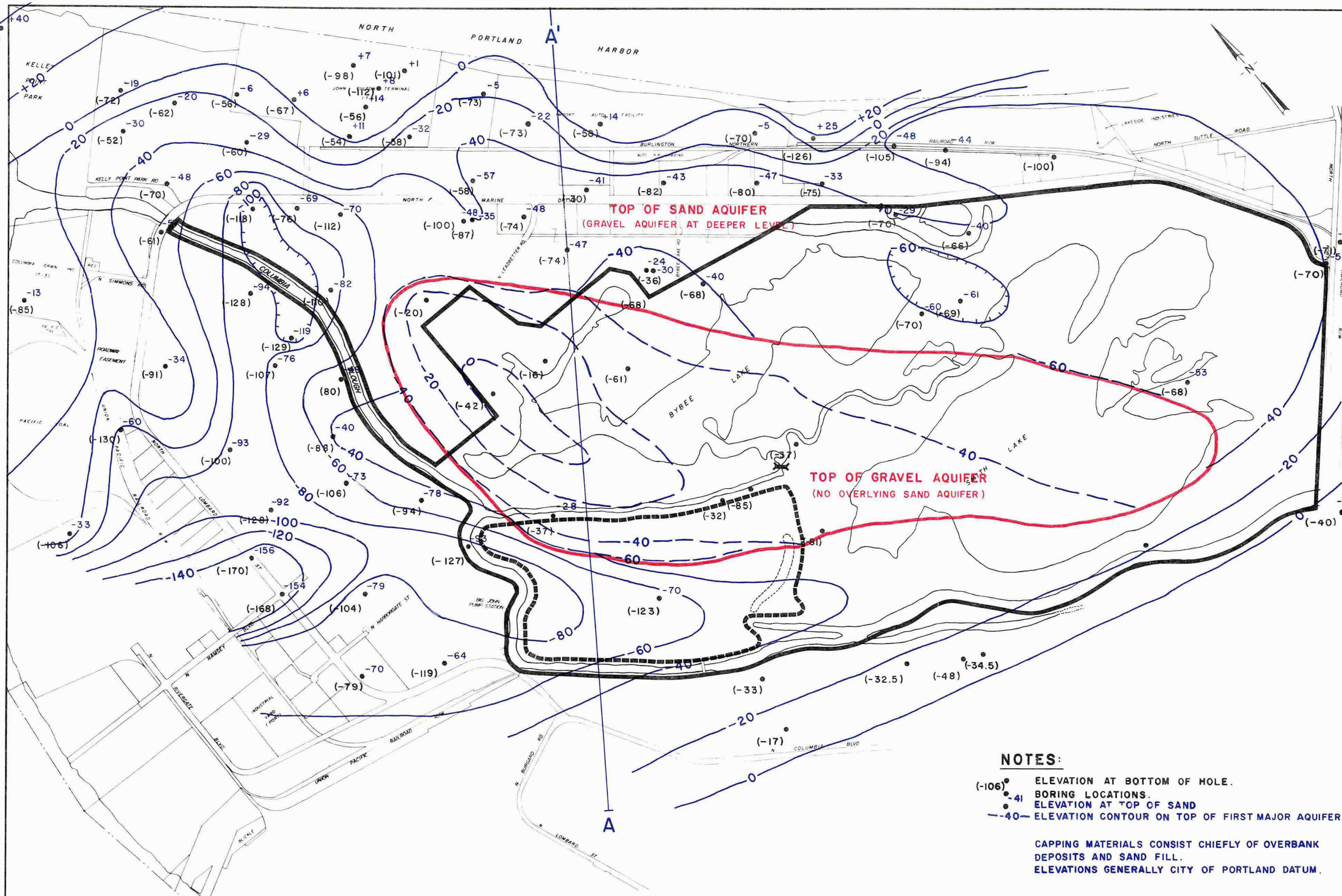
DECEMBER, 1986

SMITH AND BYBEE LAKES
MANAGEMENT PLAN
ENVIRONMENTAL STUDIES
REGIONAL GEOHYDROLOGY CROSS - SECTION

SUBMITTED BY: [signature]
SENIOR PLANNER, LAND DEVELOPMENT

DRAWING NO.: RG 86-511 9/23 (C-9)

PLATE B-1



NOTES:

(-106) • ELEVATION AT BOTTOM OF HOLE.
• BORING LOCATIONS.
-41 ELEVATION AT TOP OF SAND
—-40— ELEVATION CONTOUR ON TOP OF FIRST MAJOR AQUIFER.

CAPPING MATERIALS CONSIST CHIEFLY OF OVERBANK DEPOSITS AND SAND FILL.
ELEVATIONS GENERALLY CITY OF PORTLAND DATUM.

PREPARED BY : SHANNON & WILSON , INC.

ELEVATION CONTOURS ON TOP OF THE SAND FACIES OF THE PLEISTOCENE GRAVEL AQUIFER.

LEGEND

- LANDFILL DIKE
- CONTROL STRUCTURE
- TREE / SHRUB LINE - SMITH & BYBEE LAKES, SHORELINE - COLUMBIA SLOUGH
- STUDY AREA BOUNDARY / TOP OF BANK (APPROX. 30 FT.)
- A——A' CROSS SECTION SHOWN IN PLATES B-1, B-4, B-5

Port of Portland

GRAPHIC SCALE IN FEET

500 0 500 1000 1500 2000 2500

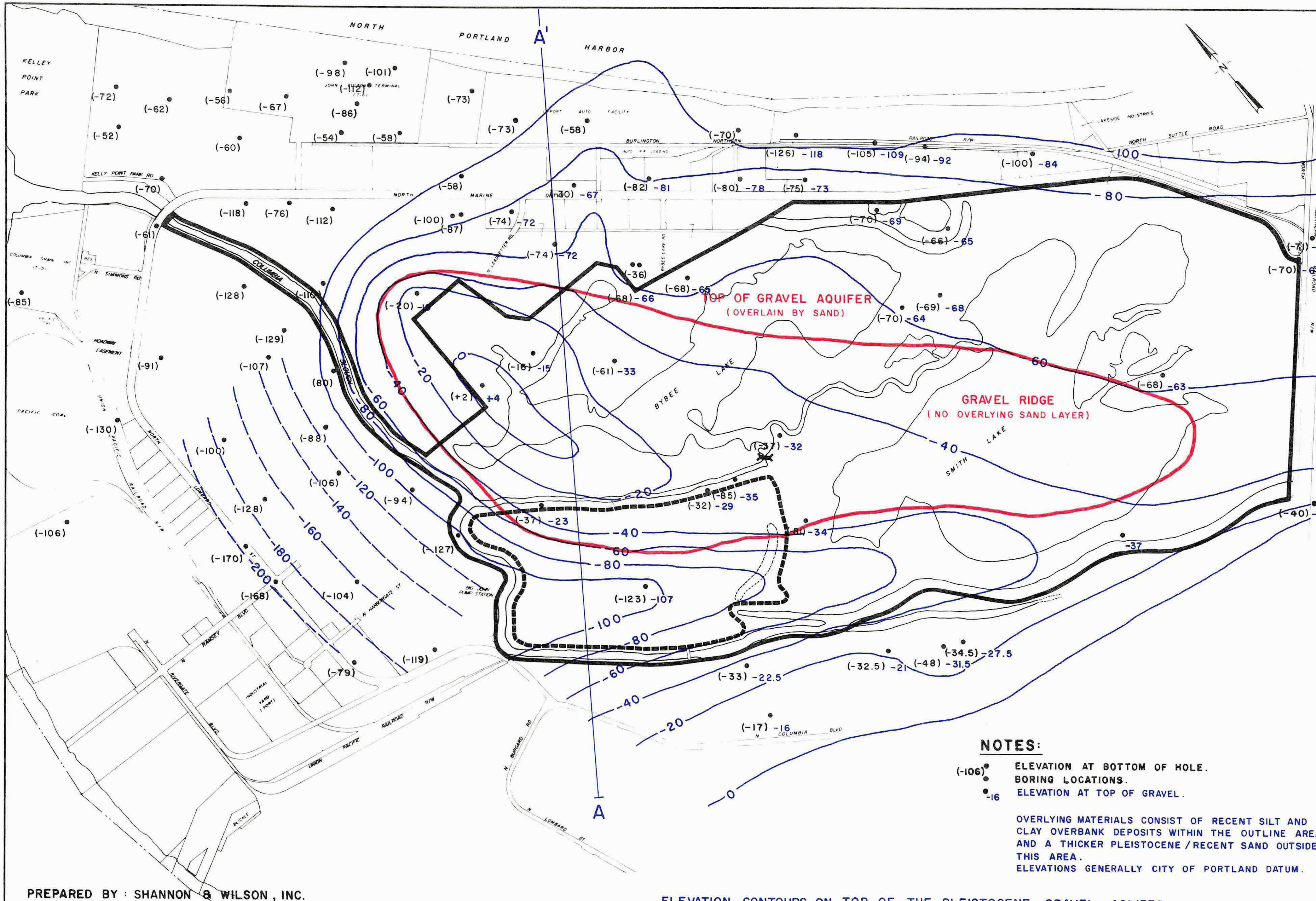
DECEMBER , 1986

SMITH AND BYBEE LAKES
MANAGEMENT PLAN
ENVIRONMENTAL STUDIES
TOP OF SAND FACIES

SENIOR PLANNER, LAND DEVELOPMENT

RG 86-511 10/23 (C-10)

PLATE B - 2



PREPARED BY : SHANNON & WILSON, INC.

ELEVATION CONTOURS ON TOP OF THE PLEISTOCENE GRAVEL AQUIFER.

LEGEND

- LANDFILL DIKE
- CONTROL STRUCTURE
- TREE / SHRUB LINE - SMITH & BYBEE LAKES, SHORELINE - COLUMBIA SLOUGH
- STUDY AREA BOUNDARY / TOP OF BANK (APPROX. 30 FT.)
- A — A' CROSS SECTION SHOWN IN PLATES B-1, B-4, B-5

Port of Portland

GRAPHIC SCALE IN FEET

500 0 500 1000 1500 2000 2500

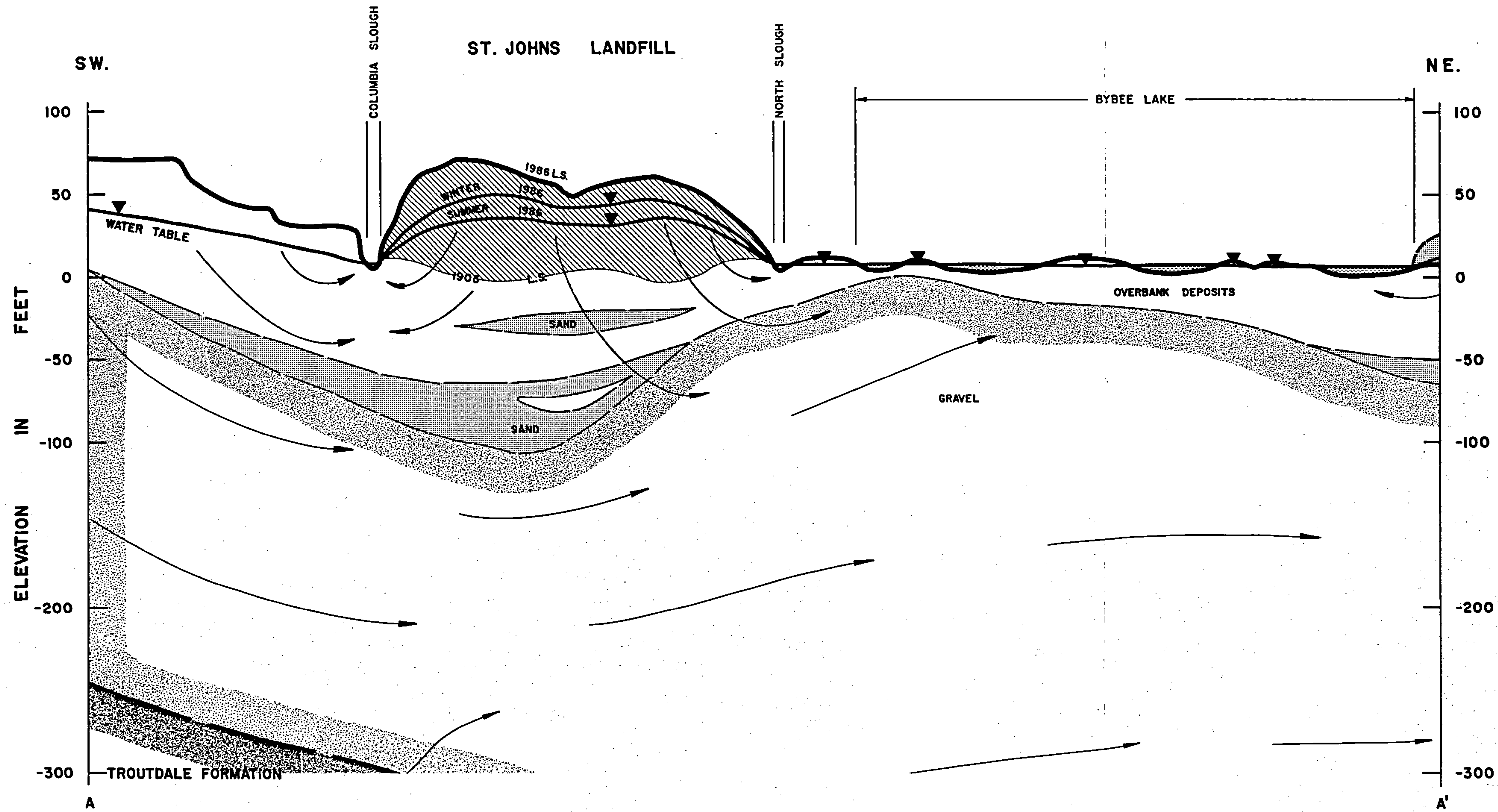
DECEMBER, 1986

SMITH AND BYBEE LAKES
MANAGEMENT PLAN
ENVIRONMENTAL STUDIES
TOP OF GRAVEL AQUIFER

SENIOR PLANNER, LAND DEVELOPMENT

RG 86-511 11/23 (C-11)

PLATE B-3



PREPARED BY: SHANNON & WILSON, INC.

CROSS-SECTION SHOWING LEACHATE MOUNDING AND GROUND-WATER FLOW PATHS AT ST. JOHNS LANDFILL.

Port of Portland

GRAPHIC SCALE IN FEET

250 0 250 500 750 1000 1250

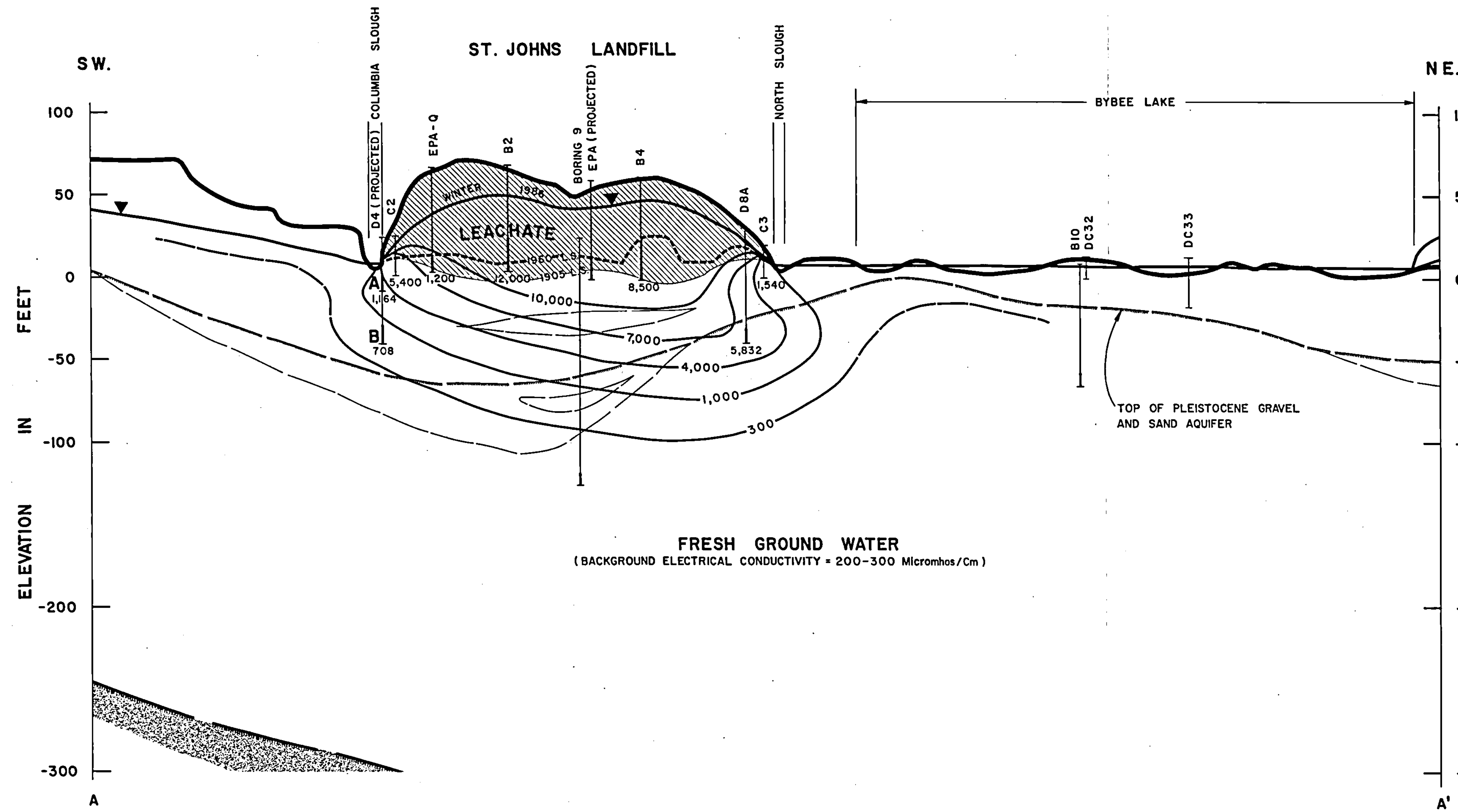
DECEMBER, 1986

SMITH AND BYBEE LAKES
MANAGEMENT PLAN
ENVIRONMENTAL STUDIES
LEACHATE AND GROUNDWATER CROSS-SECTION

SUBMITTED BY:
SENIOR PLANNER, LAND DEVELOPMENT

DRAWING NO.: RG 86-511 12/23 (C-12)

PLATE B-4



PREPARED BY: SHANNON & WILSON, INC.

CROSS-SECTION SHOWING ST. JOHNS LANDFILL ESTIMATED CONTOURS OF ELECTRICAL CONDUCTIVITY.

NOTE:

FLUID CONDUCTIVITY DATA MEASURED ON FEB. 13, 1986 UNLESS NOTED; CONDUCTIVITY VALUES IN UPPER LEVELS OF GARBAGE MASS ARE NOT KNOWN. CONDUCTIVITY PATTERN IS HIGHLY GENERALIZED AND ASSUMES UNIFORM DISTRIBUTION OF LEACHATE ALONG GROUNDWATER FLOW PATH. ACTUAL DISTRIBUTION PATTERN WOULD BE EXTREMELY COMPLEX.

Port of Portland

GRAPHIC SCALE IN FEET

250 0 250 500 750 1000 1250

DECEMBER, 1986

SMITH AND BYBEE LAKES
MANAGEMENT PLAN
ENVIRONMENTAL STUDIES
CONTOURS OF ELECTRICAL CONDUCTIVITY

SUBMITTED BY:

SENIOR PLANNER, LAND DEVELOPMENT

DRAWING NO.: RG 86-511 13/23 (C-13)

PLATE B-5

C WATER QUALITY

SMITH AND BYBEE LAKES ENVIRONMENTAL STUDIES

TECHNICAL APPENDIX C: WATER QUALITY

Project Sponsored By:
Port of Portland
and
City of Portland Bureau of Environmental Services

Project Managed By:
Fishman Environmental Services

PREPARED BY:
Stan Geiger
Scientific Resources, Inc.
12425 S.W. 57th Avenue
Portland, Oregon 97219
16 December 1986

PREPARED FOR:
Fishman Environmental Services
P. O. Box 19023
Portland, Oregon 97219

TABLE OF CONTENTS

APPENDIX

LIST OF TABLES

LIST OF FIGURES

1.0 INTRODUCTION

The primary reason for restricting water flow between Smith and Bybee Lakes and the Columbia Slough system (Fig. 1-1) was to stop outbreaks of avian botulism in Smith Lake by maintaining a higher water level in that lake (USACE 1982, 1983). The discussion of whether or not to construct the water control structure at the upper end of North Slough to retain water in the lakes only rarely mentioned the possible benefit of preventing degraded Slough water from entering the lakes (USACE 1982). Slough water quality has been a "sleeper" in the process of deciding what to do about water levels in the lakes. The following report on field investigations and review of previous data on water quality in the Sloughs provides an evaluation of whether it would be more or less desirable to restrict water in the Sloughs from the lakes. The report also provides an evaluation of the quality of the impoundment created by the control structures on the basis of historical data and data obtained during this study.

At least since 1971, when the quality of Slough water began to be documented, water quality conditions in the Columbia Slough have been poor (City of Portland 1972, 1986; Oregon Department of Environmental Quality 1974). Apparently water quality before 1971 was very bad due to use of the Slough to dispose of meat packing and other wastes (Barber 1977). The degraded water quality of the Slough since 1971 has resulted from a variety of identified influences including storm sewer outfalls and wet weather bypassing of a combination of untreated wastes and storm water runoff, meat processing plant wastes, septic tanks and cesspools in North Portland and in east Multnomah County, industrial wastes, and turbidity from carp. Slough water quality has been improved by diverting meat processing plant and other industrial wastes from the Slough, but other sources of contaminants remain (ODEQ 1974, City of Portland 1986, Quan, Sweet and Illian 1974).

Bacterial contamination of ground and surface water by leachates from sanitary landfills has been reported by the U. S. Environmental Protection Agency (EMCON Associates 1983). The St. John's Landfill, at the entrance to both of the Lakes has been identified as a source of leachate into the adjacent Sloughs (Sweet, Edwards and Associates, Inc. 1983; ODEQ 1974). As recently as fall of 1985, leachate and surface water of poor quality, being collected at the perimeter of the "Blind Slough" area of the St. John's Landfill, was being pumped into Smith Lake and into the remaining segment of Blind Slough connected to the Columbia Slough (Scientific Resources, Inc. 1986). During 1986, leachate was pumped to the City sanitary sewer system, but some pumping of water into the Columbia Slough from the remnant of Blind Slough still occurred. This pumping to the Slough was halted in mid-December, 1986, when tests revealed that the water was of poor quality. Facilities are in place for this leachate to be collected and diverted by METRO for treatment at the Columbia Blvd. Treatment Plant.

As an additional indicator of potential problems with Slough water quality, fecal coliform densities in the Columbia Slough November and December 1985 near the Landfill bridge were found to be 5,000, 9,000 and 160,000 col./100 ml. (Scientific Resources, Inc. 1986). These numbers suggested exceedence of the state standards ["A log mean of 200 fecal coliform per 100 milliliters based on a minimum of 5 samples in a 30-day period with no more

SCIENTIFIC RESOURCES, INC.

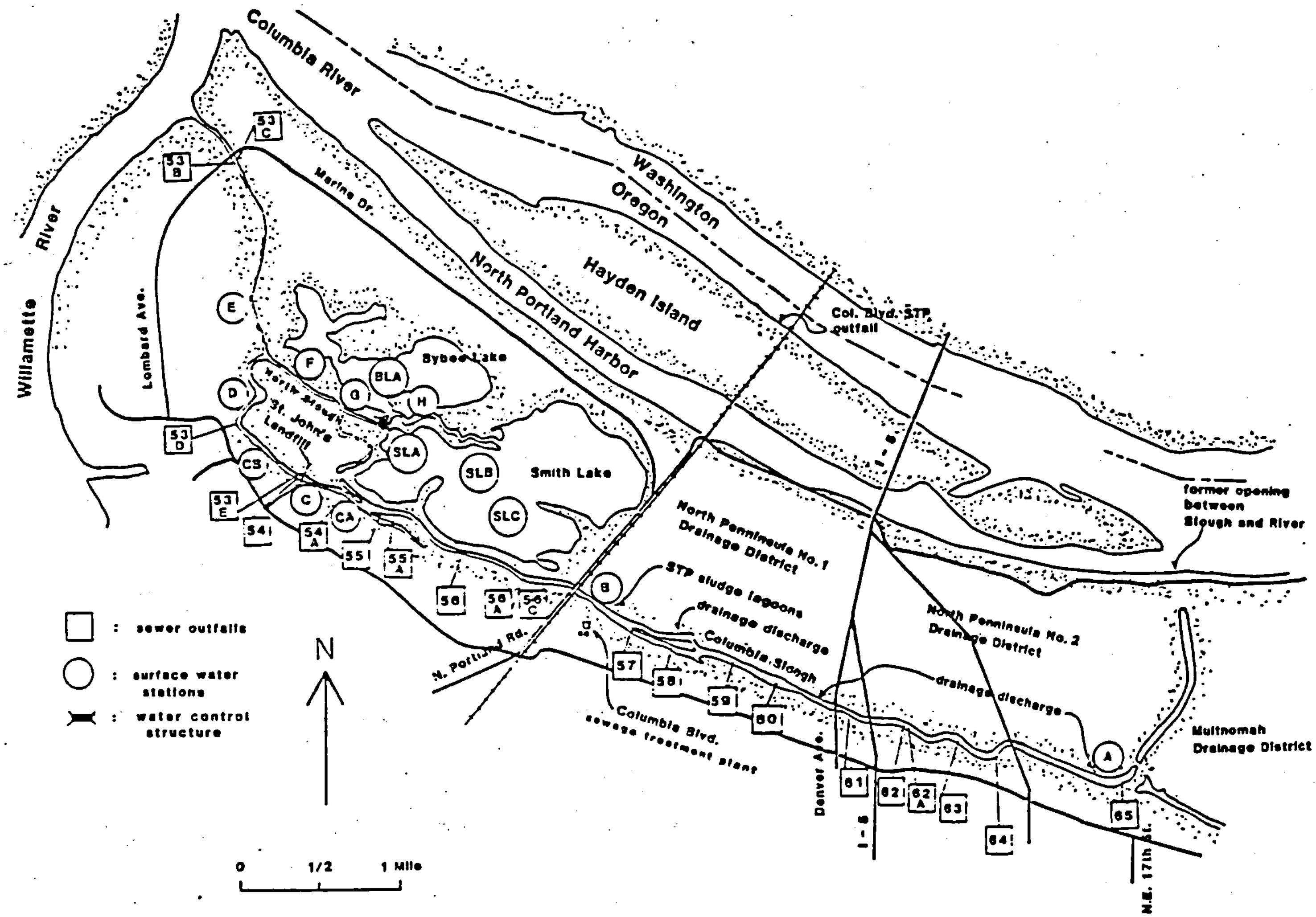


Figure 1-1. The Lower Columbia Slough system. Historical surface water sampling stations are shown as circles. Numbered storm sewer outfalls are shown as squares.

than 10 percent of the samples in the the 30-day period exceeding 400 per 100 ml." OAR 340-41-445].

Objectives. The presence of the Landfill at the entrance to Smith and Bybee Lakes, the indicators of present degraded Slough water quality, and the known or suspected influence of other contaminant sources on the water quality of the Slough and possibly the Lakes, led to the funding and design of this water quality study. Study objectives included:

1) Investigate the effects of the Landfill and other known sources of bacterial contamination on Slough water quality.

2) Review historical surface water quality data on the Slough and the Lakes from the standpoint of compliance with State water quality standards and projected beneficial uses of these waters.

2.0 FIELD INVESTIGATIONS

2.1 Methods

Field investigations were conducted during May and September, 1986. These times corresponded with high and low river conditions, respectively. The tidal influence on Slough water was used to estimate the influence of the St. John's Landfill and storm sewer outfalls on Slough water quality. Water quality parameters of Willamette-Columbia River water (hereafter called River water) were observed during tidal reversal as River water moved up the Slough to the vicinity of the Landfill; these parameters were then observed on the falling tide (River water had distinctly different temperature and conductivity). Information on discharge from the Upper Columbia Slough to the Lower Slough during the period of Slough sampling were obtained from the Multnomah County Drainage District.

Measurements of fecal coliform bacteria, temperature, conductance, dissolved oxygen, pH, velocity and flow direction of surface water were made at four stations (E, CA, B and F; see Fig. 1-1)during the tidal cycle. (Station names are those of historical water quality sampling stations in the Lower Columbia Slough, all of which are shown on Fig. 1-1.) Field Hydrolab and Chemtrix units were used to obtain measurements of pH, conductance, temperature and dissolved oxygen. Flow direction and velocity were determined by timing surface drogue movement through a measured distance. Triplicate measurements of the same set of parameters were made and samples collected: 1) within the leading edge of the River water on the rising tide at station E down-Slough of the landfill, 2) within the upper edge of the farthest excursion of the River water up-Slough, and 3) again at Station E as the River water receeded on the falling tide. These triplicate measurements were made in mid-channel and approximately one-third of the way out from each bank. Chlorophyll a samples were obtained during each of the sampling times at Station E from mid-channel. As an additional indicator of the location of Willamette River water, numbered drogues were placed in mid-channel at Station E within the leading edge of the River water, and tracked as they moved up-Slough.

On the morning of the same day that sampling was conducted in the Slough, the City of Portland Bureau of Environmental Services sampled storm and combined sewers located along the lower stretch of the Columbia Slough from just above the Columbia Boulevard Treatment Plant (sewer No. 57, see Fig. 1-1) to the Lombard St. Bridge. The term "combined" sewer indicates a sewer that carries sanitary and storm flows diverted during heavy rainfall events to outfalls discharging into the Slough. Sewers were sampled from upland manholes because many of the outfalls are located beneath the Slough water levels. Two sewers were sampled from the Slough because of inaccessibility upland. Estimates of discharge were made where there was discharge, and water samples were obtained for fecal coliform analysis.

Five wells on the north (D-1c), southwest (D-4a, D-4b) and northeast (D-8a, C-3) sides of the St. Johns landfill were sampled on 29-30 May by DEQ and 18 September by the Project Team (Fig. 2-1). Wells were first purged of three volumes of water using a submersible pump or a dedicated baler, samples were then obtained, using a dedicated baler, for bacterial analysis. Samples

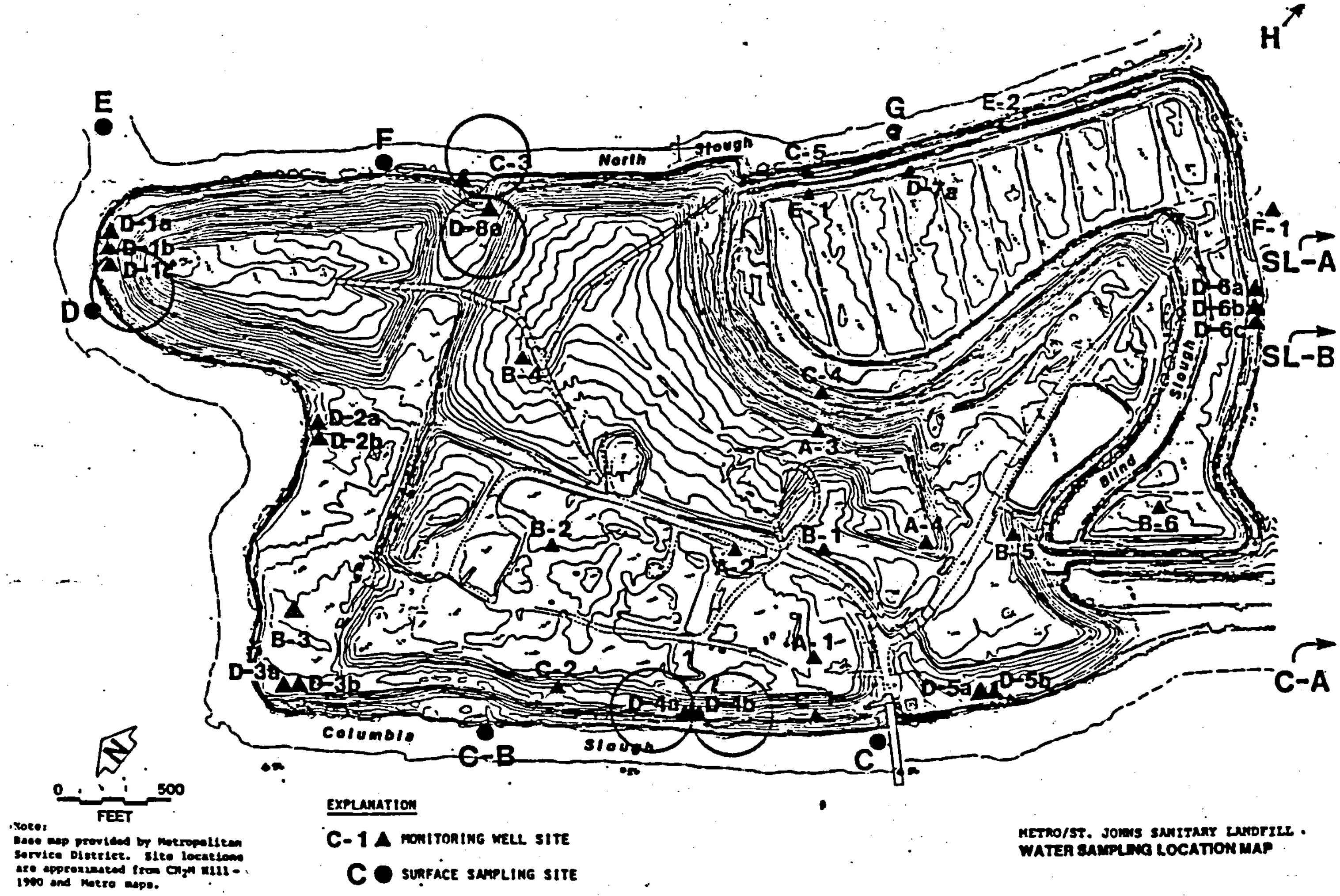


Figure 2-1. Locations of monitoring wells (circled) at the St. John's Landfill. Circled wells were sampled 29 - 30 May and 18 September 1986 for this project.

were analyzed for fecal coliform bacteria. Selection of these wells was based on well depth, location in relation to the water table gradient, which was determined from the quarterly sampling of wells at the landfill (METRO water quality data, sampled by CH2M Hill February 13, 1986), and on location in relation to recent solid waste disposal. Monitoring well specifications are provided in Table A-9 of Appendix A.

Fecal coliform samples from surface water sampling were analyzed by the Laboratory at the Columbia Boulevard Treatment Plant. Detection levels were 10 fecal coliform colonies/100 ml of sample. Chlorophyll a samples were analyzed by SRI.

2.2 Findings: High Water Sampling (27 May)

2.2.1 Hydrology

Water level fluctuations of the Columbia River at Astoria (Tongue Point) due to tidal influences the day of sampling were 9.1 ft MSL at 0402, -1.4 at 1125, 7.1 at 1804 and 3.1 at 2319. The water levels of the Columbia River at the Vancouver I-5 Bridge and the Willamette River at the Morrison Street Bridge the day of sampling are shown in Fig. 2-2. During the sampling water levels fluctuated over a range of approximately 2 ft. Water levels at the Landfill Bridge recorded through the day are shown as points on the graph in Fig. 2-2.

Rainfall (in inches) preceding the day of May 27 sampling was: 0.00 (22), 0.00 (23), 0.00 (24), 0.00 (25), trace (26) and 0.00 (27) (Columbia Boulevard Treatment Plant).

Discharge into the lower Slough from Multnomah Drainage District No. 1 was 217.3 cfs from 600 - 920 on the 27th (pumped water). Water free-flowed from the District into the lower Slough a total of 12.5 hours at a rate averaging 59.4 cfs. Lower Slough velocity and direction of flow is provided in Appendix A.

2.2.2 Temperature, Conductivity and Bacteria in Columbia Slough

River water was tracked on the rising tide as far up-Slough as the landfill bridge, and then back to the mouth of Columbia Slough on the falling tide. Differences in the quality of water at different times through the tidal cycle reflected the presence of both River and Slough water. These differences in relation to water level changes and time are shown on Figs. 2-2, 2-3 and 2-4. Differences in temperature and conductivity between River and Slough water made it relatively easy to track the River water. Generally the temperature and conductivity of the River water were around 15 - 17°C and 125 - 135 micromhos/cm, respectively, while that of the Slough water were 19 - 20+ °C and 180 - 220 micromhos/cm (Figs. 2-3 and 2-4; see data in Appendix A, Tables A-1 through A-6).

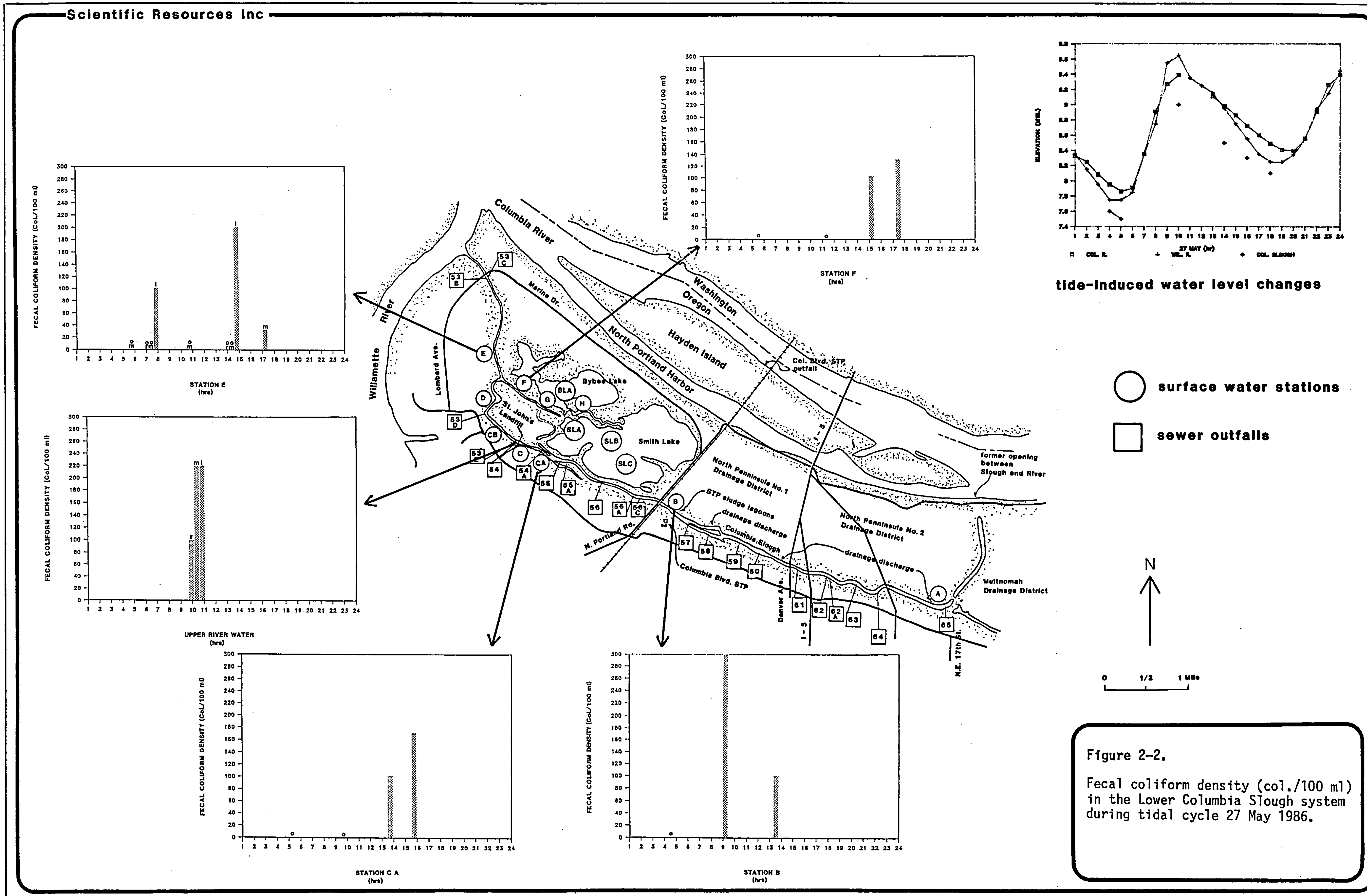


Figure 2-2.

Fecal coliform density (col./100 ml) in the Lower Columbia Slough system during tidal cycle 27 May 1986.

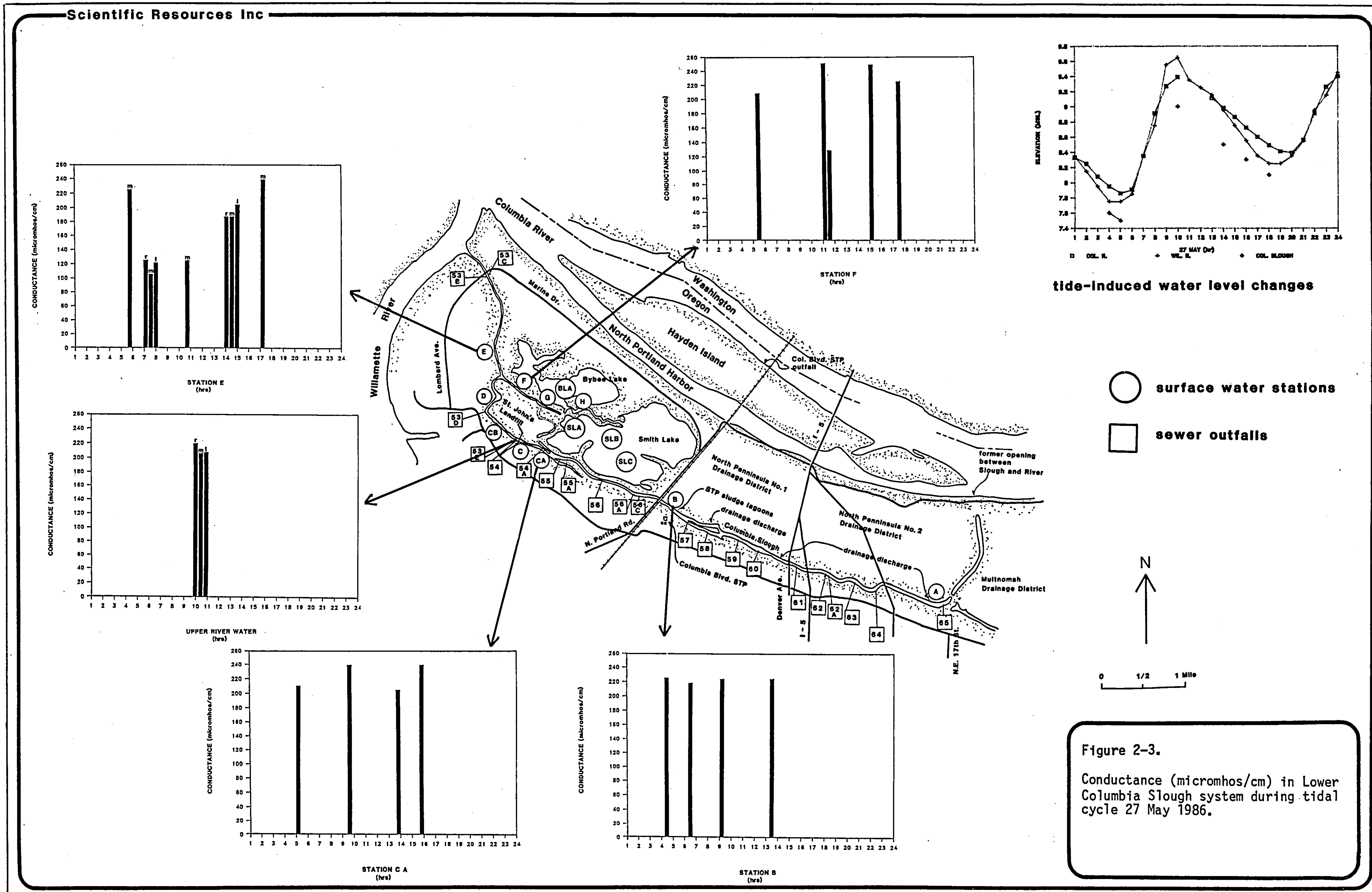


Figure 2-3.

Conductance (micromhos/cm) in Lower Columbia Slough system during tidal cycle 27 May 1986.

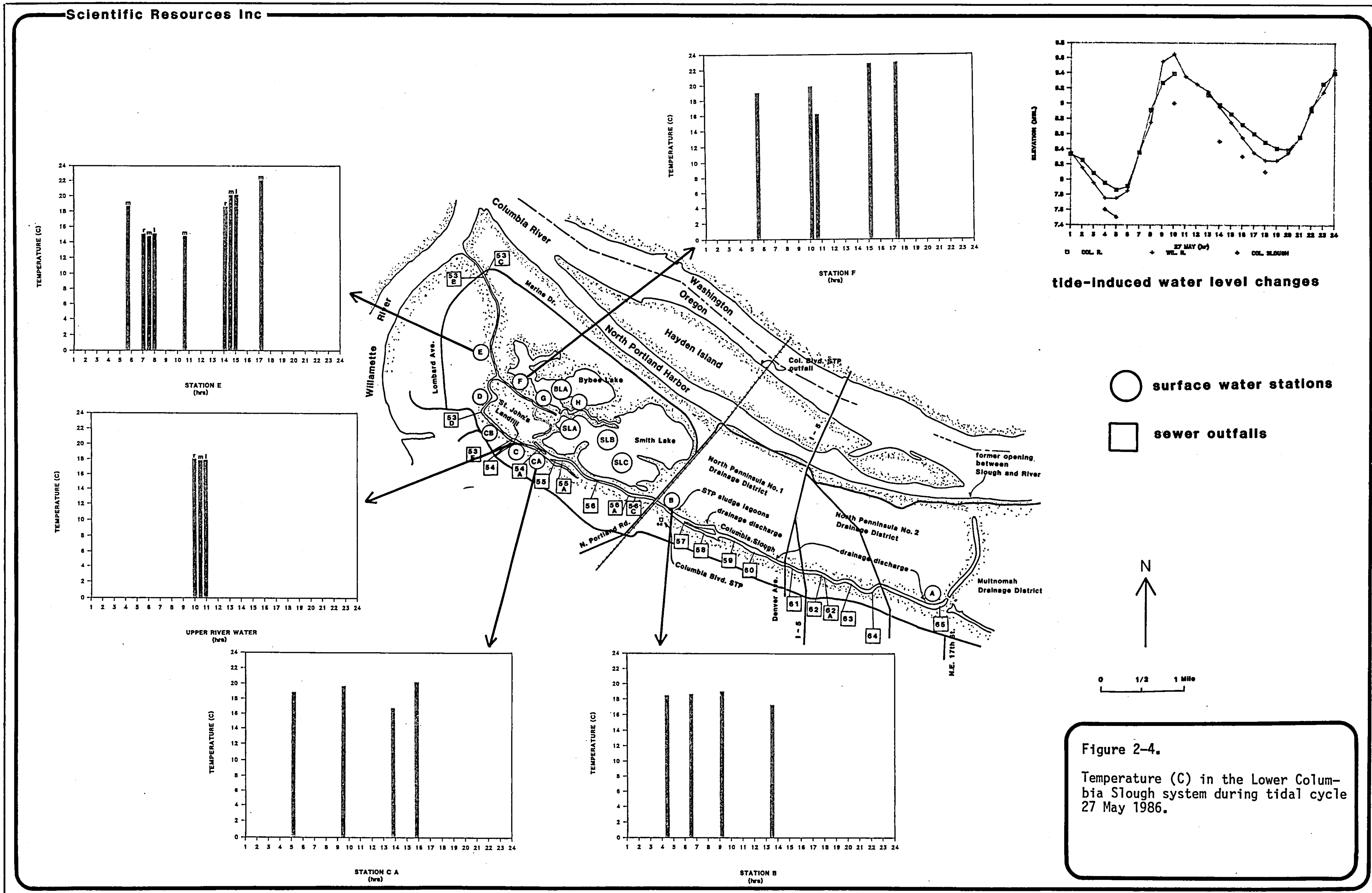


Figure 2-4.

Temperature (C) in the Lower Columbia Slough system during tidal cycle 27 May 1986.

Triplicate sampling for fecal coliform bacteria at 0753 hrs at Station E, as the River water moved up-Slough past that station, showed no bacteria at the right and middle sites (right = right-hand side of Slough looking down-Slough, or toward the mouth). On the left side, fecal coliforms were detected at levels of 100 col/100 ml (Fig. 2-2). Temperatures averaged 15.5°C and conductivity averaged 118.3 micromhos/cm.

At the furthest excursion of the River water, at 1000 hrs at the Landfill bridge, (shown as "upper River water" in Figs. 2-2, 2-3 and 2-4), temperature had increased to an average of 18.1°C, while conductivity had increased to an average of 210 micromhos/cm. Fecal coliform levels were 100, 200, and 200 col./100 ml, suggesting water passing the Landfill may have been influenced by the Landfill on its upward excursion.

As the River water receeded down-Slough, sampling at 1450 hrs at Station E showed temperature averaged 20.1°C and conductivity 195 micromhos/cm. Fecal coliform bacteria were detected at levels of 200 col./100 ml again in the sample from the left side (Fig. 2-2). At approximately the same time (1430 hrs) at the Lombard Bridge down-Slough, temperature averaged 17.4°C, conductivity averaged 133.7 micromhos/cm and fecal coliforms were not detected (Fig. 2-5); this was River water that had moved up-Slough to just below the Landfill.

The complete data set from Station E, with sampling from 0543 - 1703 hrs is provided in Appendix A Table A-1. As noted, measurements of chlorophyll a and Secchi disk depth were obtained during the day at this station. Chlorophyll a levels ranged from 16 mg/m_3 to 69.5 mg/m_3 (Appendix A, Table A-1). The low levels correspond with River water, while the high values were typical of Slough water.

Data from water quality sampling at other locations in the Slough is provided in Appendix A, Tables A2 - A6. Stations CA and B above the Landfill, and F in North Slough were sampled at mid-channel at various times through the tidal cycle. At stations CA and B, sampled at slack water at 0504 hrs and 0429 hrs, respectively, no fecal coliform bacteria were detected (Fig. 2-2). As water began to move up-Slough, sampling at Station B at 0907 hrs had the highest fecal coliform levels of the day of 300 col./100 ml, while water sampled at Station CA at 0937 hrs showed no fecal coliforms (Fig. 2-2). After the tide reversed and Slough water began to flow down-Slough (about 1100 hrs), sampling at CA and B showed the presence of fecal coliform bacteria: 100 and 170 col./100 ml at CA at 1351 hrs and 1555 hrs and 100 col./100 ml at 1326 hrs.

The data from Slough stations CA and B on May 27 do not provide consistent supporting evidence for bacterial contamination in the vicinity of the landfill. Samples collected from stations CA and B at 0937 hrs and 0907 hrs, which represented Slough water that had travelled past the Landfill on the outgoing tide, and then up-Slough past the Landfill again on the incoming tide, had no fecal coliforms in the 0937 hrs sample at CA and 300 col./100 ml in the 0907 hrs sample from B (Fig. 2-2). Fecal coliforms originating from outfall No. 57 may account for these levels at Station B (see next Section 2.2.3).

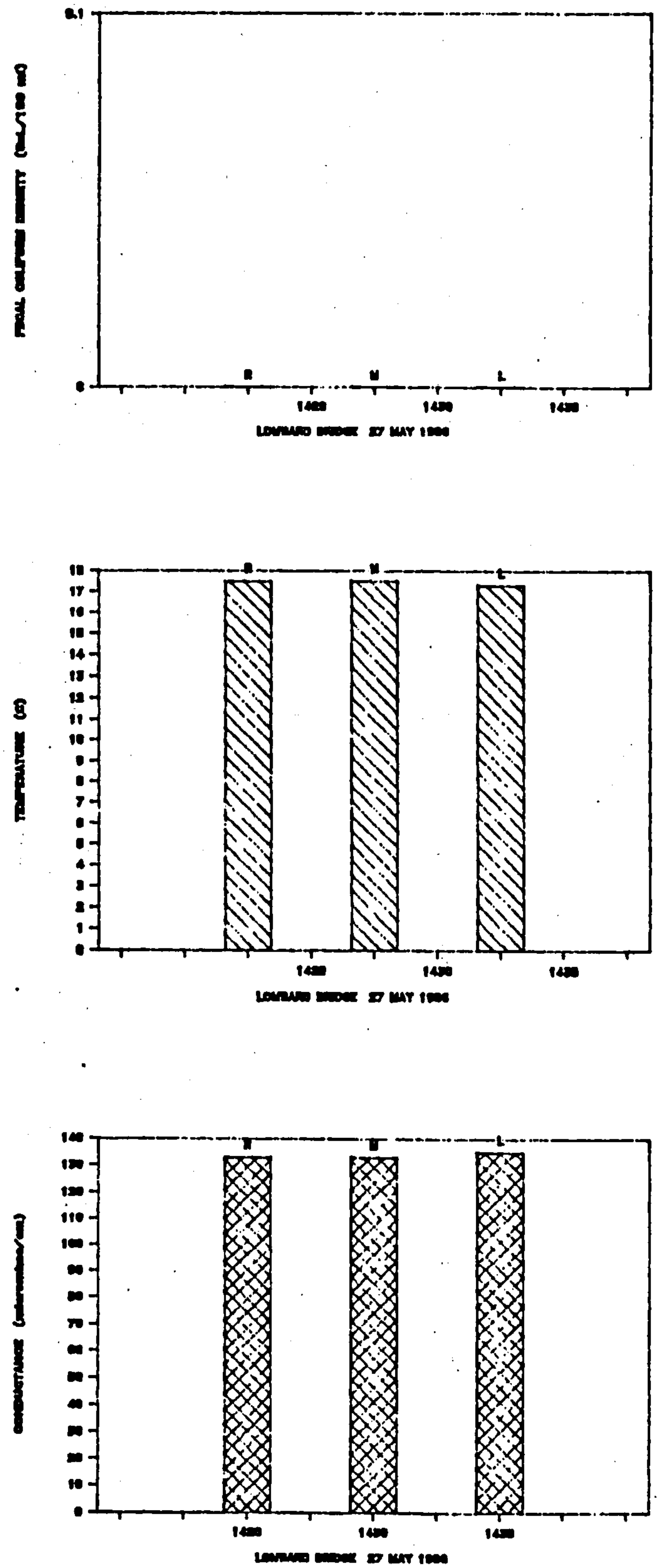


Figure 2-5. Fecal coliform density, temperature, and conductance in Columbia Slough at the Lombard Street Bridge 27 May 1986.

The station in North Slough, Station D, was sampled through the tidal cycle. Temperature and conductivity data suggest that cooler River water travelled along the bottom up North Slough raising water levels in that dead-end arm (Appendix A, Table A-2). No fecal coliforms were detected in water sampled at 0532 hrs and 1110 hrs, however, fecal coliforms were detected in samples from 1505 hrs (100 col./100 ml) and 1723 hrs (130 col./100 ml) on the falling tide. Since there are no storm or combined outfalls in North Slough, these increases in fecal coliform presumably derive from landfill surface water runoff or ground water seepage into North Slough (see Section 3.5.3).

2.2.3 Outfall Bacteria and Flow

Of the 12 sewer outfalls along the length of the Columbia Slough segment sampled (see Fig. 1-1), only 5 had flow sufficient for sampling. Results of sampling were as follows (0 = less than 10 col./100 ml.):

OUTFALL NUMBER	OUTFALL TYPE	TIME	FLOW (gpm)	FECAL COLIFORM (col./100 ml)
53B	STORM	1430	8	0
53D	STORM	1009	20	0
54A	STORM	0915	90	0
56A	STORM	0835	40	0
57	COMB.	0817	3	385,000

This source of fecal coliform bacteria near Station B could have accounted for the high fecal coliform level detected there at 0907 hrs (see Appendix Table 4 and discussion in Section 3.2).

2.2.4 Bacteria In Selected Landfill Wells

Results of sampling the five wells at the Landfill are presented below for this study (May 30, 1986), and two previous sampling periods (0 = less than 3 col./100 ml.):

WELL NUMBER/	REPLICATE	FECAL COLIFORM (col./100 ml) Nov. 21, 1984	May 14, 1985	May 30, 1986
D8A	rep. 1	240	0	93
	rep. 2			0
C3	rep. 1	7	0	0
	rep. 2			7
D1C	rep. 1	2400	150	23
	rep. 2			4
D4A	rep. 1	460	43	43
	rep. 2			0
D4b	rep. 1	2400	9	9
	rep. 2			4

Fecal coliforms were present in each of the wells sampled, but at relatively low concentrations. Differences between the two separate samples (replicates) from each of wells C3, D1C and D4b are not statistically different (APHA 1985). Differences between replicates from D8A and D4A were significant. Results of previous DEQ well sampling is provided in the Table for comparison (see Appendix A, Table A-9 for monitoring well specifications). The data suggest that fecal coliform densities in the wells, and therefore in the leachate, vary seasonally, with highest concentrations occurring during wet weather (November). However, the D series of wells were installed shortly before the November 1984 sampling, and wells could have been contaminated by garbage and leachate during installation. These results indicate that fecal coliform bacteria are in water within the Landfill. Sweet, Edwards and Associates, Inc. (1983; see also METRO 1983) reported that water within the Landfill would most likely move into adjacent Sloughs due to site-specific hyudrologic considerations. The presence of fecal coliform bacteria in well samples tend to support the findings of EMCON that fecal coliform bacteria are long-lived in landfills (EMCON 1983).

2.2.5 Smith and Bybee Lakes Bacteria

Results of sampling Smith and Bybee Lakes May 30 (single samples from mid-lake stations in each lake) showed fecal coliform bacteria at levels of 4 col./100 ml. in each lake. River, and hence, Slough levels were rising during this period, so that some Slough water may have been introduced into the lakes. Water level observations on May 28 did not find Slough water entering the lakes; water was entering the lakes on June 5.

2.3 Conductance Survey of Smith and Bybee Lakes.

On June 20 an extensive survey was done of the lakes to detect differences in conductance within each lake that might indicate influx of higher or lower conductance ground water. Higher conductance ground water might indicate affects of possible leachate contamination, as discussed in Technical Appendix B (Shannon and Wilson, 1986). Measurements of conductance have been mapped on the base map and are provided in Appendix A, as Map 1. Conductance is a measure of the capability of water to pass an electrical current, all values in this text are micromhos/cm. Higher conductance reflects the presence of more ionized chemical species in solution. Leachate from the Landfill has high conductivity (4000 - 6000 micromhos/cm; see Section 3.5.3).

Bybee Lake was surveyed along the side adjacent to the Landfill. Conductance values ranged from 185 - 197 (see Map 1, Appendix A). Conductance values in North Slough on the same day along a north-south transect across the Slough ranged from 200 on the north side to 240 in mid-Slough to 320 next to the Landfill. Conductance of ground water below the north side of the Landfill is as high as 1000 (Shannon and Wilson, 1986). These data show no indication of influence from high conductivity ground water.

Conductance values in the channel connecting Bybee to Smith Lake ranged from 195-200. Conductance values in the southwest corner of Smith Lake suggest influx of water of lower conductance; values there ranged from 165 - 173. Values elsewhere in Smith Lake generally ranged between 180 - 190, with the exception of higher values in the east end of Smith Lake. Seeps of high conductivity fluid subsequently measured along the shore of Smith Lake along Marine Drive indicate a potential source of higher conductivities in this area (Technical Appendix B, Section 3.4).

2.4 Findings: Low Water Sampling (September 17)

2.4.1 Hydrology

Water level fluctuations of the Columbia River at Astoria (Tongue Point) due to tidal influences September 16 were 8.1 ft MSL at 0009 hrs, -1.0 ft at 0705 hrs, 7.5 ft at 1320 hrs, and 1.2 ft at 1910 hrs. On the day of sampling, September 17, the high and low water levels during the day at Astoria were 8.2 ft at 0102 hrs, -0.9 ft at 0745 hrs, 7.9 ft at 1358 hrs, and 0.6 ft at 1957 hrs. The water levels of the Columbia River at the Vancouver I-5 Bridge and water levels at the Landfill Bridge recorded through the day are shown in Fig. 2-6. Water levels were on average about 2 ft lower than in May, and the range of water level change during sampling was approximately 2.5 ft. Water levels in the Slough at the time of sampling were 2 - 3 ft lower than they were at the time of the May sampling.

Precipitation recorded at the Columbia Boulevard Treatment Plant in the five days preceding the day of sampling was: 0.00 (12), 0.00 (13), 0.00 (14), 0.10 (15) and 0.01 (16). Slough sampling began around midnight on September 16; the rain started around 0600 hrs on the 17th, and by noon 0.26 in of rain had fallen.

Discharge into the lower Slough from the Upper Columbia Slough, which is controlled by the Multnomah Drainage District No. 1 (see Fig. 1-1 for location of this point north of N.E. 17th Street) was negligible on both the 16th and 17th of September (Hayford, pers. com. 1986). The upper Slough was blocked off at the lower end of Upper Columbia Slough and the flow gates were closed. This has been done during summer months to impound sufficient water for irrigation purposes.

2.4.2 Slough Temperature, Conductivity, and Bacteria

Water from the Willamette River began to enter the Columbia Slough around 0100 hrs September 17 (see Fig. 2-6 for graph of water level elevations during sampling). Temperature differences between the River and Slough water were small, with Slough temperatures around 18^{o}C and River temperatures around 19^{o}C (Fig. 2-8). Larger differences in conductance of River and Slough water (150 River versus 200 Slough) made it possible to track River water moving up-Slough (Fig. 2-7). By using measurements of conductivity and movement of drogues, River water was tracked to the point shown on Fig. 2-6, less than one-half mile northwest of N. Portland Rd.

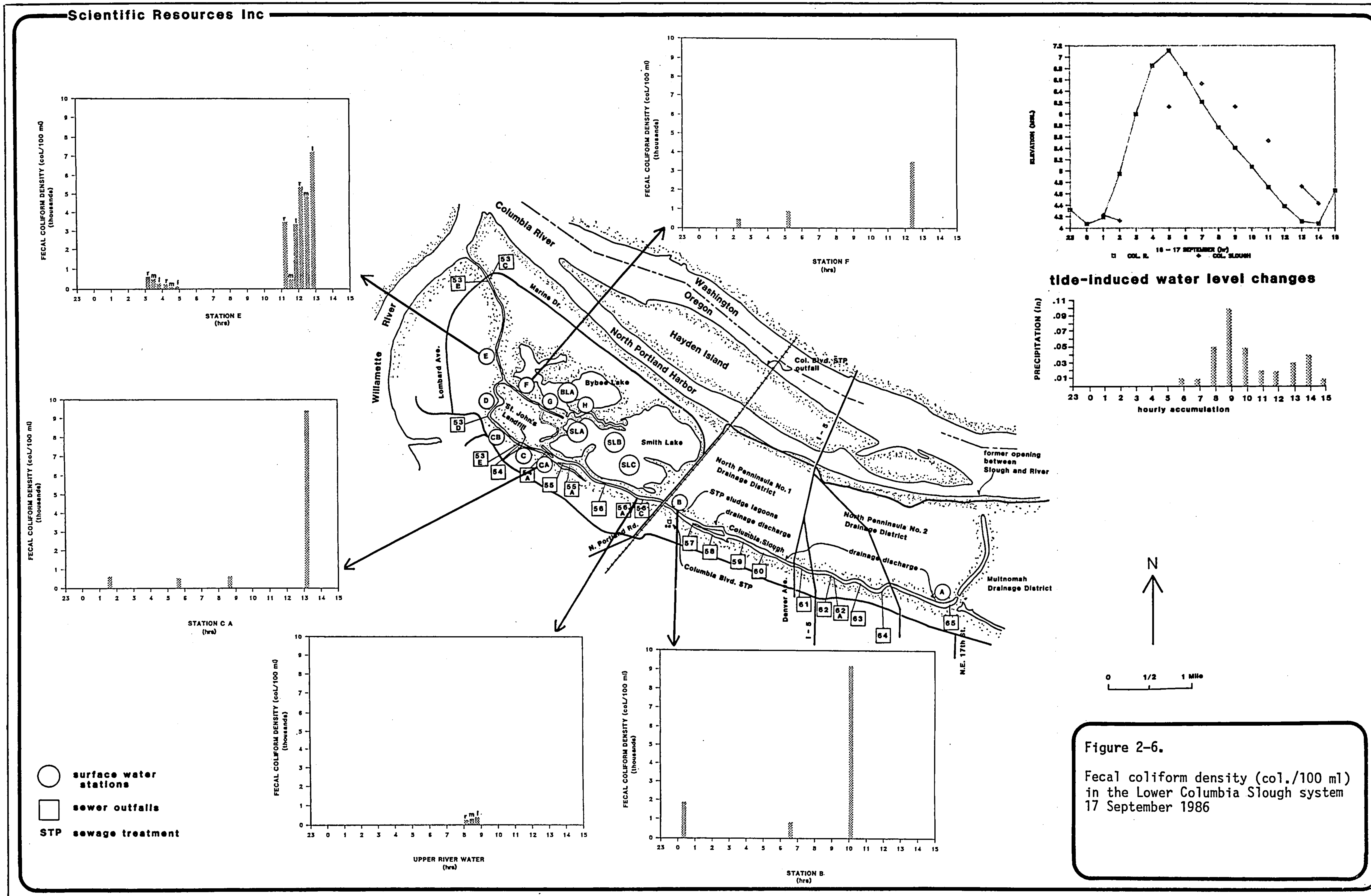


Figure 2-6.

Fecal coliform density (col./100 ml) in the Lower Columbia Slough system 17 September 1986

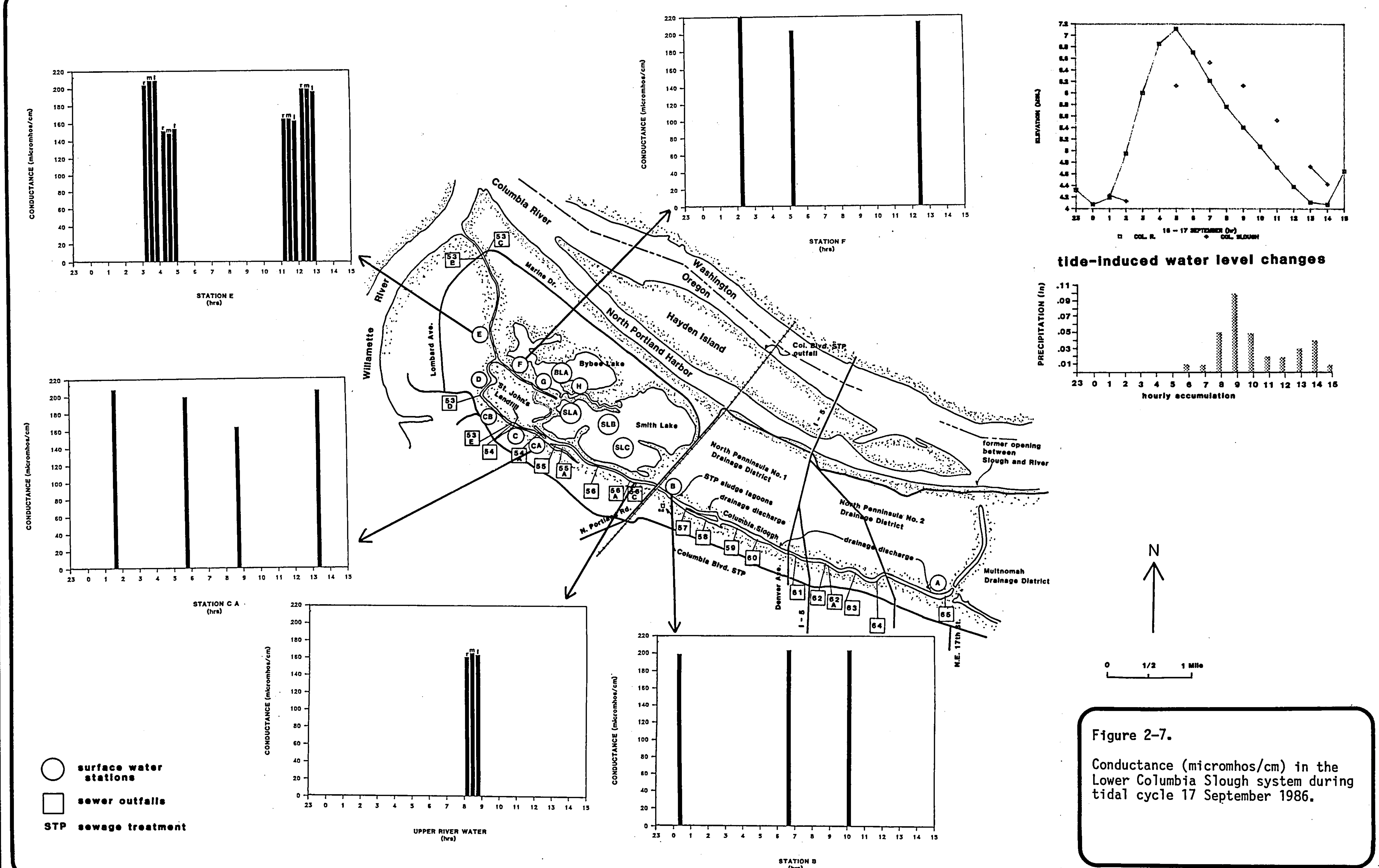


Figure 2-7.

Conductance (micromhos/cm) in the Lower Columbia Slough system during tidal cycle 17 September 1986.

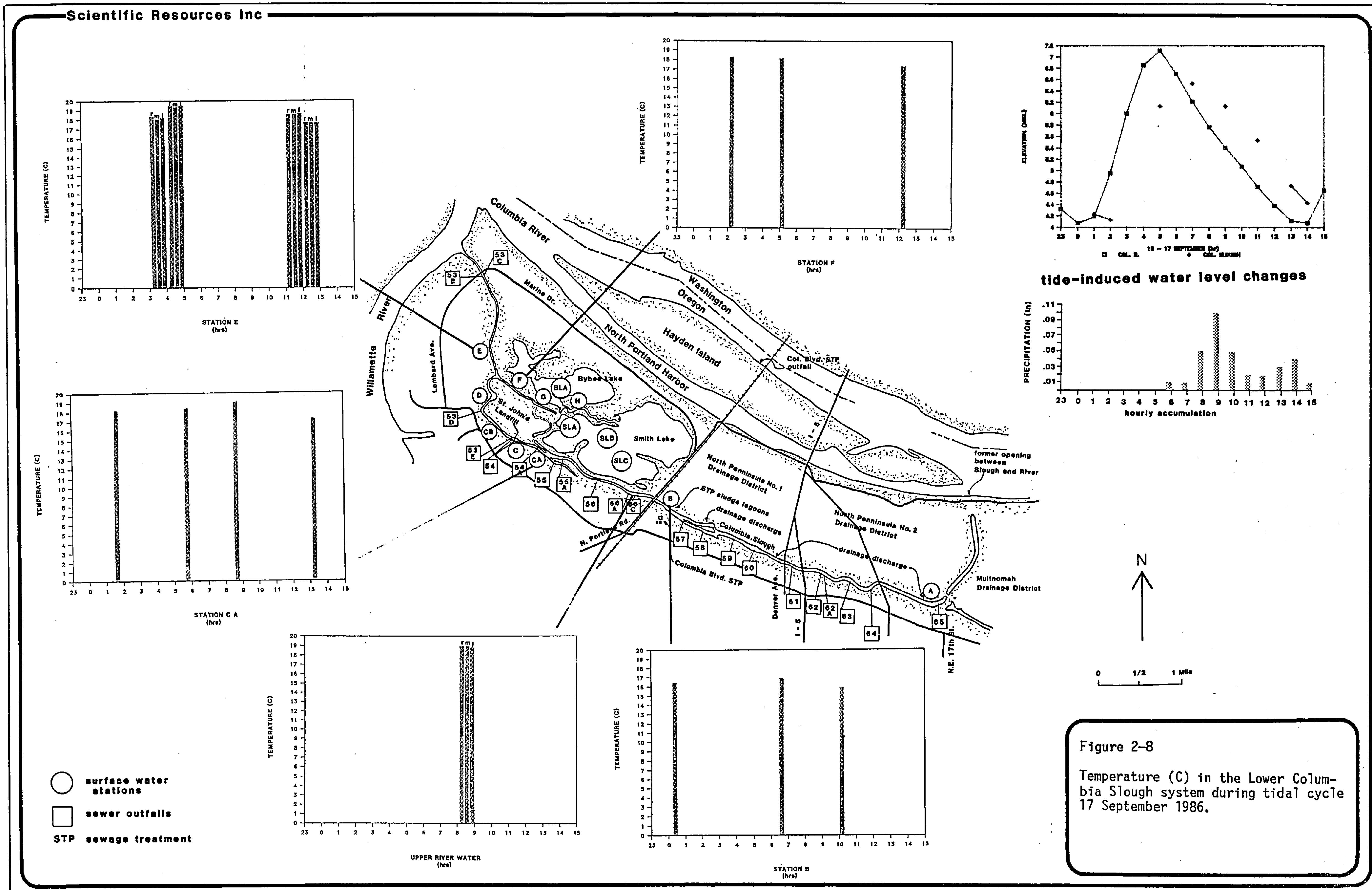


Figure 2-8

Temperature (C) in the Lower Columbia Slough system during tidal cycle 17 September 1986.

Fecal coliform bacteria levels were in excess of state water quality standards in all samples obtained from Slough surface water (Fig. 2-6). Fecal coliform densities at station E at 0349 hrs were 300 - 600 col./100 ml. Based on conductance of over 200 this water was Slough water being pushed up-Slough. At this same station at 0450 hrs fecal coliform densities ranged from 200 - 300 col./100 ml. Conductance of 150 indicated this was River water (Fig. 2-7). Early morning fecal coliform densities at stations up-Slough, e.g. at Station CA at 0138 hrs with flow down-Slough (see Appendix A, Table A-3), were 600 col./100 ml, similar to Slough water sampled at Station E. The next two samples at Station CA were of a mixture of Slough and River water at 0541 hrs, again based on conductance, with fecal densities of 500 col./100 ml, then at 0840 hrs, River water, with fecal coliform densities of 600 col./100 ml. These data suggest that early morning fecal coliform densities in the Slough were generally in the range of 300 - 600 col./100 ml. At the upper Slough Station B, however, fecal coliform densities were somewhat higher, with 1800 col./100 ml in outflowing water sampled near midnight on the 16th, and 800 col./100 ml in Slough water being pushed up-Slough at 0637 hrs.

Samples collected of River water that had moved up-Slough ("upper River water" in Fig. 2-6) past the Landfill within one-half mile of the Portland Road bridge had fecal coliform levels of 200, 300 and 600 col./100 ml (right side, middle and left side respectively). This was River water on the basis of conductance values of around 150, and this water had begun to move down-Slough at the time of sampling (Appendix A, Table A-5).

Samples collected at all Stations after 0830 hrs of both River and Slough water flowing down-Slough showed sharply increased fecal coliform densities (note four of the five graphs in Fig. 2-6 are in thousands). River water passing by Station E moving down-Slough at 1140 hrs had fecal coliform densities of 3,500, 400, and 3,300 col./100 ml (right, middle and left sides respectively). The high concentrations on the left side (facing down-Slough) could be accounted for by influx of storm sewer outfall water high in fecal coliforms. The high concentrations on the right side may suggest the influence of high coliforms in water moving out of North Slough and staying along the right bank moving down-Slough. North Slough had a sharp increase in fecal coliform density of from 900 at 0507 hrs then 3,500 col./ml at 1222 hrs.

Slough water passing Station E moving down-Slough around 1244 hrs had even higher densities of 5,300, 4,900, and 7,200 col./ml (right, middle and left sides respectively).

Measurements of chlorophyll a in samples obtained from Station E through the day were: 45.8 mg/m^3 at 0338 hrs, 10.7 mg/m^3 at 0443 hrs, 19.1 mg/m^3 at 1144 hrs, and 45.1 mg/m^3 at 1242 hrs (Appendix A, Table A-7). The low levels correspond with River water, while the high values were typical of Slough water. With the exception of the one value of 10.7 mg/m^3, the other values exceeded state water quality standards regarding chlorophyll a levels of .015 mg/l (OAR 340-41-150).

Complete data sets from each of the Stations sampled on the 17th of September are provided in Appendix A, Table A-1 through Table A-6.

2.4.3 Outfall Bacteria and Flow

Rainfall antecedent to the 17 September sampling was a trace on the 12th, trace on the 13th, 0.0 on the 14th, 0.07 in on the 15th, 0.03 in on the 16th, and 0.62 on the 17th (National Weather Service, Portland Airport). On the day of sampling, rainfall started around 0600 hrs and continued through the day. By noon 0.22 in had fallen. Combined flows (sanitary and storm flows) are diverted during heavy rainfall events to outfalls discharging into the Slough. These diversions are expected from sanitary sewers to storm sewers when rainfall exceeds 0.02 in/hr (Myra, pers. com. 1986). As a result of the rainfall, nearly all of the outfalls along the lower Slough from outfall No. 57 to the two outfalls at Lombard Street bridge had sufficient flow for sampling between 0755 hrs and 1150 hrs.

Results of the outfall sampling were as follows (see Fig. 1-1 for outfall locations):

OUTFALL NUMBER	OUTFALL TYPE	TIME	EST. FLOW (gpm)	FECAL COLIFORM BACTERIA (col./100 ml)
53B	STORM	0253	none	
53C	STORM	1150	15-20	102,000
53D	STORM	1128	200-250	27,000
53E	STORM	1115	20-25	45,000
54	COMB.	1108	500-600	162,000
54A	STORM	1045	350-450	36,000
55	COMB.	1035	300-400	180,000
55A	STORM	1020	450-550	27,000
56	COMB.	1008	4000-5000	135,000
56A	STORM	0950	1000-2000	18,000
56C	STORM	0755	23	45,000
57	COMB.	0940	1500-2000	198,000

Total flow from these outfalls was approximately 9,800 gpm (22 cfs). The influence of these outfalls on Slough water quality is perhaps apparent in the high fecal coliform densities on the left side of the Slough (the southwest side) at the "upper River water" Station and Station B (see Fig. 2-6). All of the storm sewer outfalls are, with one exception (53C), on the southwest side of the Slough. With the one exception of outfall 53C, combined sewer outfalls consistently had the highest fecal coliform densities.

Slough surface water samples were analyzed for total chloride as an additional way of detecting influence from the Landfill or outfalls. Total chloride ranged from 7.5 mg/l to 12.0 mg/l in 29 Slough surface water samples (Appendix A, Table A-8). The three lowest values (7.5, 7.5 and 8.0 mg/l) were of River water at the mouth of the Slough. With these three values removed, the remainder of the samples ranged from 9.5 to 12 mg/l. Comparisons of chloride values at Station E through the day (which ranged from 10.0 to 11 mg/l) with chloride values in the "upper River" samples (which ranged from 11.0 to 11.5 mg/l) do not show increases that might indicate Landfill leachate influence on Slough water. Chloride values for duplicate samples from one outfall (56C) were 22.5 and 22.5 mg/l (Appendix A, Table A-8), suggesting that outfalls could account for increases in total chloride in Slough water as well as for increases in fecal coliform bacteria densities.

2.4.4 Bacteria in Selected Landfill Wells

Results of sampling five wells at the Landfill on the day following the Slough sampling (September 18) are shown below; results from previous analyses are included for comparison:

WELL NUMBER		FECAL COLIFORM (Col./100 ml) May 30, 1986	Sept. 18, 1986
D8A	rep. 1	93	0
	rep. 2	0	0
C3	rep. 1	0	130
	rep. 2	7	1600
D1C	rep. 1	23	9
	rep. 2	4	2
D4A	rep. 1	43	0
	rep. 2	0	0
D4b	rep. 1	9	0
	rep. 2	4	0

Fecal coliform bacteria in well water from this sampling date were not detected in three of the five wells and were at low density (9 - 2 col./100 ml) in well D1C. Densities were high in the shallow well C3 (see Table A-9 in Appendix A for well specifications) and replicate densities were significantly different in samples from that well on the 18th of September.

Well samples from C-3 and D1C were analyzed for total chloride. The duplicate samples from C-3 each had 140 mg/l, while the duplicate samples from D-1C each had 4.0 mg/l. These findings tend to support the presence of higher levels of fecal coliform bacteria in Landfill water at the screen depth of well C-3.

A sample of leachate was collected on September 18 from a seep in the mud bank about 2 ft above the water level in North Slough adjacent to well C-3. This sample had a fecal coliform density of greater than 1,600 col./100 ml and a conductance of 4,300. The fluid issuing from the seep had a field temperature of 18.7°C compared with 20.1°C for surface water in North Slough. The unusual increase of fecal coliform densities at Station F in North Slough, that would appear not to be influenced greatly by the water in Columbia Slough, may possibly be accounted for by leachate from the Landfill evidenced by C3 and leachate-seepage having high fecal coliform densities.

2.4.5 Smith and Bybee Lakes Bacteria

Water samples were obtained from Smith and Bybee Lakes (see Fig. 1-1) for fecal coliform analyses. Fecal coliform densities were 70 col./100 ml for Smith Lake (Station SLC), and 110 col./100 ml for Bybee Lake (BLA). Water levels in the Slough were well below the level that allows flow into the lakes; the lakes had been isolated from Slough water since June (Ogden Beeman Associates Inc., 1986). Neither of these values exceeded state standards.

2.5 Implications and Conclusions

1. Water quality in the Lower Columbia Slough at traditional sampling stations below the Portland Road Bridge was influenced by Willamette-Columbia River water moving up and down the Slough under tidal influence. During low discharge (September) the excursion of River water up-Slough was greater than during the period of high discharge (May). During both low and high water periods, River water appeared to move up-Slough with only slight mixing with Slough water at the leading edge.

The influence of flow reversals in the Columbia River on water quality has been evaluated at least since 1968. Clark and Snyder (1969), in their 1968 study of flow reversals near the site of the Trojan Nuclear Plant, concluded that flow reversals could cause water to be affected longer by a point source, e.g. thermal effluent. The flow reversals in the Columbia Slough will likewise result in Slough (and River) water being affected longer by Landfill leachate or sewer outfalls.

In order for Columbia Slough water quality monitoring results to be correctly interpreted, sampling must be performed relative to tidal influence on Slough water.

2. During wet weather conditions accompanying the September sampling, the Lower Columbia Slough water appeared to be greatly influenced by wet weather bypassing of untreated wastes into the Slough through most of the 21 sewer outfalls.

Some bypassing of untreated wastes into the Slough still occurs during dry weather conditions (Portland, City of 1986), though this has been reduced through more frequent sewer maintenance since the time of earlier surveys in 1971 and 1972 (Portland, City of 1972). The sewer effluent appears to account for the high levels of fecal coliform bacteria in the lower Slough system. Both storm and combined sewers contributed fecal coliform bacteria, however, highest densities were found in combined sewer flow.

3. While data collected from the May sampling <u>suggested</u> a minimal effect of the Landfill on Slough water quality, data from the September sampling clearly indicated an effect on North Slough water quality from the Landfill.

Since North Slough is now a finger embayment of Columbia Slough, and appears to be poorly flushed, the water quality in this embayment is likely degraded by the Landfill. There is evidence that leachate from the north side of the Landfill may be affecting water quality in North Slough, as noted in Sections 2.2.2. and 3.5.3. The evidence consists of: 1) increase in conductance in North Slough water from Landfill towards Bybee Lake; 2) high conductance and high fecal coliform densities in leachate seep from the Landfill side of North Slough; 3) the highest chloride value among all surface water samples (12 mg/l; see Appendix A, Table A-8); and the high fecal coliform density at 1222 hrs on September 17 in water moving out of upper North Slough (Fig. 2-5; see Appendix A, Table A-2). Since a large amount of sediment on the Landfill banks of the Columbia and North Slough is in various contact with the Sloughs, the cumulative impact of such leachate influence cannot easily be determined.

Conductance surveys of Bybee and Smith Lakes in June showed no values in the lake areas adjacent to the Landfill that suggested leachate influence on lake water quality.

Based on the samples obtained in this study, and in comparison with the combined influence of the sewer outfalls, it appears that the Landfill has a relatively smaller impact on water quality of the Columbia Slough system.

4. State water quality standards for both fecal coliform bacteria density and the algae pigment chlorophyll a were exceeded in water quality samples obtained from the Slough, particularly on 17 September. Sufficient numbers of bacteria samples were collected to meet the DEQ criteria for exceedence (Quan, pers. com. 1987): "5 samples in a 30-day period with no more than 10 percent of the samples in the 30-day period exceeding 400 per 100 ml" (OAR 340-41-445). Of the 29 surface water samples obtained 17 September, 72.4% exceeded 400 col./100 ml. Fecal coliform densities in Smith and Bybee Lakes did not exceed state standards. Chlorophyll a values exceeded DEQ standards in May, June and September for Smith and Bybee Lakes, and for all Slough samples obtained except for one on 17 September at Station E.

3.0 HISTORICAL DATA BASE EVALUATION

3.1 Background and Objectives

Background. During preliminary studies of the Lower Columbia Slough system and Smith and Bybee Lakes in fall 1985 for the Port of Portland, Scientific Resources, Inc. and Fishman Environmental Services identified extensive data on water quality in the vicinity of the St. John's Landfill in DEQ, METRO and the City of Portland files (Scientific Resources, Inc. 1986 and Fishman Environmental Services 1985). During 1985 and early 1986 DEQ had created computer files on each of the sampling stations for eventual use in data analysis. It was proposed that, as part of the planning effort for the Port of Portland and the City of Portland, historical water quality data be consolidated and reviewed for possible trends in Lake or Slough conditions.

Sweet, Edwards and Associates, Inc. (1983) evaluated historical water quality data from the Columbia Slough for years 1971 - 1973, 1976 and 1982 - 1983. They compared mean values of selected parameters for all surface water data from individual years including data from lake and Slough sampling points. Further comparisons were then made with drinking water standards and levels of certain nutrients required for algal blooms. This approach was not used in the following evaluation because it apparently did not consider the tidal effects on River and Slough water found to influence water quality at the Lower Slough water quality monitoring stations (see section 2.0).

The approach taken in this historical evaluation focuses on summary comparisons by parameter by station for the ten year period 1977 - 1986. Further, information on Slough water quality is evaluated with respect to Slough hydrology. Slough and Lake water quality data are treated separately with respect to compliance with Oregon Water Quality Standards, but considered together for purposes of understanding seasonal Lake-Slough interactions.

Evaluation Objectives. Objectives of the historical data base evaluation included the following:

- o establish and make available the most recent ten years of monitoring data from Slough and Lakes stations in hard report form and on disk accessible with an IBM or IBM-compatible microcomputer;

- o determine what the data from the stations indicate about water quality in the Lower Columbia Slough over ten year period;

- o determine what the data from the stations indicate about water quality in Smith and Bybee Lakes over the ten year period;

- o relate findings on historical Slough water quality to present and future plans for increased public access to the area of the Landfill and Smith and Bybee Lakes.

3.2 Approach and Methods

Data resulting from the field measurements and laboratory analyses performed from sampling in the vicinity of St. John's Landfill was disbursed at the start of the project on City of Portland data sheets, in the U. S. Environmental Protection Agency's water quality management system called STORET, in data sheets for special DEQ studies, and more recently on DEQ and METRO contractor data sheets. DEQ had recently compiled its data into separate computer data files for each of the surface water stations, and these files included data from 1979 through May 1985 (Kepler, pers. com. 1986). These files were downloaded from the DEQ Harris computer by way of an IBM microcomputer to 5.25 in floppy disks, then converted to spreadsheet (Lotus) files. The data files for each of the historical monitoring stations were then completed with City of Portland Data back through 1977 and forward with DEQ and METRO data from May 1985 through September 1986. 1977 was chosen as a starting point to complement the study by Sweet, Edwards and Associates (1983) which reviewed surface water data through 1976. Tables of data for each of the Slough and Lake Stations are in Appendix B.

Files were reformatted for ease of review, e.g. major ions, nutrients and metals were separately clustered, as were the gross physical and chemical parameters such as conductance, pH, and alkalinity. Statistical summaries were made of each of the files, including range of dates for samples, number of samples per parameter, mean, minimum and maximum parameter values, and parameter standard deviations. Results reported as being below the limit of detection, e.g. less than 0.01 were entered as 0.0, 'analytical zero', indicating a sample had been collected and an analysis performed. These 0.0 values can be traced to original data sheets to determine what the lower limit of detection was at that point in time. Graphs were prepared where trends in the data or differences among stations appeared to be significant.

3.3 Evolution of Slough and Lakes Water Quality Sampling

The Columbia Slough has been sampled systematically to evaluate the quality of its water at least since 1967. Earlier sampling programs may have been conducted, but the existence and location of data was not uncovered during preliminary inquiries of the Oregon Department of Environmental Quality (DEQ), the City of Portland, or METRO. The total number of parameters in DEQ surface water quality files for stations near the St. John's Landfill, along with the duration of the file record for this review is shown in Table 3-1.

Starting in 1967 the City of Portland Water Pollution Control Laboratory at the Columbia Blvd. Wastewater Treatment Plant conducted monthly sampling of three stations in the Lower Columbia Slough: Stations A, B, and C (see Fig. 3-1).

During 1971-1973 extensive water quality sampling was done in the Columbia Slough by DEQ and the City of Portland to evaluate water quality conditions in the entire Slough watershed extending east to Fairview Lake and Fairview, where the Slough originates. Sampling of water and sediments was also done in Smith and Bybee Lakes. Data and assessments resulting from the 1971 work are reported in Portland, City of (1972), Oregon Department of

TABLE 3-1. SUMMARY OF DATA IN DEQ SURFACE WATER QUALITY FILES FOR STATIONS NEAR ST. JOHN'S LANDFILL.

PARAMETER	STA A	STA B	STA CA	STA C	STA CB	STA D	STA H	STA G	STA F	STA E	STA SLA	STA SLB	STA SLC	STA BLA
DATA END DATES**	01/12/77 12/08/81	01/19/77 12/08/81	10/18/79 08/28/86	01/12/77 08/28/86	10/18/79 08/28/86	01/12/77 08/28/86	04/07/78 06/01/83	01/12/77 08/28/86	01/12/77 08/28/86	01/12/77 08/28/86	11/18/80 08/28/86	01/06/81 12/16/85	02/20/86 08/28/86	02/20/86 08/28/86
TEMP	+	+	+	+	+	+	+	+	+	+	+	+	+	+
COND. FIELD			+	+	+	+		+	+	+	+		+	+
COND. LAB	+	+	+	+	+	+	+	+	+	+	+	+	+	+
TDS	+	+	+	+	+	+	+	+	+	+	+	+	+	+
TSS	+	+	+	+	+	+	+	+	+	+	+	+	+	+
TURBIDITY			+	+	+	+		+	+	+	+	+	+	+
PH FIELD			+	+	+	+		+	+	+	+		+	+
PH LAB	+	+	+	+	+	+	+	+	+	+	+	+	+	+
ALK LAB	+	+	+	+	+	+	+	+	+	+	+	+	+	+
HARD	+	+	+	+	+	+	+	+	+	+	+	+	+	+
DISS. CALCIUM	+		+	+	+	+		+	+	+	+		+	+
DISS. MAGNESIUM	+		+	+	+	+		+	+	+	+		+	+
POTASSIUM	+		+	+	+	+		+	+	+			+	+
SODIUM	+		+	+	+	+		+	+	+			+	+
CHLORIDE	+	+	+	+	+	+	+	+	+	+	+	+	+	+
SULFATE	+	+	+	+	+	+	+	+	+	+	+		+	+
NH3-N	+	+	+	+	+	+	+	+	+	+	+	+	+	+
NO2-N	+			+		+		+	+	+	+		+	+
NO3-N	+	+	+	+	+	+	+	+	+	+	+	+	+	+
NO3+NO2-N	+	+	+	+	+	+	+	+	+	+	+	+		+
KJELD. N (TOT)			+	+	+	+		+	+	+		+	+	+
ORTHO-PO4-P	+	+	+	+	+	+	+	+	+	+	+	+	+	+
PO4-P (TOT)	+	+	+	+	+	+	+	+	+	+	+	+	+	+
DISS. IRON	+		+	+	+	+		+	+	+	+		+	+
DISS. MANGANESE	+		+	+	+	+		+	+	+	+		+	+
ZINC	+			+		+		+	+	+				
BOD	+	+	+	+	+	+	+	+	+	+	+	+	+	+
COD	+	+	+	+	+	+	+	+	+	+	+	+	+	+
TOTAL CARBON			+	+	+	+		+	+	+	+	+	+	+
DISS. OXYGEN	+	+	+	+	+	+		+	+	+	+	+	+	+
COLOR	+		+	+	+	+		+	+	+	+		+	+
FECAL COLIFORM			+	+	+	+		+	+	+	+	+	+	+
ENTEROCOCCUS			+	+	+	+		+	+	+	+	+	+	+
TOTAL COLIFORM			+	+	+	+		+	+	+	+	+	+	+
CHLOROPHYLL A			+	+	+	+		+	+	+	+	+	+	+
PHEOPHYTIN A			+	+	+	+		+	+	+	+	+	+	+

** = PARAMETERS MAY NOT HAVE BEEN MEASURED CONTINUOUSLY BETWEEN END DATES

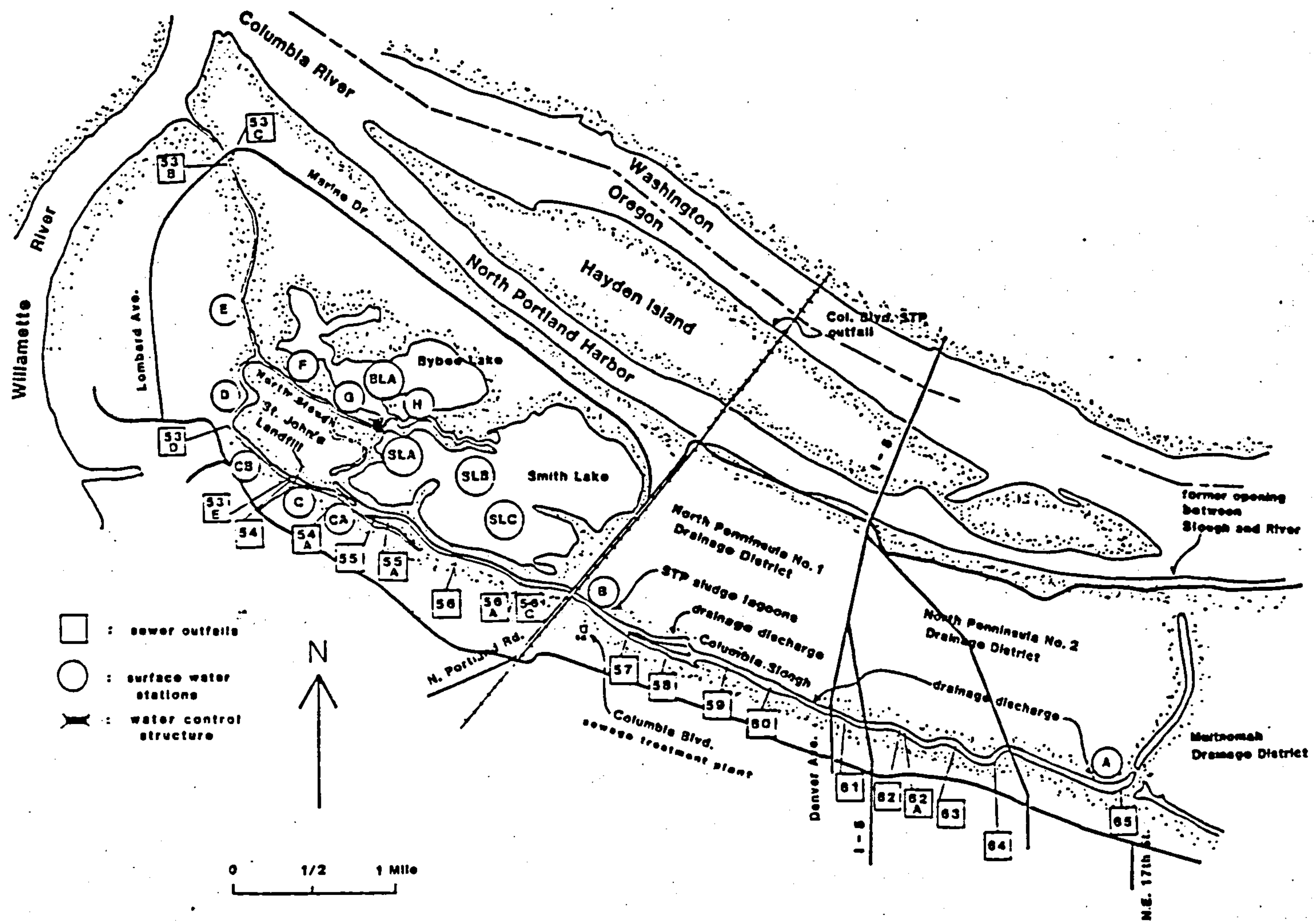


Figure 3-1 Lower Columbia Slough historical surface water quality sampling stations.

Environmental Quality (1974), and Quan, Sweet and Illian (1974). The assessment of water quality in the Slough system was in part motivated by the Corps of Engineers planning study in the early 1970's to determine the feasibility of providing additional flood protection and related water resource development in the Rivergate-North Portland area (U. S. Army Corps of Engineers 1976a, 1976b).

In 1972 the City of Portland increased the number of its sampling stations in the Lower Columbia Slough to include D, E, and F (see Fig. 3-1). The number of parameters measured was increased to include nitrogen and phosphorus compounds, sulfate, total solids, and chloride. Previously only temperature, pH, suspended solids, dissolved oxygen, 5-day Biochemical Oxygen Demand and total coliform bacteria had been measured regularly. Water levels were continuously recorded at the Landfill bridge starting in 1971 and a continuous record of water levels was produced for 1971 and 1972, which, according to the data records, related to "leachate monitoring" in the Columbia Slough. At the beginning of 1974 specific conductance was added to the list of analyses for all samples collected. Notes concerning water velocity and direction of flow at two of the six stations were added to data sheets beginning in 1974. These notes were discontinued toward the end of 1979.

In 1979, the agency that is now METRO began collecting samples at the six stations, and the City of Portland analyzed the samples at its Water Pollution Control Laboratory. In late 1980 a station was established at the landfill edge of Smith Lake and was sampled monthly for the same parameters as Slough stations. In early 1981 a second station was established in Smith Lake in deeper water, and this was also sampled monthly. In 1981 sampling was discontinued at Stations A and B in Columbia Slough. In 1982 METRO began to contract with private laboratories for analyses of monthly samples. In 1983 Station H was discontinued. This station was located in Smith Channel (the channel connecting Bybee and Smith Lakes). Discontinuation of sampling at this station was probably related to the separation of the lakes from the Slough by the water control structure installed in 1982.

3.4 Present Slough and Lakes Water Quality Sampling Program

Since 1984 DEQ and METRO have alternated sampling quarterly at the remaining Slough Stations CA, C, CB, D, E, F, G, and the two lake Stations BLA and SLC. There are many differences between the sampling program of DEQ and that of METRO and its contractor, as the matrix on the following pages indicates (B = METRO and DEQ; M = METRO only; D = DEQ only):

PARAMETER	STATIONS									
	Smith Lk.		Bybee Lk.	Slough						
	SLA	SLC	BLA	G	CA	C	CB	D	E	F
Staff gage reading	M		M							
*Temperature	B	B	B	B	B	B	B	B	B	B
*pH (field)	B	B	B	B	B	B	B	B	B	B
pH (lab)	B	B	B	B	B	B	B	B	B	B
Conductivity (field)	B	B	B	B	B	B	B	B	B	B
Conductivity (lab)	B	B	B	B	B	B	B	B	B	B
*Total solids	D	D	D	D	D	D	D	D	D	D
Suspended solids	D	D	D	D	D	D	D	D	D	D
*Turbidity	D	D	D	D	D	D	D	D	D	D
*Diss. oxygen	B	B	B	B	D	D	D	D	D	D
Alkalinity	B	B	B	B	B	B	B	B	B	B
Hardness	B	B	B	B	B	B	B	B	B	B
Sodium	D	D	D	D	D	D	D	D	D	D
Magnesium	D	D	D	D	D	D	D	D	D	D
Potassium	D	D	D	D	D	D	D	D	D	D
Sulfate	D	D	D	D	D	D	D	D	D	D
*Dissolved iron	D	D	D	D	D	D	D	D	D	D
*Dissolved manganese	D	D	D	D	D	D	D	D	D	D
Chloride	B	B	B	B	B	B	B	B	B	B
BOD5	B	B	B	B	B	B	B	B	B	B
COD	B	B	B	B	B	B	B	B	B	B
Total Kjeldahl-nitrogen	D	D	D	D	D	D	D	D	D	D
Ammonia-nitrogen	B	B	B	B	B	B	B	B	B	B
Nitrate-nitrogen	B	B	B	B	B	B	B	B	B	B
Nitrite-nitrogen	B	B	B	B	B	B	B	B	B	B
Total Phosphorus	B	B	B	B	B	B	B	B	B	B
*Fecal Coliform Bacteria	B	B	B	B	D	D	D	D	D	D
Enterococcus Bacteria	B	B	B	B	D	D	D	D	D	D
Total Coliform	B	B	B	B	D	D	D	D	D	D
*Chlorophyll _a_	D	D	D	D	D	D	D	D	D	D
Pheophytin _a_	D	D	D	D	D	D	D	D	D	D
Color	D	D	D	D	D	D	D	D	D	D

* Note DEQ rules pertaining to these parameters in following Section.

From this matrix of parameters and the symbols indicating which analyses are performed by METRO or DEQ it is apparent that DEQ is performing more analyses per sampling occasion than METRO. This suggests that certain parameters may not be critical parameters to monitor, and/or that DEQ has a special interest in obtaining data on particular parameters.

3.5 Choice of Sampling Parameters

Traditionally, sampling sites and sampling parameters appear to have been selected to monitor possible contamination of the Slough-Lakes system by storm and combined sewer effluent and the St. John's Landfill leachate. Establishing sampling Stations at sites A and B seemed to reflect an interest in the quality of water entering the Lower Columbia Slough from the Slough above N.E. 17th Street (see Fig. 3-1). Following METRO's assumption of water quality sampling in 1980, the reason for sampling appeared to be restricted to that of monitoring possible effects on Slough surface water by Landfill leachate. The set of parameters being measured quarterly by METRO has been defined in the solid waste and NPDES permits for the St. John's Landfill site.

In spring of 1986, at the request of the Port of Portland, DEQ and METRO were asked to obtain quarterly samples from Smith and Bybee Lakes and add algae nutrient parameters (e.g. total phosphorus, nitrate and nitrite nitrogen), and measures of bacterial contamination (e.g. fecal coliform bacteria densities) to sample analyses. These additions to the sampling program were part of the Port effort to assess the environment of the lakes and produce a Management Plan. According to DEQ (Schaedel 1986, pers. com.), what used to be a Landfill leachate monitoring program now has the parameters of a typical surface water monitoring program. Aside from the DEQ 1974 study and the study by Sweet, Edwards and Associates (1983), no reports were found which interpreted data generated and/or explained the rationale for parameter selection. The U. S. Geological Survey collected data from Smith and Bybee Lakes during the period June-November 1982, and issued a data report (Clifton 1983), but did not interpret the results.

3.5.1. ODEQ Surface Water Quality Standards

Some of the parameters that have been monitored through time relate directly and indirectly to Oregon's water quality standards (see list of parameters in previous Section). DEQ has the authority to require monitoring by potential polluters of water bodies, such as the operators of the St. John's Landfill, and the authority to monitor to evaluate compliance of water bodies with the state water quality standards (OAR 340-41-120). DEQ water quality standards for the 19 major drainages of the state (DEQ 1985), describe water conditions that should be prevented, and characteristics that should not be exceeded so as to protect specified beneficial uses (e.g. water contact recreation, fishing, swimming, irrigation, etc.). There is no designation of what the beneficial uses are of Columbia Slough water, even though the system annually drains approximately 100,000 acre-ft of area surface and subsurface drainage (DEQ 1974). The Columbia Slough system, extending from the east edge of Fairview to the Willamette River, serves as an area-wide drainage system for 53 square miles within North Portland and North Multnomah County. This system is regulated by Willamette Basin water quality standards (DEQ 1985).

The following numerical water quality standards apply to the Columbia Slough and Smith and Bybee Lakes (OAR 340-41-445):

PARAMETER	STANDARD
DISSOLVED OXYGEN	not less than 90% saturation
TEMPERATURE	no measurable increases outside of defined mixing zones due to a single-source discharge when temperatures are 68^{O}F or higher; or more than 0.5^{O}F

TEMPERATURE (continued)	increase when temperatures are 67.5°F or less; or more than 2°F increase from all sources when temperatures are 66°F or less.
pH	6.5 - 8.5
TURBIDITY	no more than a 10% cumulative increase in natural stream turbidities.
BACTERIA (FECAL COLI.)	not to exceed a log mean of 200 fecal coliform per 100 ml based on a minimum of 5 samples in a 30-day period with no more than 10% of the samples in the 30-day period exceeding 400 per 100 ml.
DISSOLVED CHEMICAL SUBSTANCES	these concentrations (mg/l) shall not be exceeded:

Substance	mg/l
Total dissolved solids	100
Arsenic	0.01
Barium	1.0
Boron	0.5
Cadmium	0.003
Chromium	0.02
Copper	0.005
Cyanide	0.005
Fluoride	1.0
Iron	0.1
Lead	0.05
Manganese	0.05
Phenols (totals)	0.001
Zinc	0.01

PESTICIDES AND OTHER ORGANIC TOXIC SUBSTANCES	Shall not exceed current EPA standards.
CHLOROPHYLL A	These concentrations (mg/l) shall not be exceeded: Natural lakes which thermally stratify: 0.01; Natural lakes which do not thermally stratify, reservoir , rivers and estuaries: 0.015

DEQ has additional non-quantitative anti-degradation rules such as those pertaining to fungal growths, floating solids, discoloration, offensive tastes or odors, but these conditions, if present in the Slough during the period of interest 1977-1986, were not made part of the data base.

3.5.2 Eutrophication Indices

Studies of the relationship of the thresholds of nuisance algae growth to concentrations of nutrients used by algae have resulted in empirical determinations of critical levels of certain phosphorus and nitrogen compounds (e.g. Porcella, Peterson and Larson 1980). 'Eutrophication' is the enrichment of water bodies by plant fertilizers, particularly nitrogen and phosphorus compounds. Recently, DEQ considered the adoption of nutrient standards which would have resulted in enforcement if concentrations of certain forms of nitrogen and phosphorus were exceeded (ODEQ 1986). The following concentrations (mg/l) reflect recent reviews regarding levels of these plant nutrients that should not be exceeded in order to prevent nuisance algae growth:

+TOTAL PHOSPHORUS in lakes	greater than 0.025
+TOTAL PHOSPHORUS in streams entering lakes	greater than 0.05
+TOTAL PHOSPHORUS in other streams	greater than 0.1
*DISSOLVED PHOSPHORUS	greater than 0.011
*TOTAL NITROGEN	greater than 0.180
+UN-IONIZED AMMONIA (as ammonia)	greater than 0.02

+ = DEQ 1986; * = Porcella, Peterson and Larson 1980

There are at least two primary sources of these algae/plant nutrients in the Slough system: scattered and intensive agriculture, and, ground water entering the Slough from unsewered areas in East Multnomah County. In the lower Slough, the quality of water being pumped into the Slough from North Penninsula Drainage Districts 1 and 2 would most likely each reflect agricultural and golf course fertilizer applications. No data was located on the quality of water pumped from these Districts into the Columbia Slough.

3.5.3 Indicators of Landfill Leachate Influence

All of the Slough sampling stations are within a short distance of the St. John's Landfill. The Slough water quality monitoring program is intended to detect possible influences of Landfill leachate on Slough water. A characterization of St. John's Landfill leachate is helpful in determining the water quality parameters that might reflect leachate contamination in the Slough.

Several measurements are available for water that was being pumped from the south end of the Landfill site, adjacent to the Blind Slough remnant to Columbia Slough and Smith Lake. The Landfill operators are now required to pump contaminated surface water from the expansion area to the City sanitary sewer. A sample of fluid from an active seep along the Landfill bank in North Slough was also analyzed. These data are presented on the following page:

DATE	SAMPLE	CONDUCTANCE (micromhos/cm)	FECAL COLIFORM BACTERIA (col./100 ml.)	ORGANIC NITROGEN (mg/l)	DATA SOURCE
12-85	Pump line, Blind Slough area to Smith Lake	820	13,000	57.4	(a)
9-18-86	Seep; N. Slough Bank	4,300	1,600		(b)
12-5-86	Pump line, Blind Slough area to Columbia Slough	1,255			(c)
12-5-86	Surface seeps, NW side of Landfill	530 - 15,380			(c)

(a) Scientific Resources, Inc. 1986
(b) Laboratory analysis of sample collected by P. Fishman, Fishman Environmental Services
(c) Field measurements by J. Luzier, Shannon Wilson, Inc., and P. Fishman, Fishman Environmental Services

Samples of water in Blind Slough, adjacent to the active Landfill, were obtained by METRO during 1979 and 1980. These data, for stations FA and FB, are presented in Table 3-2. All measured parameters, with the exception of pH, had values higher than found in Smith and Bybee Lakes and Columbia. It is obvious that all of the water samples discussed above were contaminated with Landfill leachate; conductance, alone, is a good indicator of contamination in this system (Shannon Wilson Inc. 1986).

It would be reasonable from this information about Landfill leachate to use two or three of these parameters that are significantly elevated as an index of Landfill contamination of Slough water. This apparently is being done with the choice of chloride, hardness, alkalinity, BOD_5, COD, conductance, and fecal coliform bacteria. It would appear essential to have leachate carefully characterized for toxic metals and organic compounds to assess the severity of leachate contamination of Slough water. Since the toxicity of certain metals tends to be inversely related to the hardness of the water (USEPA 1986), both DEQ and METRO measure the hardness of each sample.

TABLE 3-2. WATER QUALITY DATA 1979-1980 STATION F-A AND F-B.

STATION FA

DATE OF SAMPLE (m/d/y)	SAMPLERS	COND. (LAB) uhs/cm	pH (LAB)	ALK (LAB) mg/1 CaCO3	HARD. (CALC. DISS.) mg/1	Cl mg/1	NH3-N mg/1	BOD mg/1	COD mg/1
10/18/79	METRO	4700	8.0	945	800	1140	70.0	105	208
11/07/79	METRO	2530	7.5	754	642	304	44.5	650	738
01/23/80	METRO	2600	7.3	1150	830	340	32.0	570	53
02/21/80	METRO	4140	7.5	1780	1080	362	170.0	1860	1490
03/11/80	METRO	2850	7.4	1220	984	275	112.0	1080	860
04/23/80	METRO	4000	7.5	1500	878	366	158.0	740	860
05/28/80	METRO	4710	7.5	1670	722	559	208.0	170	510
SAMPLES	ANALYZED	7	7	7	7	7	7	7	7
MEAN	VALUE	3647	7.5	1288	848	478	113.5	739	674
MAXIMUM	VALUE	4710	8.0	1780	1080	1140	208.0	1860	1490
MINIMUM	VALUE	2530	7.3	754	642	275	32.0	105	53
STANDARD	DEVIATION	893	0.2	350	138	283	62.6	552	442

STATION FB

DATE OF SAMPLE (m/d/y)	SAMPLERS	COND. (LAB) uhs/cm	pH (LAB)	ALK (LAB) mg/1 CaCO3	HARD. (CALC. DISS.) mg/1	Cl mg/1	NH3-N mg/1	BOD mg/1	COD mg/1
10/18/79	METRO	8850	8.4	1760	1340	1940	60	580	1480
11/07/79	METRO	2440	7.3	803	686	364	64	0	1150
02/21/80	METRO	3850	7.5	1480	1080	360	164	1710	1820
03/11/80	METRO	2700	7.4	1050	749	242	105	980	1090
04/23/80	METRO	3700	7.6	1380	879	318	161	1040	1380
05/28/80	METRO	5300	7.8	1890	923	608	241	930	1120
SAMPLES	ANALYZED	6	6	6	6	6	6	6	6
MEAN	VALUE	4473	7.7	1394	943	639	133	873	1340
MAXIMUM	VALUE	8850	8.4	1890	1340	1940	241	1710	1820
MINIMUM	VALUE	2440	7.3	803	686	242	60	0	1090
STANDARD	DEVIATION	2164	0.4	378	218	593	64	515	258

3.5.4 Indicators of Sewer Outfall Influences on Slough Water Quality

Data available on storm sewer effluent was limited to flow, total suspended solids, BOD_5, dissolved oxygen, total and fecal coliform for 1971, and flow and fecal streptococcus for single samples during summer 1985. Sampling of storm and combined sewers during this project in 1986 provided information on flow and fecal coliform densities, and chloride on two occasions, one with and one without rainfall (see Section 2.0). Total storm overflow volumes from the upper 12 of the 21 sewer outfalls in the Lower Slough during a six-month period in 1971-1972 (October 1971 - March 1972) was estimated by the City of Portland to be 182 million cubic feet, or 4,175 acre-feet of water (Portland, City of 1972). This is approximately the same volume of water contained in Smith and Bybee Lakes when the water is at an elevation of 10.7 ft msl (see Technical Appendix A: Surface Water Hydrology).

While water from sewer outfalls may be only 4 - 6% of the total annual discharge through the Slough system, high fecal coliform densities, reported in Section 2.0, suggest that the sewers may contribute a much higher percentage of the nutrients that enter the system. The high levels of toxic metals generally in the Lower Slough and notably at Stations A and B detected in April of 1979 may indicate that the source of these metals is sewer effluent. Slough water quality characteristics that may indicate influence by sewer effluent would include fecal coliform densities, and chloride (see levels detected in sewer effluent in Section 2.2). Sewer effluent should be better characterized so as to know its composition under different hydrologic conditions. As it stands, what are being measured as indices of Landfill leachate contamination of the lower Slough are also indices of sewer contamination.

The present Slough monitoring program does not distinguish sewer effluent effects from leachate effects. Each source needs to be carefully characterized in order to find indicator parameters for each. High fecals, BOD, conductivity, etc. might also be caused by other sources (agricultural, industrial, east-county sewers, etc.). We do not have, among parameters measured to date, unique indicators of either Landfill leachate or sewers (combined or storm).

3.6 Columbia Slough Water Quality Data Review

3.6.1 Statistical Dilution

Results of Slough sampling in May and September described in Section 2.0 of this report suggests that where sampling is conducted down-Slough of the Portland Road Bridges, without regard for tidal influences and River water excursion up the Slough, water quality data will reflect the quality of both River and Slough water.

Since the conductance of River water (Columbia or Willamette; see Appendix B Tables 18 and 19) has been generally lower than that of the Slough, it would be likely that a comparison of Stations from up-Slough (e.g. Station A and B) with Stations down-Slough (e.g. Station E) would show decreases in conductance down-Slough. This decrease in conductance would result from sampling River water at stations below Station B relatively frequently over a ten-year period, producing a 'diluting' effect in statistical summaries. This effect may be seen in Fig. 3-2, which is a comparison of mean conductance values by station from Station A to Station E (see Appendix B, Table B-1 for Station values).

The same 'statistical dilution' effect would be produced in the measurement of any parameter that is of lower concentration in the River than in the Slough. Another example of what may be the effect of sampling River water during Slough sampling is a comparison of mean nitrate+nitrite-nitrogen values (Fig. 3-3). The lowest nitrate+nitrite-nitrogen value for Slough stations is 0.62 mg/l for Station G in North Slough (7 sample measurements in that file). The average nitrate+nitrite-nitrogen value for Willamette River water 1974-1981 was 0.57 mg/l (Appendix B, Table B-18) and 0.25 mg/l for the Columbia River for the sample time period.

If the focus of interest behind Slough water quality monitoring is the quality of water discharging from the Columbia Slough watershed, then the Slough must be sampled so as to obtain data on the Slough rather than on the unknown mixture of regularly intruding River water and Slough water. This is, of course a problem unique to the Lower Columbia Slough segment.

The influence of the unsewered area of east Multnomah County on the upper Columbia Slough (e.g. Quan, Sweet and Illian 1974, DEQ 1974) also indicates that monitoring the Upper Slough is important to make sense of Lower Slough Water Quality.

3.6.2 Slough Water Quality

COMPLIANCE WITH STATE WATER QUALITY STANDARDS: Slough monitoring data for dissolved oxygen, pH, fecal coliform bacteria, chlorophyll <u>a</u>, total dissolved solids, iron, and manganese can be compared with state standards (see Section 3.5 for standards). Means of Station data have been reviewed for compliance, with the caveat that comparisons of upper stations with lower are faulted by the greater frequency of River water being sampled rather than Slough water increasing from Station CA down-Slough (see preceding Section). Table 3 - 3 shows means of each of the parameters for each of the Stations from the period 1977 - 1986. Stations are arranged in the Table from highest

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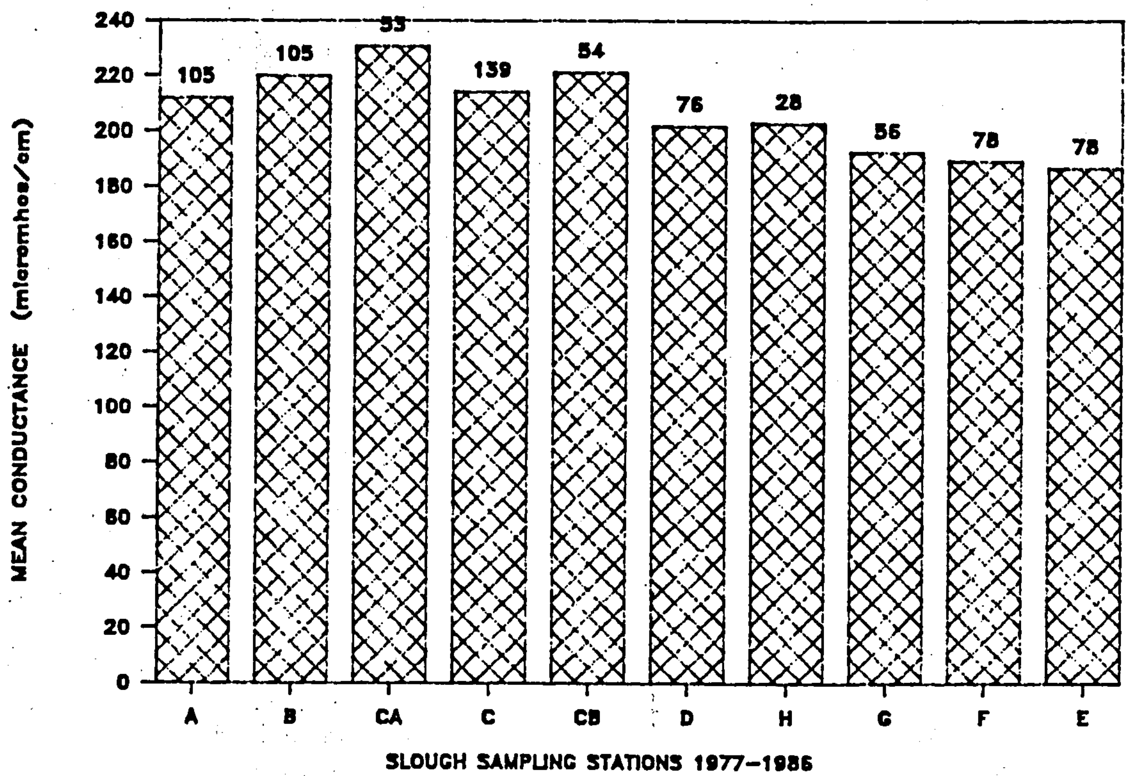


Figure 3-2 Mean conductance values (micromhos/cm) at stations in the Lower Columbia Slough 1977-1986. Numbers at the top of bars are the numbers of samples.

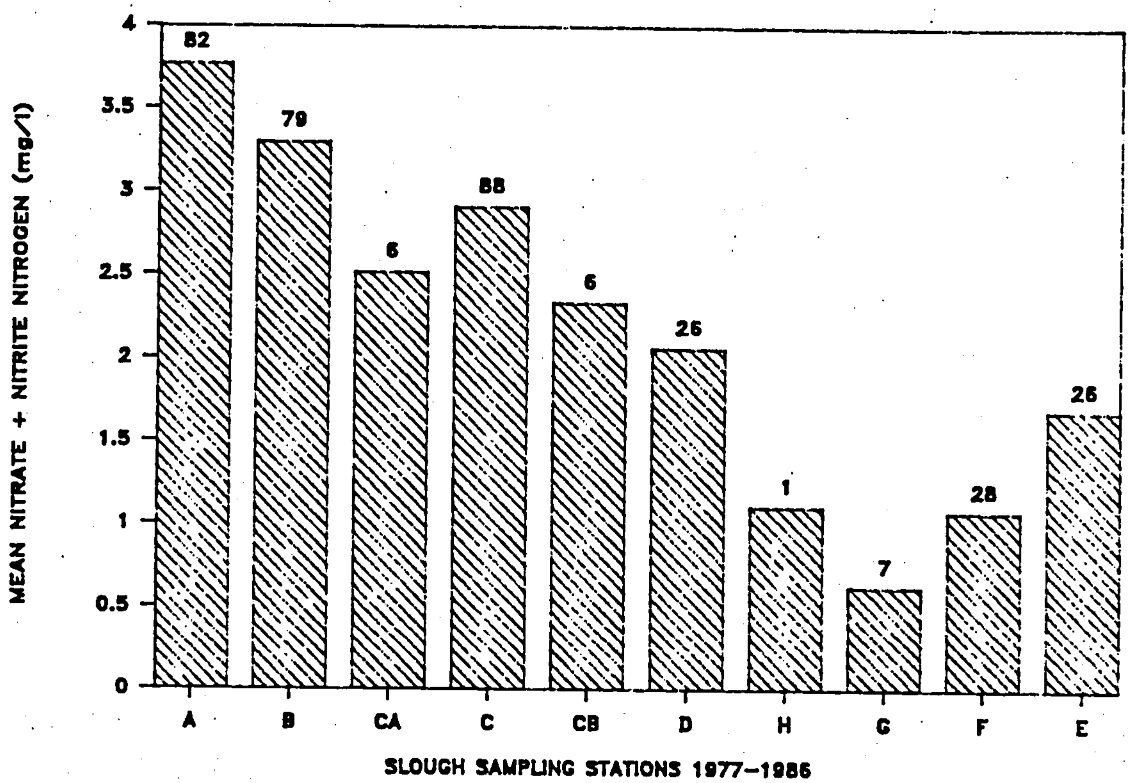


Figure 3-3 Mean nitrate+nitrate-nitrogen for Lower Columbia Slough stations. Numbers at tops of bars are numbers of samples analyzed.

Table 3-3 Summary Values of Slough Sampling Stations 1977 - 1986 (Means of All Data by Station Parameter)

ALL DATA MEANS 1977-86

SAMPLING LOCATION	T (C)	COND. (FIELD) uhs/cm	COND. (LAB) uhs/cm	TDS mg/l	TSS mg/l	pH (FIELD)	pH (LAB)	ALK (LAB) mg/l CaCO3	HARD. (CALC. DISS.) mg/l	Ca (DISS.) mg/l	Mg (DISS.) mg/l	K mg/l	Na mg/l	Cl mg/l
A	15.7		212	244	61.5		7.4	69.8	90.9	22	5.4	1.0	5.4	8.5
B	16.8		220	236	45.7		7.6	75.8	92.0					9.2
CA	13.8	233	231	234	44.0	7.3	7.7	76.8	87.7	23	8.1	3.0	7.9	8.9
C	16.1	225	214	227	50.7	7.3	7.6	75.6	65.9	23	7.7	2.9	6.6	9.2
CB	13.8	223	221	204	40.2	7.5	7.7	74.6	84.9	23	7.8	2.3	6.9	8.4
D	15.5	205	202	187	41.2	7.5	7.7	69.5	76.9	21	7.1	1.5	6.2	8.4
H	14.3		203	244	67.3		7.7	67.6	61.2					9.5
G	14.4	205	193	186	46.6	7.4	7.6	71.1	68.9	19	6.6	1.9	6.9	9.7
F	14.5	225	189	176	47.4	7.5	7.6	66.6	70.5	21	6.4	2.2	7.0	8.6
E	14.9	200	187	172	37.8	7.5	7.7	64.9	70.0	21	6.7	1.1	5.4	7.8

SAMPLING LOCATION	SO4 mg/l	NH3-N mg/l	NO2-N mg/l	NO3-N mg/l	NO3+ NO2-N mg/l	KJELD. N (TOT) mg/l	PO4-P (TOT) mg/l	Fe (DISS.) mg/l	Mn (DISS.) mg/l	Zn mg/l	BOD mg/l	COD mg/l	C (TO OR) mg/l	O (DISS.) mg/l	COLOR PT-CO
A	15.1	0.207	0.02	3.80	3.77		0.518	0.00	0.00	0.02	5.0	8.5		12.78	0
B	15.6	0.303		3.28	3.29		0.534				6.6	10.5		12.36	
CA	13.5	0.223		3.18	2.51	1.00	0.107	0.06	0.05		5.4	9.6	3	13.50	17
C	15.1	0.355	0.02	5.20	2.90	2.07	0.557	0.05	0.06	0.02	5.8	10.1	4	11.45	14
CB	13.6	0.227		2.81	2.33	1.00	0.124	0.06	0.05		4.8	9.5	3	13.03	17
D	14.0	0.275	0.02	2.15	2.06	0.60	0.366	0.08	0.02	0.04	4.5	9.0	3	11.75	14
H	0.0	0.479		0.74	1.10		5.200				9.7	13.0			
G	7.7	0.423	0.41	0.90	0.62	1.40	0.209	0.04	0.03	0.02	4.3	14.4	7	9.48	16
F	13.4	0.452	0.03	1.57	1.07	3.04	0.849	0.06	0.03	0.02	3.6	12.1	4	10.64	13
E	13.4	0.242	0.02	3.86	1.69	0.70	0.335	0.12	0.03	0.02	3.8	9.4	4	11.66	14

LOW WATER DATA MEANS JUL.-SEPT. 1977- 1986

SAMPLING LOCATION	T (C)	COND. (FIELD) uhs/cm	COND. (LAB) uhs/cm	TDS mg/l	TSS mg/l	pH (FIELD)	pH (LAB)	ALK (LAB) mg/l CaCO3	HARD. (CALC. DISS.) mg/l	Ca (DISS.) mg/l	Mg (DISS.) mg/l	K mg/l	Na mg/l	Cl mg/l
A	19.3		223	228	32.6		7.4	77.4	95.5					9.2
B	22.3		232	247	51.1		7.7	85.8	101.5					10.1
CA	20.2	276	236	251	63.0	6.8	7.6	79.7	88.5	24	8.0			10.5
C	22.0	255	226	243	55.3	7.1	7.8	78.1	83.7	23	7.8			10.0
CB	20.3	243	217	203	62.0	7.7	7.7	78.7	83.1	24	8.1			8.6
D	21.8	246	211	187	53.6	7.6	7.8	74.6	77.8	23	7.8			8.6
H	19.8		221	233	95.0		7.8	60.5	80.5					9.2
G	20.2	230	215	185	70.0	7.6	7.8	84.1	73.6	24	8.7			10.9
F	22.0	233	188	154	61.0	7.7	7.8	71.4	72.8	24	8.0			7.9
E	21.8	243	202	171	47.1	7.7	7.8	72.1	72.4	23	7.8			8.0

SAMPLING LOCATION	SO4 mg/l	NH3-N mg/l	NO2-N mg/l	NO3-N mg/l	NO3+ NO2-N mg/l	KJELD. N (TOT) mg/l	PO4-P (TOT) mg/l	Fe (DISS.) mg/l	Mn (DISS.) mg/l	Zn mg/l	BOD mg/l	COD mg/l	C (TO OR) mg/l	O (DISS.) mg/l	COLOR PT-CO
A	15.9	0.147		4.25	3.83		0.354				6.2	9.4		13.13	
B	16.0	0.293		2.95	3.34		0.527				7.9	15.0		12.61	
CA	15.0	0.215		2.95	3.40			0.05	0.09		8.2	10.0	2	17.10	15
C	15.7	0.322		15.60	3.08		0.577	0.09	0.19		6.9	14.0	2	12.05	15
CB	15.6	0.190		2.30	3.40			0.06	0.09		7.7	12.0	2	17.30	20
D	12.3	0.247		2.35	2.14		0.525	0.13	0.07		6.4	15.1	2	11.80	15
H		0.175		1.10							6.8	17.8			
G	2.4	0.209	0.00	0.50	0.00		0.159	0.00	0.08		4.9	24.6	12	9.93	30
F	9.4	0.201		1.05	0.57		0.700	0.05	0.08		4.3	18.0	2	11.00	15
E	11.8	0.214		1.70	1.43		0.500	0.05	0.08		6.1	12.0	2	11.88	20

to lowest through Station D above North Slough, then from highest to lowest in North Slough, and finally with Station E last (see Fig. 3 - 1). Additional statistical summaries are provided in Appendix B Tables 1 - 11. Also included in Table 3 - 3 are means of all values from the traditional low water periods (July - September) of each year 1977 - 1986. Data from two special studies of metals and priority pollutants in the Slough have also been reviewed and included; the Oregon Water Quality Criteria defer to the USEPA 1976 edition of Quality Criteria for Water for applicable criteria.

Dissolved Oxygen: Means of all values among all Slough stations suggests that dissolved oxygen values are usually supersaturated due to high density of algae in the Slough. All low water values are slightly elevated over all data means. DO's of less than 90% saturation may be uncommon in the Slough in all seasons due to algal evolution of oxygen.

pH: All means have been within the standard of 6.5 - 8.5. However, an inspection of the Appendix B summary Table 1 shows that pH commonly exceeded 8.0 and occasionally 9.0.

Fecal Coliform Bacteria: Historical data presented in Appendix Table 17 was only available back to 1984. Data acquired during field studies in this project are presented in Section 2.0. Historical data show ranges over all stations from 4 to 24,000 col./100 ml during the period from 21 November 1984 through 29 May 1986. Out of 31 values 11 were less than 100, 7 from between 101 and 999, and 13 1000 and above. All values exceeding 1000 occurred during the period November through May. The data suggests that during this period state standards were exceeded frequently.

Chlorophyll a: Only 1986 data was available for the period 1977 through 1986 for review. All 1986 samples obtained from Slough Stations during SRI field studies where Columbia Slough rather than River water was sampled ranged from 0.033 to 0.070 mg/l (these results are tabled separately in Appendix A, Table 7, and also from Station E in Table 1). All of these exceed state standards. Samples obtained by ODEQ 29 May 1986 from stations below Station B and including two stations in North Slough, ranged from 0.014 to 0.025 mg/l (ODEQ Laboratory Data Sheets, Run No. 86-0456). Four of the stations were just below the threshold value of 0.015 mg/l.

Total Dissolved Solids (mg/l): Means of each of the Stations exceeded the state standard of 100. As with conductance values reviewed in Section 3.6.1, total dissolved solids values decrease with increasing distance down-Slough from Station A.

Dissolved Iron (mg/l): With the exception of the lowest Station, E, all mean values are below the state standard of 0.1 mg/l. High levels at the lower Station may reflect the average higher values in the Willamette River (Appendix B Table 18).

Dissolved Manganese (mg/l): Stations CA, C and CB each had values at or in excess of the state standard of 0.05 mg/l.

Other Metals: There is little data on toxic metals in the Columbia Slough other than a series of analyses that were performed on samples from Stations A - F, 4 April 1979 (City of Portland Columbia Slough Monitoring Data Sheets), and results of sampling done by ODEQ in 1982. Results from each of these single day studies over the 10 year period show levels of copper, lead, cadmium, and zinc that exceed state standards.

Metals in Columbia Slough. The results from the City of Portland work (1979) are:

	STATIONS					
METALS (ppb)	A	B	C	D	E	F
Cadmium	8.2	4.9	6.3	7.3	4.7	3.7
Chromium	16.4	7.6	17.4	9.1	11.5	5.6
Copper	39.5	18.8	21.0	32.9	29.9	14.6
Iron	25.1	24.6	22.7	24.5	21.1	21.4
Nickel	7.9	6.5	7.7	10.9	11.6	3.8
Lead	31.2	5.9	19.9	12.6	11.5	7.7
Zinc	26.2	22.2	12.6	26.2	13.5	15.4

NOTE: The data sheet indicates these samples were acidified with concentrated nitric acid and heated on a steam bath for 30 minutes. In addition, notations on data sheets about hydrologic conditions at sampling time are that there was no current at the time of sampling (?).

On the basis of present DEQ water quality standards regarding these toxic metals, Slough water quality would have been out of compliance at all stations for cadmium, copper and zinc. On the basis of current USEPA water quality standards (USEPA 1986), the Slough water would also have been out of compliance for lead. What is of interest about this unique data set is that there is no apparent pattern of concentrations related to stations. Further, Station F in North Slough, does not have higher concentrations of metals than other Slough Stations. However this data derives from a time when North

Slough was flushed, unlike its present condition as an embayment.

Another data set on metals in the Columbia Slough was generated by ODEQ (1984) from sampling conducted 30 August 1982 at Denver Ave. (see Fig. 3-1) and the Landfill Bridge (historical station C) to determine levels of priority pollutants (129 parameters measured; see Appendix B, Table 20). There is no associated data on water levels, flow or direction of flow in the Slough.

	STATIONS	
METALS (ppb)	DENVER AVE.	C
Antimony	0.0	0.0
Arsenic	0.0	0.0
Beryllium	0.0	0.0
Cadmium	0.3	0.3
Chromium	1.4	1.4
Copper	5.0	9.0
Nickel	29.0	11.0
Lead	15.6	22.8
Mercury	0.0	0.0
Selenium	0.0	0.0
Silver	0.0	0.0
Thallium	0.0	0.0
Zinc	16.0	31.0

On the basis of these results, only copper and zinc exceed state water quality standards. Associated data on levels of these metals in sediment and in crayfish captured in the Slough indicate arsenic, beryllium, cadmium, chromium, copper, lead, mercury and nickel were present in both media at each station. Levels of zinc appeared to be relatively high in both sediment and crayfish at each station. Silver was present only in sediment at each station. Antimony and selenium were not detected in sediment or crayfish (for further information on sediments see Fishman Environmental Services 1986, Technical Appendix D).

COMPARISON WITH EUTROPHICATION INDICES:

Total Phosphorus (mg/l): A comparison of stations in the Slough shows that mean values at all stations are in excess of the suggested threshold value of 0.1 mg/l. Means ranged from 0.107 to 5.2.

Total Nitrogen (mg/l): A suggested threshold (see Section 3.5) has been 0.180 mg/l. Where data was available for Kjeldahl nitrogen, total nitrogen was determined by using mean values as follows ((Kjeld.N - NH3-N) + NO2-N + NO3-N). Resulting values were:

STATION	
CA	3.96
C	6.94
CB	3.58
D	2.50
G	2.29
F	4.18
E	4.34

All of these values far exceed the suggested threshold value, and indicate eutrophic conditions in the Slough.

Un-ionized Ammonia (mg/l): A suggested threshold (see Section 3.5) has been 0.02 mg/l. Ranges of NH3-N were from a low of 0.207 Station A to highs of from 0.423 to 0.479 in North Slough Stations. These values indicate excessive eutrophication in the Slough and especially in North Slough.

COMPARISON WITH LANDFILL LEACHATE INDICES:

Values of chloride, hardness, alkalinity, BOD5, COD, conductance and fecal coliform bacteria may indicate influence by the Landfill if values are relatively higher at stations that would be influenced by the Landfill (see Section 3.5). The caveat of the influence on Slough data of intruding River water still applies, however.

Chloride (mg/l): Means of chloride values were in a narrow range of from 7.8 to 9.7 (Table 3 - 3). While the Station in upper North Slough had the highest mean Station B also had a high value of 9.2.

Hardness (mg/l): Means of calculated hardness were in a range of 70.0 to 92.0 (Table 3-3). These have been the calculated values, using the sum of factors applied to calcium and magnesium in Slough water. These values appear to have a trend of higher values at upper stations to lower at lower stations, reflecting perhaps a diluting effect from lower hardness in intruding River water.

Alkalinity (mg/l): Means of alkalinity ranged from 64.9 at Station E to 76.8 at Station CA. The range seems fairly narrow, and a trend of higher values at upper stations and lower at lower stations appears to be present here also.

BOD5 (mg/l): If the higher value from Station H, which was at the mouth of Smith Channel before the Control Structure was installed, is removed, values are in a narrow range of 3.8 at Stations E and F to 6.6 at Station B. Lower values occur at lower stations. Data sets for individual stations are extremely variable.

COD (mg/l): Means of values ranged from 9.0 at Station D to 14.4 at Station G in North Slough (Table 3-3). There appears to be no trend in values along the Slough, nor does there appear to be a relationship to BOD. Data sets for individual stations are extremely variable.

Conductance (micromhos/cm): Conductance values ranged from 187 at Station E to 231 at Station CA (Fig. 3-2; Table 3-3). These values appear to be influenced by sampling intruding River water of lower conductance at lower stations. High values are at upper stations, while low values are at lower stations. Trends of these values agree fairly well with trends among values for total dissolved solids (TDS) (Table 3-3).

Summary: Among these possible indices of the influence of Landfill leachate on Slough water quality, none suggest that influence. Sampling of River water with Slough water tends to preclude determination of influence.

3.7 Smith and Bybee Lake Water Quality

3.7.1 Evolution of Lakes Monitoring Program

The water quality of Smith and Bybee Lakes was monitored on a regular basis starting in 1981. Prior to 1981 water quality was apparently monitored only once in each of 1972, 1974 and 1980 (ODEQ 1974, Shulters 1975, and Johnson et al. 1985). METRO began sampling Smith Lake in late fall of 1980 (see Appendix B, Tables B - 13 through B - 16 for the data sets for the following discussion). This sampling may have been prompted by considerations of water quality as related to valuable wildlife habitat within and adjacent to the St. John's Landfill. The filling of Blind Slough resulting from the expansion of the Landfill entailed an evaluation of Blind Slough water quality (reviewed in Section 3.5). Considerations of mitigation for wildlife habitat lost through this expansion, as well as concern for impact of the expansion on adjacent lake water quality may have resulted in the initiation of monitoring by METRO (Herb 1986). Considerations of the construction of the water control structure in fall of 1982 resulted in the Corps of Engineers sponsoring a U. S. Geological Survey-conducted July - October 1982 water quality data collection program for each of the Lakes (Clifton 1983). Three sites have been monitored in Smith Lake (SLA, SLB, and SLC; see Fig. 3 - 1). One site (BLA) has been monitored in Bybee Lake.

3.7.2 Quality of Lake Water

Water quality data in the Appendix B Tables 13 - 16 are summarized in Appendix B Table 12. Bacteria data has been provided in Appendix B Table 17. Each of the parameters monitored have been summarized for entire data set values and for all low water values (July - September). The data base was reviewed to determine quality on the basis of: 1) compliance with state water quality standards; 2) eutrophication indices; and 3) indices of Landfill leachate influence (see Section 3.5).

COMPLIANCE WITH STATE WATER QUALITY STANDARDS: The state standards for which there is monitoring data for comparison are dissolved oxygen, pH, fecal coliform bacteria, chlorophyll _a_, total dissolved solids, iron and manganese (see Section 3.5 for standards).

Dissolved Oxygen: No values were below 90% saturation. Detailed diurnal studies of dissolved oxygen during summer of 1982 (Clifton 1983) support these results and showed that water was well-mixed in each of the lakes, and that only rarely were oxygen concentrations decreased even near the bottom at night.

pH: All values have been within the standard of 6.5 - 8.5

Fecal Coliform Bacteria: Determination of compliance cannot be assessed due to the infrequency of sampling. The highest value recorded in historical data was from Bybee Lake in September 1974 with 640 col./100 ml (data from that same date for Smith Lake showed comparably high levels of 420 col./100 ml). Data from 1986 showed no value exceeding 256 col./100 ml. Comparison of past late fall bacteria values with present values suggests an improvement in fecal contamination.

Chlorophyll _a_: There are only recent values for comparison with this recently established standard. Water quality surveys conducted during this study in May and September of 1986 reported the following values (mg/l):

	30 May	17-18 September
Bybee Lake	0.042	0.061/0.076
Smith Lake	0.016	0.086/0.084

These values are each in excess of the state standard of 0.01 mg/l (= 10 $mg/^3$).

Total Dissolved Solids (mg/l): The mean value at Station SLA in Smith Lake was 140; at SLB the mean was 148. In Bybee Lake (BLA) the mean value was 132. These each exceed the state standard of 100.

Dissolved Iron (mg/l): The mean value at Station SLA in Smith Lake was 0.12. The single value at Station SLC in Smith Lake was 0.05 (there is no data on iron from SLB). In Bybee Lake the mean value was 0.08. The mean value at Station SLA does exceed state standards.

Dissolved Manganese (mg/l): The mean value at Station SLA in Smith Lake was 0.2. There was no data from SLB and manganese was not detected at SLC or at the Station in Bybee Lake. The mean at Station SLA exceeds state standards.

COMPARISON WITH EUTROPHICATION INDICES:

Total Phosphorus (mg/l): A comparison of stations in each of the lakes shows that values generally indicate eutrophy:

	Mean(S.D.)All Data	Mean(S.D.)Summer
Smith Lake (SLA)	0.227(0.113)	0.180(0.090)
Smith Lake (SLB)	0.100(0.050)	0.080(0.040)
Smith Lake (SLC)	0.132(0.034)	0.149(0.041)
Bybee Lake (BLA)	0.093(0.064)	0.117(0.069)

The proposed state standard (threshold for problems) was as 0.025 mg/l for lakes (see Section 3.5).

Total Nitrogen (mg/l): A suggested threshold (see Section 3.5) has been 0.180 mg/l. A comparison of Stations from Bybee and Smith Lake where data is available shows values indicate eutrophy:

	Mean (All Data)	Mean (Summer)
Smith Lake (SLB)	1.030	1.100
Bybee Lake (BLA)	1.460	1.070

Un-ionized Ammonia (mg/l): A suggested threshold (see Section 3.5 has been 0.02 mg/l). A comparison of Stations from each of the lakes shows values indicate eutrophy:

	Mean(S.D.) All Data	Mean(S.D) Summer
Smith Lake (SLA)	0.180(0.420)	0.050(0.040)
Smith Lake (SLB)	0.101(0.098)	0.105(0.071)
Smith Lake (SLC)	0.020(0.010)	0.020(0.020)
Bybee Lake (BLA)	0.127(0.104)	0.074(0.044)

COMPARISON WITH AVAILABLE LANDFILL LEACHATE INDICATORS:

Values of chloride, hardness, alkalinity, BOD5, COD, conductance and fecal coliform bacteria may, if higher than "naturally occurring values" in the area, indicate influence of the Landfill (see Section 3.5). There are only two stations in Smith Lake with sufficient data for comparison (SLA nearest the Landfill and SLB towards the center of the lake.

Chloride (mg/l): The station nearest the Landfill (SLA) had the highest mean value (11.0), whereas Station SLB had a mean value of 7.5. Bybee Lake (BLA) with only four data points had a mean value of 9.4 mg/l.

Hardness (mg/l): Station SLA had a mean value of 65.5; Station SLB 66.0. The Bybee Lake Station (BLA) had a mean value of 74.0.

Alkalinity (mg/l): Station SLA had a mean value of 66.1; Station SLB 63.0. The Bybee Lake Station (BLA) had a mean value of 98.6.

BOD5 (mg/l): Station SLA had a mean value of 15; Station SLB 10. The Bybee Lake Station (BLA) had a mean value of 6.0.

COD (mg/l): Station SLA had a mean value of 17; Station SLB 7. The Bybee Lake Station (BLA) had a mean value of 26.

Conductance (micromhos/cm): Station SLA had a mean value of 183; Station SLB 185. The Bybee Lake Station (BLA) had a mean value of 188.

Summary: These parameters do not indicate a consistent trend, nor do the values appear sufficiently elevated to suggest that the Landfill leachate is influencing Lakes water quality. For example chloride values in Smith Lake are higher near the Landfill. Sturgeon and Blue Lakes have had reported chloride values of 18 and 3 mg/l respectively (Johnson et al. 1985); neither appear to be influenced by known sources of chloride. Higher values at the Smith Lake station nearer the Landfill may reflect the influence of pumped leachate from the east Landfill expansion area (Scientific Resources, Inc 1986), however, this leachate is now being pumped to the Columbia Boulevard Wastewater Treatment Plant.

3.8 Conclusions and Recommendations

3.8.1 Slough

1. Conclusion. Water within the Lower Columbia Slough is Willamette-Columbia River water, Columbia Slough water, or a mixture of the two; their locations in the Slough at any particular time is determined by discharge and tidal influences. The target water to be sampled in the Slough should be Columbia Slough water. This would seem to follow from an interest in the quality of water being discharged from the Columbia Slough system. Sampling should therefore be conducted relative to tidal influence on water levels and water movement.

Recommendation. Sampling to determine long-term trends in water quality should be done by sampling Slough water on the outgoing tide. Information on flow direction and velocity and water level height should be obtained at the time of sampling and made part of the data base for later interpretation.

2. Conclusion. The discharge from the Upper Columbia Slough, discharge from the storm and combined sewers, discharge from the two lower drainage districts, and, lastly, the St. John's Landfill are each known to influence water quality in the Lower Slough. Water quality would appear to be influenced by each and differently at different times of the year.

Recommendation. Slough sampling stations should be selected which provide information on the known influences on water quality in the lower Columbia Slough. For example, discontinuing monitoring at Station A just below where upper Columbia Slough water leaves Multnomah Drainage District No. 1 eliminates the opportunity to track the quality of upper Slough water through time, say, for example in relation to the sewering of East Multnomah County. The influence of water pumped from inside the drainage districts to the Columbia Slough (North Pennninsula Numbers 1 and 2, and Multnomah County District) is unknown because this water is not being monitored. Heavy use of fertilizers within these districts may be influencing quality of the water that is discharged.

3. Conclusion. Storm and combined sewer outfall appear to be one of the major influences on Slough water quality during the wet season (September - June). Selected sewer outfalls should be monitored regularly to determine quality during base flow where this occurs, and quality during wet weather bypassing.

Recommendation. Priority pollutant analyses should be performed regularly and interpreted in a timely manner on selected sewer outflows. Levels of toxic metals at all stations in the Lower Slough indicate continuing toxic metals contamination. Industrial wastes entering the Slough through the sewers during wet weather bypassing may be a source of this contamination. Data from the City of Portland's Water Pollution Control Laboratory on industrial effluents in the Columbia Corridor (Cook, pers. comm. 1986) may suggest where monitoring should occur.

4. Conclusion. The influence of discharge from North Penninsula Drainage Districts Numbers 1 and 2 on the Columbia Slough is apparently unknown. It is suspected that water discharged may be seasonally high in plant fertilizers.

Recommendation. Slough monitoring should be designed to obtain data on Drainage District discharges.

5. Conclusion. Beneficial uses of the Columbia Slough watershed have not been defined.

Recommendation. DEQ should define beneficial uses for the Columbia Slough watershed, and define water quality standards relative to those uses.

6. Conclusion. Recently created surface water data files for the St. John's Landfill area were made available by ODEQ for use in this study. These files had been created to facilitate ODEQ analysis of sampling results. It appears there has been no analysis and reporting of results from the routine monitoring throughout the period 1977 - 1986 by the City of Portland, METRO or DEQ. A document evaluating and containing results of a special 1982 study of USEPA priority pollutants (ODEQ 1984) appeared to be in draft form.

Recommendation. Water quality data collected by ODEQ, METRO, or the City of Portland, as required in ODEQ permits, should be analyzed in a timely manner, to provide feedback on the adequacy of the sampling program. We recommend yearly analyses using updated Station files. If it is necessary to collect data, it is at least as important to interpret the data generated. If water quality standards are meant to be the basis for enforcement action, then the lack of timely analysis of routine monitoring data will have the effect of retarding enforcement of standards.

7. Conclusion. There is a relative scarcity of information on USEPA priority pollutants in the Slough.

Recommendations. Priority pollutants should be measured more frequently. Parameters selected for measurement at Slough stations should relate closely to DEQ and USEPA water quality standards. For example, at least yearly priority pollutant analyses should be performed on a representative set of samples from Slough and Lake stations.

8. Conclusions. Water quality parameters currently being monitored quarterly by ODEQ and METRO differ in many ways. ODEQ is monitoring more parameters than METRO, and this appears to result from METRO's monitoring being defined by its permit to operate the St. John's Landfill, whereas ODEQ has added what appear to be additional important parameters (nutrients, dissolved oxygen, chlorophyll a, e.g.) to its monitoring program to test for compliance. A six month frequency of monitoring appears to be inadequate to test for compliance.

Recommendation. Monitor parameters that test or indicate compliance with state water quality standards more frequently than once each six months. Provide for changes in METRO permit monitoring requirements to facilitate more frequent monitoring of appropriate parameters, excluding 'special study' parameters, so that sufficient data for evaluation will be obtained. Characterize Landfill leachate and outfall effluent adequately to identify indicators of these potential contaminant sources.

3.8.2 Lakes

1. Conclusion. Fecal coliform data suggests that retention of water in the lakes has resulted in lower and complying values within each of the lakes. There have been no reported waterfowl deaths due to avian botulism, also a bacterial disease, since the water control structure was installed. Deaths of waterfowl due to botulism were reported for Smith Lake during the late 1970's.

Recommendation. Continue retaining water in Smith Lake by means of a control structure.

2. Conclusion. Data on chlorophyll a and comparisons with eutrophication indices indicates consistently that each of the lakes are eutrophic. This was also the conclusion of Johnson et al. 1985 for both lakes, though from one survey data set. Under present ODEQ-enforced Oregon Administrative Rules (340-41-150) chlorophyll a values have been exceeded.

Recommendation. ODEQ should request the Environmental Quality Commission to place these lakes on a study schedule and develop a proposed control strategy for attaining compliance. DEQ has the option of modifying the chlorophyll a standards for the lakes if it is found that there are natural reasons for the eutrophic condition. This determination should most likely be conducted in association with the determination of beneficial uses for the Columbia Slough watershed (see Section 3.8.1).

3. Conclusion. The eutrophic condition of these two lakes has been exacerbated by the installation of a control structure whereby more water is now retained in the lakes during summer and fall. High concentrations of plant fertilizers nitrogen and phosphorus, associated with higher minimum water levels and larger volumes have resulted in abundant submersed, emersed and microscopic plant growth in each of the Lakes, but especially in Smith Lake (see Appendix E of Fishman Environmental Services 1986). Increased submersed and emergent plant growth may inhibit wind mixing of these Lakes, much as baffles in waterbeds reduce water movement, thereby reducing sediment disturbance and turbidity, which has discouraged rooted plant growth in Vancouver and Sturgeon Lakes.

Recommendation. Future water quality monitoring should include more frequent measurements of plant nutrients (nitrogen and phosphorus compounds), turbidity and Secchi disk transparency in each lake, at least monthly during the period from the freshet through October.

4. Conclusion The source of the increased fertility of each of the Lakes appears to be sediment, directly through wind mixing and indirectly through rooted plants that utilize nutrients from the sediment then partially decompose and release nutrients to the water. That this is indeed the case would have to be determined by an appropriate sampling strategy. This was beyond the scope of the present project. The nutrient contribution of the Willamette-Columbia Rivers to the enrichment of the lakes appears to be negligible, whereas dilution and flushing effects from freshet refilling of the lakes by River water during winter and spring appears to be especially beneficial.

Recommendation. ODEQ should perform a loading analysis of Bybee and Smith Lakes similar to that performed by Schaedel (1986) for Garrison Lake, as part of its response to each of the Lakes being out of compliance with state water quality standards. With recent changes in the USEPA Clean Lakes program, it may be possible for ODEQ to recommend use of these funds for "Phase II" improvements, particularly in Smith Lake.

4.0 WATER QUALITY MANAGEMENT AND HUMAN USE OF SLOUGH AND LAKES

A revised sampling strategy for the Columbia Slough, more intensive sampling of Smith and Bybee Lakes, and the definition of Columbia Slough watershed beneficial water uses will continue the trend toward improved water quality in this complex system initiated by ODEQ and Corps of Engineers studies in the early 1970's. Additional data will provide important diagnostic information needed to continue improving the quality of Slough Water.

Use of Smith Lake for body contact recreation such as swimming may require the introduction of water to Smith Lake low in nitrogen and phosphorus to improve the flushing of this lake. This has been done with success at Vancouver Lake, and is being accomplished at Sturgeon Lake through the introduction of Columbia River water. Well water, that may contain lower concentrations of plant nutrients, could be an alternative to Columbia River water. While Columbia River water is also enriched water, it has less nitrogen and phosphorus than water in Smith Lake (see Tables 18 and 19 of Appendix B for average Columbia River values). A more detailed characterization of Smith Lake water quality will be required in order to determine benefits from addition of either well water or water from the Columbia River. Since characterizing the hydrology of both Bybee and Smith Lakes is now complicated by the changing duration and volumes of flooding of the Lakes by winter and spring freshets (the only source of water to the lakes except for rainfall), more detailed characterization of a range of most probable hydrologic scenarios will be required to develop the water budget required to support projections of nutrient loading.

Generally, the Lower Columbia Slough and Smith and Bybee Lakes appear to have better quality water now than in the years preceding the past 10 years (see Section 1.0). This report has documented where future improvements can be made. Possible reductions in nitrogen and phosphorus in ground water entering the upper Columbia Slough resulting from the sewering of east Multnomah County will contribute to improvements in water quality in the Lower Slough. Perhaps such improvement will be apparent at the end of the next ten years of water quality data analysis.

5.0 REFERENCES

APHA. 1985. Standard methods for the examination of water and wastewater. 16th Edition. American Public Health Association. 1268 pp.

Barber, Lawrence. 1977. Columbia Slough. Sponsored by the Columbia Slough Development Corporation. 31 pp.

Clark, Shirley M. and George R. Snyder. 1969. Timing and extent of a flow reversal in the Lower Columbia River. Limnol. and Oceanogr. 14(6):960-965.

Clifton, Daphne G. 1983. Water-quality data for Smith and Bybee Lakes, Portland, Oregon, June to November 1982. U. S. Department of the Interior, Geological Survey. Open-File Report 83-204. 56 pp.

Columbia Slough Environmental Improvement Task Force. 1972. A plan for the North Portland Peninsula. 36 pp.

Cook, Jim. 1986. City of Portland, Supervisor of Water Pollution Control Laboratory. Personal communication with Stan Geiger, Scientific Resources, Inc. 12 September 1986.

EMCON Associates. 1983. Field assessment of site closure, Boone County Kentucky. Prepared by EMCON Associates, San Jose, California for the Solid and Hazardous Waste Research Division, Municipal Environmental Research Laboratory, Cincinnati, Ohio, U. S. E. P. A. 61 pp.

Fishman Environmental Services. 1985. Smith and Bybee Lakes baseline data report. Prepared by FES, Portland, Oregon for the Port of Portland, Portland, Oregon. December 30, 1985.

Fishman Environmental Services. 1986. Smith and Bybee Lakes environmental studies. Prepared for the Port of Portland and the City of Portland. Prepared by FES, Portland, Oregon. pp. + Appendices.

Hayford, Tim. 1986. Manager of Multnomah Drainage District No. 1. Personal communication with Stan Geiger, S.R.I. 30 October 1986.

Herb, Gene. 1986. District Wildlife Biologist, Forest Grove, Oregon Department of Fish and Wildlife. Personal communication with Stan Geiger, Scientific Resources, Inc. November 25, 1986.

Kepler, R. 1986. Oregon Department of Environmental Quality. Water Quality Specialist. Personal communication with Stan Geiger May - August 1986, Scientific Resources, Inc.

Metropolitan Service District. 1983. St. John's Landfill: Present and future. November 1983. 36 pp.

Myra, George. 1986. Bureau of Sanitary Engineering, City of Portland, Oregon. Personal Communication with Stan Geiger, S.R.I. 19 May, 1986.

Oregon Department of Environmental Quality. 1974. Water quality in Columbia Slough, Oregon 1971-1973. April, 1974. 88 pp. [This is an Appendix to U. S. Army Engineers. 1976. Rivergate-North Portland Area Oregon. Feasibility Report on Water Resource Development]

Oregon Department of Environmental Quality. 1984. Oregon ambient water quality data summary - 1979 - 1983. Prepared by ODEQ, Portland, Oregon. (Draft?) 40 pp + Appendices.

Oregon Department of Environmental Quality. 1985. Regulations relating to water quality control in Oregon. Sections from Oregon Administrative Rules, Chapter 340.

Oregon Department of Environmental Quality. 1986. Memorandum to the Environmental Quality Commission from Fred Hansen, DEQ Director regarding Agenda Item No. O, January 31, 1986, EQC Meeting: Proposed Adoption of Standards for Nuisance Phytoplankton Growth. Paged by Section.

Porcella, Donald B., Spencer A. Peterson and David P. Larsen. 1980. Index to evaluate lake restoration. Journal of the Environmental Engineering Division. EE6 (15893): 1151-1169.

Portland, City of. 1967 - 1982. Water quality data sheets. Provided for the use of Stan Geiger, Scientific Resources, Inc. by George Myra, Bureau of Sanitary Engineering, Portland, Oregon.

Portland, City of. 1972. A report on the monitoring of overflows in twelve outfalls on the Columbia Slough (Oct. 1971 to Mar. 1972 Inclusive). City Engineer. 8 pp. + Appendices.

Portland, City of. 1986. Sewer outfall report. Bureau of Environmental Services. February 1986. 39 pp.

Quan, E. L. 1987. Oregon Department of Environmental Quality, Senior Planner. Personal communication with Stan Geiger, Scientific Resources, Inc. of February, 1987.

Quan, E. L., H. R. Sweet, and Joseph R. Illian. 1974. Subsurface sewage disposal and contamination of ground water in East Portland, Oregon. Ground Water 12(6):356-368.

Schaedel, A. 1986. Discussion draft report on Garrison Lake water quality. August 1986. Version 2, August 20, 1986. Oregon Department of Environmental Quality, Portland, Oregon. 20 pp. + Ap.

Scientific Resources, Inc. 1986. Smith and Bybee Lake Area fall-winter data collection. Prepared by SRI, Portland, Oregon, for Fishman Environmental Services, [for Port of Portland], Portland, Oregon. 17 pp. + Appendices. 31 January 1986.

Shulters, M. V. 1975. Lakes of Oregon. Volume 3. Hood River, Multnomah, Washington, and Yamhill Counties. Open-File Report. Prepared by the U. S. Geological Survey in Cooperation with the Oregon State Engineer. 93 pp.

Smith, Richard A. and Richard B. Alexander. 1983. A statistical summary of data from the U. S. Geological Survey's National Water Quality Networks. U. S. Geological Survey Open-File Report 83-533. U.S.G.S., Reston, Virginia.

Sweet, Edwards and Associates, Inc. 1983. METRO/St. John's Sanitary Landfill water quality study. 42 pp.

U. S. Army Corps of Engineers. 1976a. Rivergate - North Portland Area, Oregon. Feasibility report on water resources development. Main Report. A study to determine feasibility of providing additional flood protection and related water resource development in the Rivergate-North Portland Area. Portland District, U. S. Army Engineers. January 1976. 119 pp. + Appendices.

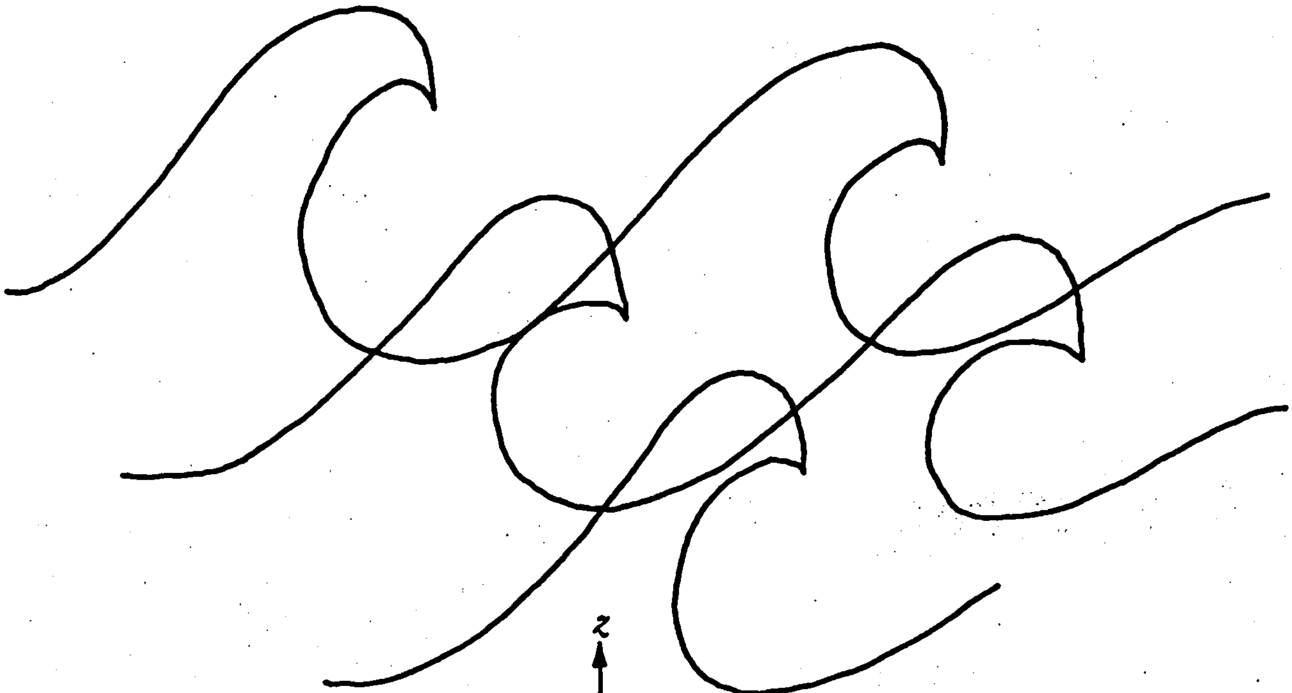
U. S. Army Corps of Engineers. 1976b. Revised draft Environmental Impact Statement. Rivergate-North Portland flood control study. Office of the Chief of Engineers, Department of the Army, Washington, D.C. January 1976. Paged by Section.

U. S. Army Corps of Engineers. 1982. Final Environmental Assessment, 404(b)(1) Evaluation and Finding of No Significant Impact. Reference No. 071-OYA-2-004236 (Columbia Slough - Water Control Structures). 29 April 1982. J. F. Bechly, Chief, Nav. Div. 12 pp.

U. S. Army Corps of Engineers. 1983. Memorandum for Record: Smith and Bybee lakes: Completion of water quality tasks assigned to NPPEN-HH-R. Douglas Larson. 3 June 1983. 10 pp. + Attachments.

U. S. Environmental Protection Agency. 1986. Quality criteria for water. 1986. EPA 440/5-86-001. Office of Water Regulations and Standards, Washington, D. C. Not paged; organized alphabetically by parameter.

APPENDIX A



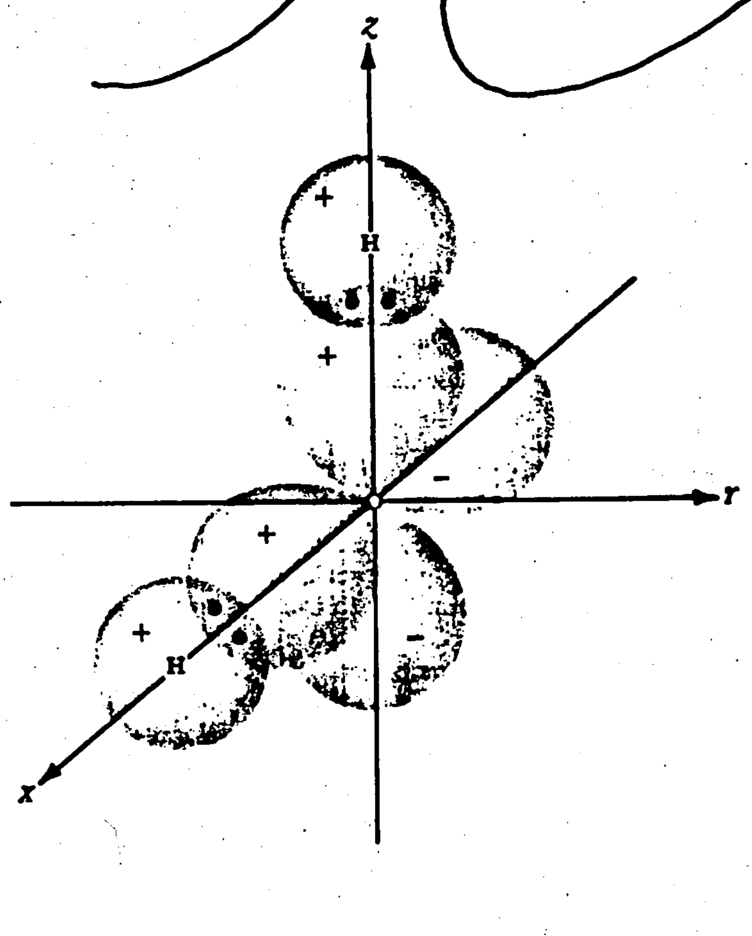


TABLE A-1 WATER QUALITY SAMPLING RESULTS COLUMBIA SLOUGH STATION E MAY AND SEPTEMBER 1986.

DATE (STA E)	TIME/Samp. Loc.		FLOW/DIRECTION (fs; up-dn)	FECAL COLIFORM (Col./100 ml)	TEMPERATURE (C)	CONDUCTANCE (Micromhos/cm)	DISSOL. OXYGEN (mg/l)	p H	CHLOROPHYLL A (mg/cu m)	SECCHI DISK (m)
27-May-86	0543	Middle	0.5/UP	0	19.6	225	12.0	7.3	57.7	
	0753	Right S.		0	15.6	125				
	0756	Middle	1.0/UP	0	15.3	108	11.7	7.4	16.0	
	0758	Left S.		100	15.6	122				
	1043	Middle	0.6/DN	0	15.0	125	12.4	7.7	33.1	0.8
	1443	Right S.		0	19.7	190				
	1449	Middle	0.3/DN	0	20.3	190				0.5
	1450	Left S.		200	20.3	205	13.4			
	1703	Middle	0.4/DN	30	22.1	240	14.7	7.5	69.5	0.4
17-Sep-86	0357	Right S.	2.0/UP	600	18.4	205	10.4	7.3		
	0338	Middle	1.7/UP	500	18.2	210	10.8	7.2	45.8	
	0349	Left S.	2.0/UP	300	18.3	210	10.6	7.3		
	0451	Right S.	2.0/UP	300	19.5	153	8.4	7.4		
	0443	Middle	2.4/UP	200	19.4	152	8.6	7.3	10.7	
	0457	Left S.	2.0/UP	200	19.5	154	8.4	7.3		
	1202	Right S.	0.9/DN	3500	18.6	165	8.7			
	1149	Middle	1.3/DN	400	18.6	165	8.8		19.1	
	1157	Left S.	1.3/DN	3300	18.7	163	8.8			
	1248	Right S.	1.3/DN	5300	17.9	200	9.8			
	1237	Middle	1.5/DN	4900	17.9	200	9.7		45.1	
	1244	Left S.	1.2/DN	7200	17.9	198	9.7			

Blanks = no data available

TABLE A-8 WATER QUALITY SAMPLING RESULTS COLUMBIA SLOUGH MISCELLANEOUS STATIONS MAY AND SEPTEMBER 1986

DATE (MISC. SAMPLES)	TIME/Samp. Loc.		FLOW/DIRECTION (fs; up-dn)	FECAL COLIFORM (Col./100 ml)	TEMPERATURE (C)	CONDUCTANCE (Micromhos/cm)	DISSOL. OXYGEN (mg/1)	p H	SECCHI DISK (m)
27-May-86 (LOMBARD BR.)	1420	Right S.	0.1/DN	0	17.5	133			
	1430	Middle	0.1/DN	0	17.5	133			
	1435	Left S.	0.1/DN	0	17.3	135			
17-Sep-86 (SLOUGH MOUTH)	1118	Right S.	1.3/DN	300	19.0	157	8.9		
	1114	Middle	1.5/DN	300	19.0	157	8.9		
	1123	Left S.	1.5/DN	3900	19.0	157	8.9		

Blanks = no data available

TABLE A – 7. CHLOROPHYLL A AND PHEOPHYTIN A VALUES (MG/CU M) MAY, JUNE AND SEPTEMBE

STATIONS/DATE	CHLa (mg/cum)	PHEOa (mg/cum)
MAY 27, 1986		
Sta E/0550	57.7	38.1
Sta E/0755	16.0	16.1
Sta E/1047	33.1	-
Sta E/1450	49.2	9.2
Sta E/1709	69.5	23.3
N. Slough/1113	102.6	-
Bybee Lk. 30 May	41.5	1.7
Smith Lk. 30 May	16.0	15.6
JUNE 20, 1986		
Bybee Lk.	18.7	9.0
Smith Lk.	21.4	5.3
SEPTEMBER 17-18, 1986		
Sta E/0338 (9/17)	45.8	37.6
Sta E/0443 (9/17)	10.7	12.0
Sta E/1144 (9/17)	19.1	16.7
Sta E/1242 (9/17)	45.1	32.7
Bybee Lk.(willows)	60.6	46.0
Bybee Lk.(gage)	74.8	24.0
Smith Lk. (willows)	85.5	17.5
Smith Lk. (gage)	83.8	19.4

TABLE A – 8 Chloride (mg/l) in 17 September 1986 samples of Columbia Slough, stormwater outfalls, and September 18, 1986 St. Johns Landfill well water.

COLUMBIA SLOUGH STATIONS:		CHLORIDE (mg/l)
STATION B	0637	10.0
	1000	10.5
	1217	10.5
UPPER RIVER (L)	0836	11.0
(C)	0821	11.5
(R)	0827	11.0
STATION CA	0138	10.0
	0541	9.5
	0839	11.0
	1319	10.5
STATION E (L)	0349	10.0
(C)	0357	10.0
(R)	0357	10.0
STATION E (L)	0457	11.0
(C)	0442	11.0
(R)	0450	11.0
STATION E (L)	1157	10.5
(C)	1150	10.0
(R)	1202	11.0
STATION E (L)	1244	10.0
(C)	1238	10.5
(R)	1248	10.0
STATION F	0215	12.0
	0507	9.0
	1224	11.0
WILL. R. MOUTH (L)	1123	7.5
	1114	7.5
	1118	8.0
WILL R. MOUTH	0308	11.0
STORM SEWER OUTFALLS:		
OUTFALL 56C (1)	0755	22.5
(2)	0755	22.5

TABLE A - 8 Continued.

LANDFILL WELLS:

C3-1 (9/18) (1)	140.0
(2)	140.0
D1-C (9/18) (1)	4.0
(2)	4.0

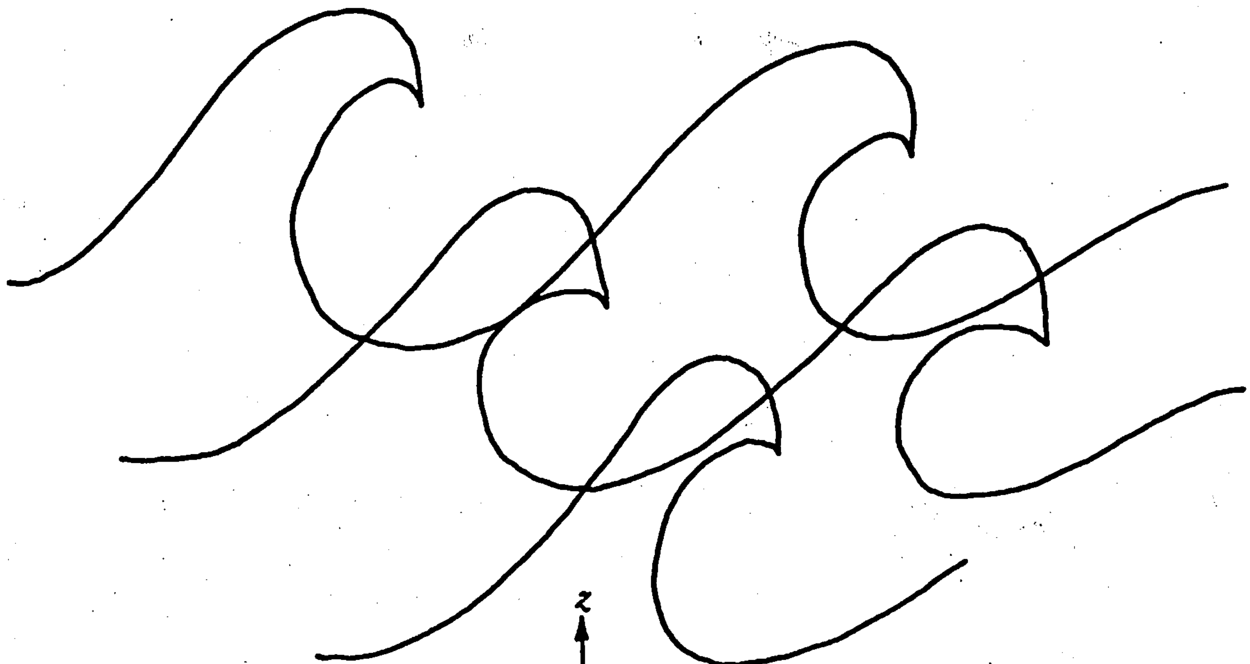
UPDATED 12/08/86 COMPILED BY DAVID B. LIVERMORE, 1986, SHANNON & WILSON, INC.

WELL OR PIEZ. NUMBER	REF PT ELEV. (FEET)	DIAM & DEPTH (IN*FT)	SCREEN INTERVAL DEPTH (FEET)	SCREEN PACK (FEET)	SCREEN LENGTH (FEET)	ELEV OF SCREEN BOTTOM	MATERIAL AT SCREEN	(—2/13/86—) S.W.L. (FEET)	S.W.L. ELEV. (FEET)	(——AVERAGE (1977-86)——) TEMP (C)	LAB COND (umhos/cm)	NH3-N TOTAL (mg/L)	CL (mg/L)
A1H SHAL	66.23	2"	—	3.5	~2.5	+20.6	GARBAGE	16.60	49.63	—	3745	141.00	339
A1L DEEP	66.23	2"	—	3.5	2.5	+6.6	GARBAGE	—	—	—	5760	290.00	272
A2H SHAL	63.20	2"	—	3.5	~2.5	+20.7	GARBAGE	—	—	—	4723	297.33	469
A2L DEEP	63.20	2"	—	3.5	2.5	+6.7	GARBAGE	—	—	—	4324	215.90	545
A3H SHAL	59.00	2"	—	3.5	~2.5	+10.0	GARBAGE	—	—	—	5904	306.50	598
A3L DEEP	59.00	2"	—	3.5	2.5	+4.0	GARBAGE	—	—	—	6710	772.00	717
A4	62.26	2"	—	3.5	—	+20.6	OIL SUMP	19.70	42.56	—	—	—	—
B1	56.53	3"	—	21	19	+0.50	GARBAGE	7.90	48.63	—	7256	360.90	1040
B2	69.33	3"	—	21	19	+6.00	GARBAGE\CLAY	19.30	50.03	—	8421	460.64	1531
B3	36.73	3"	—	21	19	-1.20	GARBAGE\CLAY	—	—	20.5	5275	335.57	516
B4	60.73	3"	—	21	19	+0.30	GARBAGE\CLAY	14.60	46.13	—	8320	539.17	1244
B5	31.70	3"	—	21	19	-10.70	SILTY CLAY	—	—	18.7	4351	132.00	543
B6	15.75	3"	—	21	19	-9.00	CLAY\SAND	7.20	8.55	11.8	584	22.42	13
C1	39.88	2"	—	—	3	+3.30	?	30.46	9.42	16.7	3708	196.33	389
C2	25.63	2"	—	—	3	+1.00	?	13.15	12.48	16.3	5374	152.93	969
C3	21.30	2"	—	—	3	+1.50	?	8.70	12.60	11.6	1970	11.59	193
C4	—	2"	—	—	3	-0.9	?	—	—	—	918	20.00	8
C5	18.71	2"	—	—	3	-5.30	?	9.30	9.41	13.3	420	3.67	12
D-1A	27.02	3*38	28-38	12	10	-10.98	CLAY	19.60	7.42	14.6	1545	6.30	164
D-1B	27.54	3*68	58-68	12	10	-40.46	CLAY	17.20	10.34	14.5	1038	12.92	41
D-1C	27.22	3*109	88-108	23	20	-80.78	CLAY\SILT	17.00	10.22	14.3	625	9.40	11
D-2A	26.82	3*41	31-41	12	10	-14.18	CLAY	10.50	16.32	12.2	845	16.47	32
D-2B	27.43	3*71	61-71	12	10	-43.57	SILT	15.40	12.03	10.8	844	15.58	16
D-3A	37.46	3*49	39-49	12	10	-11.54	CLAY	25.60	11.86	18.7	3467	141.61	289
D-3B	37.96	3*80	70-80	12	10	-42.04	SILTY CLAY	26.55	11.41	18.5	1340	41.03	161
D-4A	23.15	2*31	21-31	10	10	-7.85	SILTY CLAY	11.80	11.35	16.8	1077	18.47	39
D-4B	22.92	3*61	51-61	12	10	-38.08	SILTY CLAY	10.11	12.81	17.4	649	12.28	11
D-5A	31.27	3*41	31-41	12	10	-9.73	CLAY	18.20	13.07	16.7	2532	0.78	309
D-5B	31.58	3*71	61-71	12	10	-39.42	SILTY CLAY	21.80	9.78	17.4	796	7.37	4
D-6A	30.04	3*40	30-40	12	10	-9.96	CLAY	19.40	10.64	12.4	688	4.22	4
D-6B	30.44	3*61	51-61	11	10	-30.56	CLAY	20.20	10.24	12.6	335	4.79	3
D-6C	30.36	3*110	90-110	22	20	-79.64	SAND & GRAVEL	21.20	9.16	12.4	315	0.07	8
D-7A	29.50	3*57	47-57	12	10	-27.50	SILT & SAND	20.10	9.40	13.3	320	0.27	8
D-8A	33.79	3*71	66-71	6	5	-37.21	SAND & GRAVEL	23.50	10.29	16.2	4254	201.58	425
E1L SHAL	—	2*31	29.5-31	9	1.5	-14.00	SANDY SILT	—	—	14.0	525	10.32	19
E1H DEEP	—	2*45	43.5-45	7	1.5	-28.00	SANDY SILT	—	—	14.7	515	1.32	13
E2L SHAL	31.01	2*31	29.5-31	7	1.5	-14.43	SANDY SILT	21.00	10.01	13.9	569	1.09	13
E2H DEEP	31.27	2*98	96.5-98	50	1.5	-81.43	GRAVEL	21.40	9.87	13.4	620	3.95	11
F1	16.34	3*27	25.5-27	5	1.5	-14.92	SANDY SILT	6.10	10.26	13.4	221	2.22	6
EPA-B	56.06	2*50	40-50	21.5	10	+6.06	GARBAGE	30.72	25.34	36.0	9500	—	—
EPA-O	59.27	2*58	48-58	22	10	+1.27	GARBAGE	37.17	22.10	26.0	5500	—	—
EPA-P	60.27	2*58	48-58	22	10	+2.27	GARBAGE	17.00	43.27	—	—	—	—
EPA-Q	67.63	2*63	53-63	22	10	+4.63	GARBAGE	19.33	48.30	35.0	1200	—	—
EPA-R	45.74	2*48	38-48	22	10	-2.26	CLAYEY SILT	29.31	16.43	23.0	4300	—	—

NOTES: Elevations of EPA well casings are from Pg. 46 of EPA dioxin study (1986;TDD R10-8410-13).
Well EPA-O elevation from R E Meyer Consulatants Survey (11/11/85).
Groundwater samples and static water levels of EPA wells measured on 8-15-85.
Reported depths of E & F wells were measured from the original ground surface. Current well depths may differ.
Measuring point elevations referenced to City of Portland Datum.

Table A - 9 St. John's Landfill monitoring well specifications

APPENDIX B



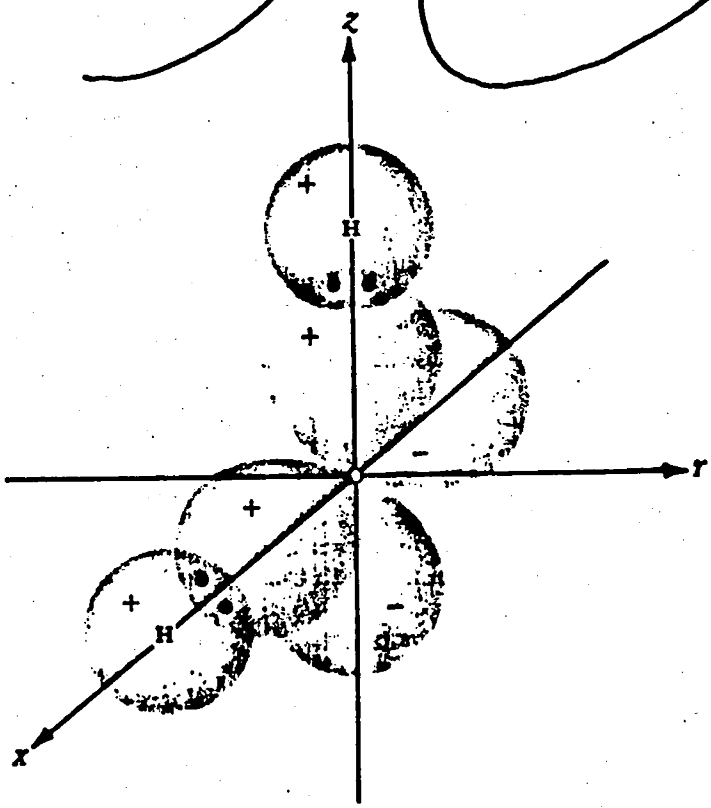


TABLE B - 1 Summary values of Columbia Slough and North Slough water quality sampling stations.

DATE OF SAMPLE (m/d/y)	SAMPLERS	T (C)	COND. (FIELD) uhs/cm	COND. (LAB) uhs/cm	TDS mg/l	TSS mg/l	pH (FIELD)	pH (LAB)	ALK (LAB) mg/l CaCO3	HARD. (CALC. DISS.) mg/l	Ca (DISS.) mg/l	Mg (DISS.) mg/l	K mg/l	Na mg/l	Cl mg/l	SO4 mg/l	NH3-N mg/l	NO2-N mg/l	NO3-N mg/l	NO3+ NO2-N mg/l	KJELD. N (TOT) mg/l	PO4-P (TOT) mg/l	Fe (DISS.) mg/l	Mn (DISS.) mg/l	Zn mg/l	BOD mg/l	COD mg/l	C (TC OR) mg/l	O (DISS.) mg/l	COLOR PT-CO
STATION A (STORET NO. STJOHN01) DATES SAMPLED 1977 - 1981																														
SAMPLES	ANALYZED	84	0	105	89	88	0	105	25	22	1	1	1	1	105	81	101	1	14	82	0	80	1	1	1	100	24	0	80	1
MEAN	VALUE	15.7		212	244	62		7.4	70	91	22	5.4	1	5.4	8.5	15.1	0.2	0.02	3.80	3.77		0.5	0.0	0.0	0.02	5.0	8.5		12.8	0.0
MAXIMUM	VALUE	24.0		319	1827	1560		8.5	85	170	22	5.4	1	5.4	23.9	24.5	1.5	0.02	5.10	5.30		2.7	0.0	0.0	0.02	15.1	27.0		20.0	0.0
MINIMUM	VALUE	0.0		126	38	8		6.6	42	40	22	5.4	1	5.4	4.3	0.0	0.0	0.02	0.26	0.00		0.2	0.0	0.0	0.02	0.0	0.0		6.5	0.0
STANDARD	DEVIATION	5.7		32	174	165		0.4	8	21					2.2	3.4	0.2		1.11	0.80		0.4				2.8	6.3		2.9	
LOW WATER VALUES JULY - SEPT																														
SAMPLES	ANALYZED	28	0	31	29	28	0	31	5	4	0	0	0	0	31	26	30	0	2	26	0	26	0	0	0	29	5	0	26	0
MEAN	VALUE	19.3		223	228	33		7.4	77	96					9.2	15.9	0.1		4.25	3.83		0.4				6.2	9.4		13.1	
MAXIMUM	VALUE	24.0		274	278	62		8.4	85	97					23.9	19.8	0.5		4.40	4.40		0.6				15.1	20.0		16.9	
MINIMUM	VALUE	0.0		174	187	20		6.8	72	94					6.6	13.7	0.0		4.10	3.20		0.2				2.4	0.0		7.3	
STANDARD	DEVIATION	4.4		27	19	8		0.3	5	2					3.1	1.6	0.1		0.15	0.34		0.1				2.7	8.1		2.4	
STATION B (STORET NO. STJOHN02) DATES SAMPLED 1977 - 1981																														
SAMPLES	ANALYZED	83	0	105	88	88	0	104	24	20	0	0	0	0	104	79	99	0	13	79	0	80	0	0	0	100	23	0	80	0
MEAN	VALUE	16.8		220	236	46		7.6	76	92.0					9.2	15.6	0.3		3.3	3.3		0.5				6.6	10.5		12.4	
MAXIMUM	VALUE	28.0		290	640	350		9.1	93	177.0					15.0	20.7	0.9		4.5	4.8		1.2				14.1	31.0		20.0	
MINIMUM	VALUE	2.5		126	165	7		6.9	42	9.7					5.8	7.6	0.0		1.9	1.8		0.0				0.0	0.0		6.7	
STANDARD	DEVIATION	6.4		32	51	37		0.5	11	28.0					1.5	2.5	0.2		0.7	0.5		0.2				3.2	6.8		2.9	
LOW WATER VALUES JULY - SEPT																														
SAMPLES	ANALYZED	27	0	32	28	28	0	32	6	4	0	0	0	0	32	26	30	0	2	26	0	26	0	0	0	29	6	0	26	0
MEAN	VALUE	22.3		232	247	51		7.7	86	101.5					10.1	16.0	0.3		3.0	3.3		0.5				7.9	15.0		12.6	
MAXIMUM	VALUE	28.0		290	310	90		8.9	93	106.0					14.2	20.1	0.6		3.3	3.8		0.8				14.0	31.0		16.8	
MINIMUM	VALUE	17.5		140	188	20		7.0	82	96.0					7.4	13.2	0.0		2.6	2.6		0.3				5.1	0.0		6.7	
STANDARD	DEVIATION	2.7		33	27	20		0.4	4	3.6					1.3	2.0	0.1		0.4	0.3		0.1				2.1	10.3		1.8	
STATION CA (STORET NO. STJOHN09) DATES SAMPLED 1979 - 1986																														
SAMPLES	ANALYZED	10	10	53	10	10	10	53	53	53	6	6	1	1	53	6	53	0	15	6	1	1	6	2	0	29	31	6	4	6
MEAN	VALUE	13.8	233	231	234	44	7.3	7.7	76.8	87.7	23	8.1	3	7.9	8.9	14	0.22		3.2	2.51	1	0.107	0.06	0.05		5.4	9.6	3	13.5	17
MAXIMUM	VALUE	22.5	429	290	300	110	9.0	9.2	98.0	176.0	25	8.8	3	7.9	21.9	15	0.90		4.5	3.40	1	0.107	0.11	0.09		11.0	29.0	7	18.4	20
MINIMUM	VALUE	0.8	175	145	182	15	6.1	6.7	52.0	9.1	22	7.6	3	7.9	4.4	11	0.00		2.0	0.26	1	0.107	0.00	0.00		0.0	0.0	1	7.1	10
STANDARD	DEVIATION	7.0	68	30	35	24	0.8	0.4	9.5	21.8	1	0.4			2.5	1	0.19		0.7	1.06			0.03	0.05		3.1	7.4	2	4.5	4
LOW WATER VALUES JULY - SEPT																														

SUMMARY VALUES OF SLOUGH SAMPLING STATIONS

DATE OF SAMPLE (m/d/y)	SAMPLERS	T (C)	COND. (FIELD) uhs/cm	COND. (LAB) uhs/cm	TDS mg/l	TSS mg/l	pH (FIELD)	pH (LAB)	ALK (LAB) mg/l CaCO3	HARD. (CALC. DISS.) mg/l	Ca (DISS.) mg/l	Mg (DISS.) mg/l	K mg/l	Na mg/l	Cl mg/l	SO4 mg/l	NH3-N mg/l	NO2-N mg/l	NO3-N mg/l	NO3+ NO2-N mg/l	KJELD. N (TOT) mg/l	PO4-P (TOT) mg/l	Fe (DISS.) mg/l	Mn (DISS.) mg/l	Zn mg/l	BOD mg/l	COD mg/l	C (TO OR) mg/l	O (DISS.) mg/l	COLOR PT-CO
SAMPLES	ANALYZED	3	3	12	3	3	3	12	12	12	1	1	0	0	12	1	12	0	2	1	0	0	1	1	0	5	6	1	1	1
MEAN	VALUE	20.2	276	236	251	63	6.8	7.6	79.7	88.5	24	8.0			10.5	15	0.22		3.0	3.40			0.05	0.09		8.2	10.0	2	17.1	15
MAXIMUM	VALUE	22.5	429	290	300	110	8.2	8.2	90.0	104.0	24	8.0			21.9	15	0.50		3.4	3.40			0.05	0.09		11.0	23.0	2	17.1	15
MINIMUM	VALUE	18.0	175	145	226	37	6.1	6.8	59.0	60.0	24	8.0			7.2	15	0.00		2.5	3.40			0.05	0.09		6.0	0.0	2	17.1	15
STANDARD	DEVIATION	1.8	110	37	34	33	1.0	0.4	9.1	12.9					3.8		0.18		0.4							1.9	9.4			

STATION C (STORET NO. STJOHN03) DATES SAMPLED 1977 - 1986

DATE OF SAMPLE (m/d/y)	SAMPLERS	T (C)	COND. (FIELD) uhs/cm	COND. (LAB) uhs/cm	TDS mg/l	TSS mg/l	pH (FIELD)	pH (LAB)	ALK (LAB) mg/l CaCO3	HARD. (CALC. DISS.) mg/l	Ca (DISS.) mg/l	Mg (DISS.) mg/l	K mg/l	Na mg/l	Cl mg/l	SO4 mg/l	NH3-N mg/l	NO2-N mg/l	NO3-N mg/l	NO3+ NO2-N mg/l	KJELD. N (TOT) mg/l	PO4-P (TOT) mg/l	Fe (DISS.) mg/l	Mn (DISS.) mg/l	Zn mg/l	BOD mg/l	COD mg/l	C (TO OR) mg/l	O (DISS.) mg/l	COLOR PT-CO
SAMPLES	ANALYZED	97	10	139	92	92	10	140	57	53	7	7	1	2	137	86	135	1	17	88	4	84	7	3	1	107	36	6	86	7
MEAN	VALUE	16.1	225	214	227	50.7	7.3	7.6	75.6	86.9	23	7.7	2.9	6.6	9.2	15.1	0.355	0.02	5.20	2.90	2.07	0.56	0.05	0.06	0.02	5.8	10.1	4	11.4	14
MAXIMUM	VALUE	28.5	303	285	737	570.0	8.9	9.1	91.0	172.0	26	8.5	2.9	7.7	18.6	30.0	1.700	0.02	42.00	8.20	4.00	1.70	0.09	0.19	0.02	15.0	29.0	7	17.4	25
MINIMUM	VALUE	0.8	170	111	108	2.0	6.5	6.6	47.0	8.6	22	5.5	2.9	5.5	1.9	7.0	0.000	0.02	0.28	0.27	0.83	0.00	0.00	0.00	0.02	0.0	0.0	2	6.0	0
STANDARD	DEVIATION	6.9	32	33	64	58.3	0.7	0.5	9.8	20.6	1	0.9		1.1	1.9	3.0	0.276		9.27	0.94	1.19	0.26	0.04	0.09		2.6	7.8	2	2.7	8

LOW WATER VALUES JULY - SEPT

DATE OF SAMPLE (m/d/y)	SAMPLERS	T (C)	COND. (FIELD) uhs/cm	COND. (LAB) uhs/cm	TDS mg/l	TSS mg/l	pH (FIELD)	pH (LAB)	ALK (LAB) mg/l CaCO3	HARD. (CALC. DISS.) mg/l	Ca (DISS.) mg/l	Mg (DISS.) mg/l	K mg/l	Na mg/l	Cl mg/l	SO4 mg/l	NH3-N mg/l	NO2-N mg/l	NO3-N mg/l	NO3+ NO2-N mg/l	KJELD. N (TOT) mg/l	PO4-P (TOT) mg/l	Fe (DISS.) mg/l	Mn (DISS.) mg/l	Zn mg/l	BOD mg/l	COD mg/l	C (TO OR) mg/l	O (DISS.) mg/l	COLOR PT-CO
SAMPLES	ANALYZED	31	3	40	28	28	3	40	14	12	1	1	0	0	40	27	38	0	3	27	0	26	1	1	0	30	8	1	27	1
MEAN	VALUE	22.0	255	226	243	55.3	7.1	7.8	78.1	83.7	23	7.8			10.0	15.7	0.322		15.60	3.08		0.58	0.09	0.19		6.9	14.0	2	12.1	15
MAXIMUM	VALUE	28.5	303	285	288	110.0	8.2	8.7	90.3	104.0	23	7.8			18.6	21.3	0.900		42.00	3.70		0.90	0.09	0.19		10.0	29.0	2	17.2	15
MINIMUM	VALUE	15.0	225	140	192	26.0	6.5	7.0	58.0	58.0	23	7.8			5.6	12.1	0.000		1.60	2.40		0.40	0.09	0.19		3.7	0.0	2	7.5	15
STANDARD	DEVIATION	3.0	34	32	28	20.0	0.8	0.4	10.3	14.9					2.1	2.3	0.211		18.68	0.34		0.14				1.6	10.3		2.1	

STATION CB (STORET NO. STJOHN10) DATES SAMPLED 1979 - 1986

DATE OF SAMPLE (m/d/y)	SAMPLERS	T (C)	COND. (FIELD) uhs/cm	COND. (LAB) uhs/cm	TDS mg/l	TSS mg/l	pH (FIELD)	pH (LAB)	ALK (LAB) mg/l CaCO3	HARD. (CALC. DISS.) mg/l	Ca (DISS.) mg/l	Mg (DISS.) mg/l	K mg/l	Na mg/l	Cl mg/l	SO4 mg/l	NH3-N mg/l	NO2-N mg/l	NO3-N mg/l	NO3+ NO2-N mg/l	KJELD. N (TOT) mg/l	PO4-P (TOT) mg/l	Fe (DISS.) mg/l	Mn (DISS.) mg/l	Zn mg/l	BOD mg/l	COD mg/l	C (TO OR) mg/l	O (DISS.) mg/l	COLOR PT-CO
SAMPLES	ANALYZED	10	10	54	10	10	10	54	54	54	6	6	1	1	54	6	54	0	15	6	1	1	6	2	0	29	32	6	4	6
MEAN	VALUE	13.8	223	221	204	40	7.5	7.7	74.6	84.9	23	7.8	2.3	6.9	8.4	13.6	0.23		2.8	2.33	1	0.124	0.06	0.05		4.8	9.5	3	13.0	17
MAXIMUM	VALUE	22.4	286	270	266	112	8.6	9.0	113.0	174.0	25	8.5	2.3	6.9	15.8	15.0	0.80		4.4	3.40	1	0.124	0.10	0.09		12.0	25.0	8	17.3	20
MINIMUM	VALUE	0.8	180	140	155	16	6.7	6.5	47.0	8.0	17	6.2	2.3	6.9	1.8	9.6	0.00		1.2	0.27	1	0.124	0.05	0.00		0.0	0.0	1	7.0	10
STANDARD	DEVIATION	7.0	29	34	37	26	0.7	0.4	11.9	21.1	3	0.8			2.1	1.8	0.19		1.0	1.12			0.02	0.05		3.0	6.8	2	4.2	5

LOW WATER VALUES JULY - SEPT

DATE OF SAMPLE (m/d/y)	SAMPLERS	T (C)	COND. (FIELD) uhs/cm	COND. (LAB) uhs/cm	TDS mg/l	TSS mg/l	pH (FIELD)	pH (LAB)	ALK (LAB) mg/l CaCO3	HARD. (CALC. DISS.) mg/l	Ca (DISS.) mg/l	Mg (DISS.) mg/l	K mg/l	Na mg/l	Cl mg/l	SO4 mg/l	NH3-N mg/l	NO2-N mg/l	NO3-N mg/l	NO3+ NO2-N mg/l	KJELD. N (TOT) mg/l	PO4-P (TOT) mg/l	Fe (DISS.) mg/l	Mn (DISS.) mg/l	Zn mg/l	BOD mg/l	COD mg/l	C (TO OR) mg/l	O (DISS.) mg/l	COLOR PT-CO
SAMPLES	ANALYZED	3	3	13	3	3	3	13	13	13	1	1	0	0	13	1	13	0	2	1	0	0	1	1	0	5	7	1	1	1
MEAN	VALUE	20.3	243	217	203	62	7.7	7.7	78.7	83.1	24	8.1			8.6	15.0	0.19		2.3	3.40			0.06	0.09		7.7	12.0	2	17.3	20
MAXIMUM	VALUE	22.4	286	270	266	112	8.5	8.3	113.0	109.0	24	8.1			15.8	15.0	0.60		3.4	3.40			0.06	0.09		12.0	24.0	2	17.3	20
MINIMUM	VALUE	18.5	210	150	160	28	6.7	6.8	54.0	59.0	24	8.1			1.8	15.0	0.00		1.2	3.40			0.06	0.09		2.9	0.0	2	17.3	20
STANDARD	DEVIATION	1.6	32	43	46	36	0.8	0.5	15.7	16.7					3.4		0.18		1.1							2.9	9.3			

STATION D (STORET NO. STJOHN04) DATES SAMPLED 1977 - 1986

SUMMARY VALUES OF SLOUGH SAMPLING STATIONS

DATE OF SAMPLE (m/d/y)	SAMPLERS	T (C)	COND. (FIELD) uhs/cm	COND. (LAB) uhs/cm	TDS mg/l	TSS mg/l	pH (FIELD)	pH (LAB)	ALK (LAB) mg/l CaCO3	HARD. (CALC. DISS.) mg/l	Ca (DISS.) mg/l	Mg (DISS.) mg/l	K mg/l	Na mg/l	Cl mg/l	SO4 mg/l	NH3-N mg/l	NO2-N mg/l	NO3-N mg/l	NO3+ NO2-N mg/l	KJELD. N (TOT) mg/l	PO4-P (TOT) mg/l	Fe (DISS.) mg/l	Mn (DISS.) mg/l	Zn mg/l	BOD mg/l	COD mg/l	C (TO OR) mg/l	O (DISS.) mg/l	COLOR PT-CO
SAMPLES	ANALYZED	33	10	76	30	30	10	77	57	54	7	7	2	2	77	27	72	1	17	26	1	21	7	3	1	49	35	6	24	7
MEAN	VALUE	15.5	205	202	187	41	7.5	7.7	69.5	76.9	21	7.1	1.5	6.2	8.4	14.0	0.28	0.02	2.15	2.06	0.6	0.366	0.08	0.02	0.04	4.5	9.0	3	11.7	14
MAXIMUM	VALUE	27.0	275	270	254	104	8.6	8.8	93.0	167.0	25	8.3	1.6	6.5	13.8	19.3	1.40	0.02	4.40	4.10	0.6	0.700	0.18	0.07	0.04	11.0	44.0	7	17.4	20
MINIMUM	VALUE	0.8	110	90	111	4	6.6	6.6	29.6	7.1	14	4.6	1.3	5.8	3.3	8.0	0.00	0.02	0.28	0.27	0.6	0.000	0.00	0.00	0.04	0.0	0.0	1	6.9	0
STANDARD	DEVIATION	7.0	48	41	36	22	0.6	0.4	13.8	22.9	3	1.3	0.2	0.3	2.1	3.2	0.25		1.19	1.10		0.199	0.06	0.03		2.3	8.4	2	2.3	7

LOW WATER VALUES JULY - SEPT

DATE OF SAMPLE (m/d/y)	SAMPLERS	T (C)	COND. (FIELD) uhs/cm	COND. (LAB) uhs/cm	TDS mg/l	TSS mg/l	pH (FIELD)	pH (LAB)	ALK (LAB) mg/l CaCO3	HARD. (CALC. DISS.) mg/l	Ca (DISS.) mg/l	Mg (DISS.) mg/l	K mg/l	Na mg/l	Cl mg/l	SO4 mg/l	NH3-N mg/l	NO2-N mg/l	NO3-N mg/l	NO3+ NO2-N mg/l	KJELD. N (TOT) mg/l	PO4-P (TOT) mg/l	Fe (DISS.) mg/l	Mn (DISS.) mg/l	Zn mg/l	BOD mg/l	COD mg/l	C (TO OR) mg/l	O (DISS.) mg/l	COLOR PT-CO
SAMPLES	ANALYZED	9	3	18	7	7	3	18	14	12	1	1	0	0	18	5	16	0	2	5	0	4	1	1	0	9	8	1	5	1
MEAN	VALUE	21.8	246	211	187	54	7.6	7.8	74.6	77.8	23	7.8			8.6	12.3	0.25		2.35	2.14		0.525	0.13	0.07		6.4	15.1	2	11.8	15
MAXIMUM	VALUE	27.0	275	270	254	104	8.3	8.4	89.0	102.0	23	7.8			13.8	15.0	0.80		3.50	3.40		0.600	0.13	0.07		11.0	44.0	2	17.4	15
MINIMUM	VALUE	18.5	225	140	142	36	6.9	7.2	50.0	54.0	23	7.8			3.3	10.0	0.00		1.20	1.40		0.400	0.13	0.07		2.1	0.0	2	9.5	15
STANDARD	DEVIATION	2.5	21	44	39	23	0.6	0.3	12.6	16.1					2.7	1.8	0.24		1.15	0.77		0.083				2.3	13.3		2.9	

STATION H (STORET NO. STJOHN08) DATES SAMPLED 1978 - 1983

DATE OF SAMPLE (m/d/y)	SAMPLERS	T (C)	COND. (FIELD) uhs/cm	COND. (LAB) uhs/cm	TDS mg/l	TSS mg/l	pH (FIELD)	pH (LAB)	ALK (LAB) mg/l CaCO3	HARD. (CALC. DISS.) mg/l	Ca (DISS.) mg/l	Mg (DISS.) mg/l	K mg/l	Na mg/l	Cl mg/l	SO4 mg/l	NH3-N mg/l	NO2-N mg/l	NO3-N mg/l	NO3+ NO2-N mg/l	KJELD. N (TOT) mg/l	PO4-P (TOT) mg/l	Fe (DISS.) mg/l	Mn (DISS.) mg/l	Zn mg/l	BOD mg/l	COD mg/l	C (TO OR) mg/l	O (DISS.) mg/l	COLOR PT-CO
SAMPLES	ANALYZED	4	0	28	10	10	0	28	27	23	0	0	0	0	28	1	24	0	10	1	0	1	0	0	0	17	17	0	0	0
MEAN	VALUE	14.3		293	244	67		7.7	68	61.2					9.5	0.0	0.5		0.7	1.1		5.2				9.7	13.0			
MAXIMUM	VALUE	21.5		880	796	180		8.1	170	97.0					58.0	0.0	6.2		1.7	1.1		5.2				104.0	40.0			
MINIMUM	VALUE	6.5		94	122	18		7.1	34	6.5					3.2	0.0	0.0		0.0	1.1		5.2				0.5	0.0			
STANDARD	DEVIATION	5.9		138	189	48		0.3	26	20.0					9.7	0.0	1.3		0.6			0.0				23.7	9.8			

LOW WATER VALUES JULY - SEPT

DATE OF SAMPLE (m/d/y)	SAMPLERS	T (C)	COND. (FIELD) uhs/cm	COND. (LAB) uhs/cm	TDS mg/l	TSS mg/l	pH (FIELD)	pH (LAB)	ALK (LAB) mg/l CaCO3	HARD. (CALC. DISS.) mg/l	Ca (DISS.) mg/l	Mg (DISS.) mg/l	K mg/l	Na mg/l	Cl mg/l	SO4 mg/l	NH3-N mg/l	NO2-N mg/l	NO3-N mg/l	NO3+ NO2-N mg/l	KJELD. N (TOT) mg/l	PO4-P (TOT) mg/l	Fe (DISS.) mg/l	Mn (DISS.) mg/l	Zn mg/l	BOD mg/l	COD mg/l	C (TO OR) mg/l	O (DISS.) mg/l	COLOR PT-CO
SAMPLES	ANALYZED	2	0	6	3	3	0	6	6	4	0	0	0	0	6	0	4	0	1	0	0	0	0	0	0	3	5	0	0	0
MEAN	VALUE	19.8		221	233	95		7.8	81	80.5					9.2		0.2		1.1							6.8	17.8			
MAXIMUM	VALUE	21.5		261	264	120		7.9	86	91.0					12.2		0.5		1.1							7.7	40.0			
MINIMUM	VALUE	18.0		165	210	80		7.5	67	69.0					6.4		0.0		1.1							5.4	0.0			
STANDARD	DEVIATION	1.8		37	23	18		0.1	6	8.1					2.0		0.2									1.0	13.8			

STATION G (STORET NO. STJOHN07) DATES SAMPLED 1977 - 1986

DATE OF SAMPLE (m/d/y)	SAMPLERS	T (C)	COND. (FIELD) uhs/cm	COND. (LAB) uhs/cm	TDS mg/l	TSS mg/l	pH (FIELD)	pH (LAB)	ALK (LAB) mg/l CaCO3	HARD. (CALC. DISS.) mg/l	Ca (DISS.) mg/l	Mg (DISS.) mg/l	K mg/l	Na mg/l	Cl mg/l	SO4 mg/l	NH3-N mg/l	NO2-N mg/l	NO3-N mg/l	NO3+ NO2-N mg/l	KJELD. N (TOT) mg/l	PO4-P (TOT) mg/l	Fe (DISS.) mg/l	Mn (DISS.) mg/l	Zn mg/l	BOD mg/l	COD mg/l	C (TO OR) mg/l	O (DISS.) mg/l	COLOR PT-CO
SAMPLES	ANALYZED	14	10	56	11	11	10	57	56	52	7	7	2	2	57	8	53	5	20	7	1	6	6	3	1	30	36	6	8	7
MEAN	VALUE	14.4	205	193	186	47	7.4	7.6	71.1	68.9	19	6.6	1.9	6.9	9.7	7.7	0.42	0.41	0.90	0.62	1.4	0.209	0.04	0.03	0.02	4.3	14.4	7	9.5	16
MAXIMUM	VALUE	23.4	238	445	351	122	8.4	9.1	130.0	119.0	24	8.7	2.7	8.2	34.0	20.2	5.00	2.01	3.20	3.10	1.4	0.300	0.10	0.08	0.02	11.1	51.0	12	17.2	30
MINIMUM	VALUE	0.8	141	80	114	20	6.6	6.5	26.0	6.3	13	4.6	1.1	5.6	3.4	2.4	0.00	0.00	0.00	0.00	1.4	0.137	0.00	0.00	0.02	0.0	0.0	4	5.5	0
STANDARD	DEVIATION	6.8	29	58	62	27	0.5	0.4	22.3	24.1	3	1.2	0.8	1.3	5.0	5.7	0.83	0.80	0.78	1.05		0.062	0.04	0.04		2.8	11.9	3	3.5	9

LOW WATER VALUES JULY - SEPT

DATE OF SAMPLE (m/d/y)	SAMPLERS	T (C)	COND. (FIELD) uhs/cm	COND. (LAB) uhs/cm	TDS mg/l	TSS mg/l	pH (FIELD)	pH (LAB)	ALK (LAB) mg/l CaCO3	HARD. (CALC. DISS.) mg/l	Ca (DISS.) mg/l	Mg (DISS.) mg/l	K mg/l	Na mg/l	Cl mg/l	SO4 mg/l	NH3-N mg/l	NO2-N mg/l	NO3-N mg/l	NO3+ NO2-N mg/l	KJELD. N (TOT) mg/l	PO4-P (TOT) mg/l	Fe (DISS.) mg/l	Mn (DISS.) mg/l	Zn mg/l	BOD mg/l	COD mg/l	C (TO OR) mg/l	O (DISS.) mg/l	COLOR PT-CO
SAMPLES	ANALYZED	5	3	14	3	3	3	14	14	12	1	1	0	0	14	1	12	2	4	1	0	2	1	1	0	6	9	1	3	1
MEAN	VALUE	20.2	230	215	185	70	7.6	7.8	84.1	73.6	24	8.7			10.9	2.4	0.21	0.00	0.50	0.00		0.159	0.00	0.08		4.9	24.6	12	9.9	30

SUMMARY VALUES OF SLOUGH SAMPLING STATIONS

DATE OF SAMPLE	SAMPLERS	T	COND. (FIELD)	COND. (LAB)	TDS	TSS	pH (FIELD)	pH (LAB)	ALK (LAB) mg/l CaCO3	HARD. (CALC. DISS.)	Ca (DISS.)	Mg (DISS.)	K	Na	Cl	SO4	NH3-N	NO2-N	NO3-N	NO3+ NO2-N	KJELD. N (TOT)	PO4-P (TOT)	Fe (DISS.)	Mn (DISS.)	Zn	BOD	COD	C (TO OR)	O (DISS.)	COLOR
(m/d/y)		(C)	uhs/cm	uhs/cm	mg/l	mg/l				mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	PT-CO
MAXIMUM	VALUE	23.4	238	260	200	122	8.4	9.1	125.0	101.0	24	8.7			23.0	2.4	0.90	0.00	1.00	0.00		0.180	0.00	0.08		11.0	51.0	12	17.2	30
MINIMUM	VALUE	16.0	225	150	176	30	6.9	6.8	56.0	6.3	24	8.7			4.7	2.4	0.00	0.00	0.00	0.00		0.137	0.00	0.08		0.0	0.0	12	5.5	30
STANDARD	DEVIATION	2.5	6	33	10	39	0.6	0.5	17.4	24.1					4.9		0.29		0.50			0.021				3.5	15.8		5.2	
STATION F (STORET NO. STJOHN05) DATES SAMPLED 1977 - 1986																														
SAMPLES	ANALYZED	36	10	78	31	31	10	80	58	54	7	7	2	2	77	26	76	1	16	28	4	23	7	3	1	48	36	6	25	7
MEAN	VALUE	14.5	225	189	176	47.4	7.5	7.6	66.6	70.5	21	6.4	2.2	7.0	8.6	13.4	0.452	0.03	1.57	1.07	3.04	0.849	0.06	0.03	0.02	3.8	12.1	4	10.6	13
MAXIMUM	VALUE	27.3	291	311	256	132.0	8.6	8.6	108.0	127.0	24	8.7	3.1	8.4	20.0	21.7	4.500	0.03	3.70	3.10	3.70	10.000	0.18	0.08	0.02	11.7	38.0	8	17.1	20
MINIMUM	VALUE	0.8	142	80	114	7.0	6.5	6.6	28.0	6.1	13	4.2	1.2	5.6	3.1	5.9	0.000	0.03	0.00	0.00	1.40	0.020	0.00	0.00	0.02	0.0	0.0	2	5.9	0
STANDARD	DEVIATION	7.8	46	52	44	29.6	0.6	0.4	18.7	22.7	4	1.7	1.0	1.4	3.5	4.9	0.725		1.03	0.74	0.95	1.970	0.06	0.04		2.2	10.5	2	2.4	6
LOW WATER VALUES JULY - SEPT																														
SAMPLES	ANALYZED	9	3	18	6	6	3	18	14	12	1	1	0	0	18	5	16	0	2	5	0	4	1	1	0	9	8	1	5	1
MEAN	VALUE	22.0	233	188	154	61.0	7.7	7.8	71.4	72.8	24	8.0			7.9	9.4	0.201		1.05	0.57		0.700	0.05	0.08		4.3	18.0	2	11.0	15
MAXIMUM	VALUE	27.3	238	260	220	102.0	8.4	8.6	94.1	95.0	24	8.0			16.9	15.0	0.700		1.60	1.30		1.000	0.05	0.08		11.7	38.0	2	17.1	15
MINIMUM	VALUE	18.5	225	118	121	27.0	6.9	7.2	52.0	52.0	24	8.0			3.1	6.0	0.000		0.50	0.30		0.500	0.05	0.08		0.0	0.0	2	8.8	15
STANDARD	DEVIATION	2.6	6	45	32	26.2	0.6	0.3	13.2	15.3					3.7	3.2	0.202		0.55	0.37		0.187				3.3	15.0		3.1	
STATION E (STORET NO. STJOHN05) DATES SAMPLED 1977 - 1986																														
SAMPLES	ANALYZED	34	10	78	29	29	10	78	58	54	7	7	2	2	78	27	74	1	16	26	1	21	7	3	1	49	36	6	24	7
MEAN	VALUE	14.9	200	187	172	38	7.5	7.7	64.9	70.0	21	6.7	1.1	5.4	7.8	13.4	0.24	0.02	3.9	1.69	0.7	0.34	0.12	0.03	0.02	3.8	9.4	4	11.7	14
MAXIMUM	VALUE	26.0	286	270	234	76	8.3	8.6	92.4	166.0	25	8.1	1.2	5.5	18.0	19.3	1.00	0.02	34.0	3.90	0.7	0.80	0.33	0.08	0.02	14.0	32.0	11	17.3	20
MINIMUM	VALUE	0.8	101	80	98	8	6.6	6.6	26.0	6.1	12	3.8	1.0	5.3	3.2	7.3	0.00	0.02	0.0	0.28	0.7	0.00	0.00	0.00	0.02	0.0	0.0	1	6.8	0
STANDARD	DEVIATION	7.2	54	47	40	18	0.6	0.4	15.5	23.9	4	1.5	0.1	0.1	2.6	3.8	0.20		7.9	1.11		0.20	0.11	0.04		2.3	8.0	3	2.2	7
LOW WATER VALUES JULY - SEPT																														
SAMPLES	ANALYZED	9	3	18	7	7	3	18	14	12	1	1	0	0	18	5	16	0	2	5	0	4	1	1	0	9	8	1	5	1
MEAN	VALUE	21.8	243	202	171	47	7.7	7.8	72.1	72.4	23	7.8			8.0	11.8	0.21		1.7	1.43		0.50	0.05	0.08		6.1	12.0	2	11.9	20
MAXIMUM	VALUE	26.0	286	270	234	76	8.3	8.5	92.4	101.0	23	7.8			13.2	15.0	0.64		3.2	2.40		0.60	0.05	0.08		14.0	25.0	2	17.3	20
MINIMUM	VALUE	18.5	205	135	118	26	6.9	7.2	52.0	54.0	23	7.8			3.4	9.8	0.00		0.2	0.33		0.40	0.05	0.08		2.0	0.0	2	9.4	20
STANDARD	DEVIATION	2.3	33	45	38	18	0.6	0.3	12.8	15.2					2.9	2.2	0.21		1.5	0.66		0.07				3.1	9.1		2.8	

TABLE B - 2 Columbia Slough Station A water quality data 1977 - 1981
(USEPA STORET No. STJOHN01)

DATE OF SAMPLE (m/d/y)	SAMPLERS	T (C)	COND. (FIELD) uhs/cm	COND. (LAB) uhs/cm	TDS mg/l	TSS mg/l	pH (FIELD)	pH (LAB)	ALK (LAB) mg/l CaCO3	HARD. (CALC. DISS.) mg/l	Ca (DISS.) mg/l	Mg (DISS.) mg/l	K mg/l	Na mg/l	Cl mg/l	SO4 mg/l	NH3-N mg/l	NO2-N mg/l	NO3-N mg/l	NO3+ NO2-N mg/l	KJELD. N (TOT) mg/l	PO4-P (TOT) mg/l	Fe (DISS.) mg/l	Mn (DISS.) mg/l	Zn mg/l	BOD mg/l	COD mg/l	C (TO DR) mg/l as C	O (DISS.) mg/l	COLOR PT-CO
01/12/77	DEQ			148				7.5	70	77	22	5.4	1	5.4	4.3	12.3		0.02	0.26	0.08			0.0	0.0	0.02		0.0			0
01/19/77	CITY	11.0		208	238	51		7.2							8.9	18.7	0.1			5.30		0.3				3.9			10.3	
01/26/77	CITY	5.5		208	202	10		7.5							8.8	19.3	0.1			4.50		0.2				3.1			13.4	
02/02/77	CITY	6.5		207	217	34		6.9							9.0	16.2	0.1			4.40		0.2				5.4			12.3	
02/09/77	CITY	7.0		211	211	14		6.6							9.0	18.6	0.0			4.70		0.2				4.1			13.3	
02/16/77	CITY	10.3		200	250	25		7.2							9.0	20.7	0.1			5.20		0.3				3.6			12.2	
03/16/77	CITY	11.0		200	109	33		6.6							8.0	15.5	0.1			3.70		0.4				3.7			12.4	
04/06/77	CITY	16.0		235	229	31		6.7							9.2	9.2	0.2			3.90		0.4				6.6			16.2	
06/08/77	CITY	24.0		195	198	23		8.2							8.2	15.2	0.5			2.60		0.2				10.3			19.3	
06/15/77	CITY	19.3		215	217	24		7.5							9.2	18.6	0.2			3.30		0.4				6.5			16.0	
06/22/77	CITY	19.5		205	199	24		7.4							8.1	18.6	0.1			3.10		0.3				8.0			16.6	
06/30/77	CITY	21.3		210	215	22		8.1							13.2	18.6	0.2			2.60		0.2				10.1			20.0	
12/02/77	CITY	11.0		129	150	8		6.8							4.4	0.0	0.0			0.00		0.6				6.5			8.1	
01/18/78	CITY	8.0		210	38	223		6.8							8.0	14.2	0.2			3.60		0.7				1.8			8.5	
01/25/78	CITY	8.0		203	218	27		7.0							7.7	15.0	0.1			3.70		0.4				1.4			8.6	
02/02/78	CITY	7.5		185	202	36		7.1							6.5	11.4	0.2			3.60		0.8				1.5			9.0	
02/08/78	CITY	9.0		142	232	58		6.9							6.2	11.4	0.3			3.00		0.9				2.8			8.6	
02/23/78	CITY	9.9		218	221	50		7.1							6.5	13.2	0.2			3.10		0.4				2.0			9.8	
03/01/78	CITY	9.0		193	212	44		7.2							5.8	12.1	0.3			3.30		0.7				2.3			10.3	
03/09/78	CITY	10.0		190	237	72		7.4							7.1	7.7	0.3			3.50		0.4				4.6			10.7	
03/15/78	CITY	10.0		201	215	52		7.0							8.1	11.7	0.3			3.80		0.6				3.6			13.2	
03/22/78	CITY	14.0		222	243	46		7.3							8.2	15.3	0.2			4.00		0.6				5.8			15.8	
04/07/78	CITY	18.8		192	229	37		7.6							7.8	14.7	0.2			3.40		0.5				8.7			16.0	
04/12/78	CITY	14.6		208	217	27		7.2							8.2	15.6	0.1			4.50		0.3				3.9			12.9	
05/09/78	CITY	16.5		200	204	32		7.0							7.6	14.2	0.2			4.10		0.4				7.8			14.2	
05/17/78	CITY	18.0		191	198	26		6.9							7.2	13.4	0.2			3.40		0.4				6.0			11.8	
06/07/78	CITY	22.5		230	217	28		8.2							9.6	15.0	0.2			2.10		0.4				8.8			18.8	
06/21/78	CITY	20.0		198	195	26		7.0							7.6	16.3	0.1			3.30		0.2				8.1			17.0	
06/28/78	CITY	21.0		230	231	25		6.7							8.2	13.5	0.0			3.70		0.3				8.6			15.2	
07/05/78	CITY	16.5		204	227	21		6.8							7.8	14.7	0.1			4.30		0.3				4.2			11.1	
07/12/78	CITY	18.0		212	206	34		7.7							8.5	15.0	0.2			3.80		0.4				8.8			16.5	
07/19/78	CITY	18.4		190	187	26		7.2							7.3	13.8	0.1			3.20		0.3				10.0			14.1	
07/26/78	CITY	23.0		228	211	26		7.3							8.0	13.8	0.2			3.30		0.2				7.0			16.3	
08/02/78	CITY	20.5		220	214	25		7.4							10.0	16.7	0.2			3.90		0.2				10.1			16.9	
08/09/78	CITY	23.0		228	221	29		7.3							7.8	16.8	0.1			3.70		0.2				10.2			15.8	
08/16/78	CITY	18.5		191	237	32		7.2							7.0	13.7	0.1			3.60		0.2				8.3			11.2	
08/23/78	CITY	15.7		188	235	28		6.9							7.4	14.5	0.1			4.10		0.4				2.4			10.2	
08/30/78	CITY	19.5		202	254	34		7.4							8.2	15.2	0.1			4.20		0.4				3.9			11.8	
09/06/78	CITY	16.5		198	221	28		7.3							8.2	15.3	0.1			4.20		0.3				5.1			12.9	
09/13/78	CITY	15.0		202	207	29		7.2							6.6	15.0	0.1			3.90		0.4				4.3			11.2	
09/20/78	CITY	18.0		245	278	20		7.4							23.9	16.5	0.1			3.90		0.3				6.7			16.0	
09/27/78	CITY	18.5		205	259	34		7.4							8.4	14.7	0.1			3.90		0.4				5.0			12.6	
10/04/78	CITY	18.2		204	211	8		7.4							8.8	16.3	0.1			4.10		0.3				4.5			13.0	
10/11/78	CITY	11.8		202	208	36		7.3							8.8	15.2	0.0			4.40		0.3				4.3			12.6	
10/25/78	CITY	13.0		202	234	38		7.2							8.8	17.0	0.1			5.00		0.4				3.8			11.2	
12/13/78	CITY	6.0		152	223	24		7.0							7.5	13.6	0.3			4.00		0.8				2.4			8.1	

BLANK SPACES = NO SAMPLES; 0.0 VALUES = LESS THAN LOWER LIMIT OF DETECTION.

DATE OF SAMPLE (m/d/y)	SAMPLERS	T (C)	COND. (FIELD) uhs/cm	COND. (LAB) uhs/cm	TDS mg/l	TSS mg/l	pH (FIELD)	pH (LAB)	ALK (LAB) mg/l CaCO3	HARD. (CALC. DISS.) mg/l	Ca (DISS.) mg/l	Mg (DISS.) mg/l	K mg/l	Na mg/l	Cl mg/l	SO4 mg/l	NH3-N mg/l	NO2-N mg/l	NO3-N mg/l	NO3+ NO2-N mg/l	KJELD. N (TOT) mg/l	PO4-P (TOT) mg/l	Fe (DISS.) mg/l	Mn (DISS.) mg/l	Zn mg/l	BOD mg/l	COD mg/l	C (TO DR) mg/l as C	O (DISS.) mg/l	COLOR PT-CO
01/24/79	CITY	6.5		201	209	26		6.7							9.1	14.3	0.2			4.40		0.7				3.7			9.8	
01/31/79	CITY	2.5		222	212	16		7.0							9.3	15.9	0.1			4.60		0.4				2.3			12.8	
02/07/79	DEQ	3.5		126				7.1	42						7.0												27.0			
02/14/79	CITY	11.0		157	205	42		7.0							7.6	13.1	0.3			3.90		0.8				1.8			8.9	
02/21/79	CITY	9.0		191	211	30		7.0							7.1	14.1	0.1			4.00		0.4				2.1			10.5	
03/01/79	CITY	10.0		183	208	44		7.1							6.9	13.7	0.2			3.90		0.6				2.9			11.3	
03/06/79	DEQ	11.5		186				7.5	65						8.0												14.0			
03/07/79	CITY	16.0		183	194	36		7.1							6.8	12.8	0.2			3.80		0.6				2.5			10.2	
03/14/79	CITY	13.0		192	207	34		7.1							7.5	14.1	0.1			4.10		0.5				3.8			12.0	
03/21/79	CITY	14.5		194	210	20		7.5							7.4	13.9	0.1			4.00		0.4				5.3			16.5	
03/29/79	CITY	12.0		181	330	154		7.2							8.6	4.4	1.0			4.20		2.0				2.8			10.5	
04/04/79	CITY	17.0		209	444	258		7.3							10.0	15.2	1.5			4.00		2.7				5.6			11.9	
04/11/79	CITY	12.0		182	278	80		7.2							7.6	15.9	0.4			4.00		1.1				3.7			12.0	
04/18/79	CITY	14.0		193	1827	1560		7.5							12.6	12.4	0.3			2.70		0.2				3.9			6.5	
04/25/79	CITY	16.0		197	370	190		7.2							8.6	14.7	1.1			3.90		1.9				3.9			10.5	
05/02/79	CITY	19.0		213	237	64		7.3							8.5	24.5	0.4			4.30		0.8				4.2			10.9	
05/09/79	CITY	16.0		188	227	82		7.5							7.7	12.4	0.4			3.40		1.0				6.1			12.3	
05/16/79	CITY	20.0		208	163	96		8.2							8.2	13.0	0.5			4.00		1.0				14.2			15.9	
05/24/79	METRO	22.0		255	248	42		7.7							8.1	14.1	0.2			4.30		0.6				10.0			14.1	
05/30/79	METRO	21.0		212	253	54		8.5							7.9	12.5	0.2			4.00		0.6				10.3			17.3	
06/06/79	METRO	20.5		230	261	80		7.6							8.0	20.0	0.4			4.20		0.8				5.0			10.7	
06/13/79	METRO	20.5		241	239	48		8.1							7.8	19.2	0.2			3.80		0.5				6.3			14.9	
06/20/79	METRO	17.0		201	255	45		6.9							7.7	20.7	0.3			4.40		0.5				3.1			9.7	
06/27/79	METRO	22.0		246	251	54		8.5							7.9	18.2	0.3			3.90		0.6				6.3			16.3	
07/05/79	METRO	20.0		232	230	40		7.6							8.3	17.0	0.2			4.00		0.5				5.6			14.7	
07/11/79	METRO	20.5		239	220	40		7.7							14.0	18.7	0.3			4.00		0.4				4.7			13.7	
07/18/79	METRO	24.0		274	238	30		8.4							9.7	18.9	0.2			3.50		0.4				6.9			16.9	
07/21/79	DEQ	0.0																												
07/25/79	METRO	22.0		230	247	38		7.5							8.5	19.8	0.1			4.30		0.3				3.9			13.2	
07/30/79	DEQ	21.5		265				7.6	75						10.0												20.0			
08/01/79	METRO	24.0		237	236	40		7.8							7.8	17.0	0.1			3.50		0.4				5.9			14.5	
08/08/79	METRO	22.5		242	239	42		7.9							9.4	16.3	0.2			3.50		0.4				5.9			15.9	
08/15/79	METRO	21.0		248	241	34		7.3							7.3	18.5	0.1			4.00		0.3				3.8			11.2	
08/22/79	METRO	21.0		192	235	30		7.1							8.6	14.6	0.1			3.60		0.3				15.1			10.3	
08/29/79	METRO	20.5		208	228	32		7.2							8.4	15.7	0.1			3.70		0.3				4.5			11.0	
09/05/79	METRO	19.5		174	206	38		7.0							8.2	14.2	0.2			3.50		0.5				2.6			7.3	
09/12/79	METRO	22.0		226	228	42		7.3							9.0	16.3	0.1			4.40		0.4				4.8			12.2	
09/19/79	METRO	21.0		188	249	62		7.5							9.0	15.2	0.2			3.30		0.6				4.6			11.7	
09/26/79	METRO	20.0		219	227			7.5							8.9	15.2	0.2			4.30		0.4							12.2	
10/18/79	METRO			220				7.9	70	84					8.5		0.1									2.4	10.0			
11/07/79	METRO			253				7.2	70	86					7.8		0.2									1.8	11.0			
01/23/80	METRO			220				7.9	67	87					8.8		0.2			4.40						1.8	4.0			
02/21/80	METRO			222				7.9	70	91					8.4		0.1									1.5	5.0			
03/11/80	METRO			220				7.5	68	86					8.6		0.2		4.40							3.0	6.0			
04/23/80	METRO			140				7.8	70	89					7.8		0.0		3.60							5.0	6.0			
05/28/80	METRO			245				7.3	67	170					8.9		0.0		4.40							6.0	10.0			

BLANK SPACES = NO SAMPLES; 0.0 VALUES = LESS THAN LOWER LIMIT OF DETECTION.

WATER QUALITY DATA 1977-1981 STATION A (STORET NO. STJOHN01).

DATE OF SAMPLE (m/d/y)	SAMPLERS	T (C)	COND. (FIELD) uhs/cm	COND. (LAB) uhs/cm	TDS mg/l	TSS mg/l	pH (FIELD)	pH (LAB)	ALK (LAB) mg/l CaCO3	HARD. (CALC. DISS.) mg/l	Ca (DISS.) mg/l	Mg (DISS.) mg/l	K mg/l	Na mg/l	Cl mg/l	SO4 mg/l	NH3-N mg/l	NO2-N mg/l	NO3-N mg/l	NO3+ NO2-N mg/l	KJELD. N (TOT) mg/l	PO4-P (TOT) mg/l	Fe (DISS.) mg/l	Mn (DISS.) mg/l	Zn mg/l	BOD mg/l	COD mg/l	C (TO OR) mg/l as C	O (DISS.) mg/l	COLOR PT-CO
06/26/80	METRO			319				7.6	73	90					10.6		0.1		4.20							6.7	10.0			
07/24/80	CITY			270				7.6	85	97					12.4		0.1		4.40							5.9	6.0			
11/18/80	METRO			257				8.0	69	93					8.2		0.2		5.10							3.1	10.0			
01/06/81	METRO			250				7.3	68	98					7.4		0.4									1.3	4.0			
02/03/81	METRO			270				7.1	69	40					7.8		0.2		4.60							1.3	3.0			
04/06/81	CITY			216	190	32		7.6	66	78					7.0		0.2		3.20							3.8	13.0			
05/06/81	METRO			242	224	36		8.5	77	88					7.7		0.1		3.30							0.0	8.0			
06/01/81	METRO			260	270	48		8.0	79	95					8.8		0.2		3.70							0.0	9.2			
07/06/81	METRO			250	212	22		7.3	72	94					8.4		0.5		4.10							5.9	3.0			
08/12/81	METRO			260	196	32		7.8	82	94					9.6		0.1									7.9	18.0			
09/16/81	METRO			260	236	24		7.7	73	97					8.0		0.0									6.7	0.0			
10/14/81	METRO			250	240	42		6.9	65	93					7.2		0.1									3.6	5.0			
11/04/81	METRO			232	266	36		7.6	70	93					11.2		0.2		4.40							1.8	2.0			
12/08/81	METRO			185	204	40		7.1	62	79					16.0		0.2		3.50							1.3				
SAMPLES	ANALYZED	84	0	105	89	88	0	105	25	22	1	1	1	1	105	81	101	1	14	82	0	80	1	1	1	100	24	0	80	1
MEAN	VALUE	15.7		212	244	62		7.4	70	91	22	5.4	1	5.4	8.5	15.1	0.2	0.02	3.80	3.77		0.5	0.0	0.0	0.02	5.0	8.5		12.8	0.0
MAXIMUM	VALUE	24.0		319	1827	1560		8.5	85	170	22	5.4	1	5.4	23.9	24.5	1.5	0.02	5.10	5.30		2.7	0.0	0.0	0.02	15.1	27.0		20.0	0.0
MINIMUM	VALUE	0.0		126	38	8		6.6	42	40	22	5.4	1	5.4	4.3	0.0	0.0	0.02	0.26	0.00		0.2	0.0	0.0	0.02	0.0	0.0		6.5	0.0
STANDARD	DEVIATION	5.7		32	174	165		0.4	8	21					2.2	3.4	0.2		1.11	0.80		0.4				2.8	6.3		2.9	

BLANK SPACES = NO SAMPLES; 0.0 VALUES = LESS THAN LOWER LIMIT OF DETECTION.

TABLE B - 3 Columbia Slough Station B water quality data 1977 - 1981
(USEPA STORET No. STJOHN02)

DATE OF SAMPLE (m/d/y)	SAMPLERS	T (C)	COND. (FIELD) uhs/cm	COND. (LAB) uhs/cm	TDS mg/l	TSS mg/l	pH (FIELD)	pH (LAB)	ALK (LAB) mg/l CaCO3	HARD. (CALC. DISS.) mg/l	Ca (DISS.) mg/l	Mg (DISS.) mg/l	K mg/l	Na mg/l	Cl mg/l	SO4 mg/l	NH3-N mg/l	NO2-N mg/l	NO3-N mg/l	NO3+ NO2-N mg/l	KJELD. N (TOT) mg/l	PO4-P (TOT) mg/l	Fe (DISS.) mg/l	Mn (DISS.) mg/l	Zn mg/l	BOD mg/l	COD mg/l	C (TO OR) mg/l	O (DISS.) mg/l	COLOR PT-CO
01/19/77	CITY	10.5		214	215	33		7.0							10.6	17.0	0.5			4.6		0.3				3.2			8.2	
01/26/77	CITY	5.0		213	195	7		7.6							9.2	20.0	0.4			4.0		0.3				2.9			11.7	
02/02/77	CITY	5.5		227	228	27		7.4							10.6	17.3	0.1			4.2		0.2				6.4			12.7	
02/09/77	CITY	6.0		231	235	40		7.4							10.3	20.5	0.1			4.2		0.2				6.1			14.1	
02/16/77	CITY	10.1		205	256	41		7.3							9.5	19.2	0.3			4.4		0.3				4.4			10.2	
03/16/77	CITY	9.5		203	210	41		7.1							8.6	17.4	0.2			3.1		0.4				3.7			10.6	
04/06/77	CITY	17.0		245	236	40		7.1							10.2	7.6	0.2			3.6		0.4				6.9			13.3	
06/08/77	CITY	23.0		205	202	32		8.3							8.4	13.5	0.9			1.8		0.0				11.8			17.7	
06/15/77	CITY	22.5		221	234	56		7.7							9.6	18.7	0.3			2.2		0.6				8.9			16.7	
06/22/77	CITY	22.0		235	272	58		7.6							10.1	20.7	0.3			2.6		0.5				10.4			14.5	
06/30/77	CITY	24.0		218	251	62		8.4							15.0	19.3	0.4			2.2		0.3				9.9			16.5	
12/02/77	CITY	11.2		143	173	20		6.9							5.8		0.4					0.6				4.5			7.4	
01/18/78	CITY	7.5		224	215	35		7.0							8.5	15.3	0.4			2.9		0.7				2.2			8.1	
01/25/78	CITY	7.5		231	220	25		7.0							8.5	17.0	0.3			3.2		0.6				2.0			7.3	
02/02/78	CITY	7.6		190	218	47		7.1							8.4	15.0	0.6			3.0		0.8				2.2			8.4	
02/08/78	CITY	9.0		162	228	42		7.0							7.1	16.1	0.4			2.7		0.8				3.8			7.6	
02/23/78	CITY	10.4		220	224	38		7.2							6.9	14.7	0.2			3.6		0.5				2.5			9.5	
03/01/78	CITY	9.0		210	218	39		7.3							6.6	8.4	0.3			3.0		0.6				3.1			9.0	
03/09/78	CITY	11.2		202	219	40		7.4							6.9	12.4	0.2			3.2		0.4				5.6			10.1	
03/15/78	CITY	11.5		214	198	26		7.2							8.1	14.0	0.2			3.8		0.5				6.5			15.4	
03/22/78	CITY	14.7		210	252	60		7.7							8.2	15.3	0.2			3.4		0.6				7.6			17.1	
04/07/78	CITY	15.0		199	218	24		8.4							7.9	15.6	0.2			3.3		0.4				10.3			18.1	
04/12/78	CITY	14.0		219	204	16		7.4							8.6	16.0	0.2			3.4		0.3				6.0			12.0	
05/09/78	CITY	16.0		204	214	32		7.6							8.5	15.6	0.3			3.3		0.3				14.1			15.7	
05/17/78	CITY	17.5		179	174	18		7.3							6.6	12.6	0.2			2.2		0.3				7.4			12.2	
06/07/78	CITY	25.0		238	224	44		8.9							9.6	14.0	0.2			2.4		0.6				13.2			20.0	
06/21/78	CITY	20.0		210	203	30		7.2							8.4	9.3	0.1			2.6		0.5				10.9			13.1	
06/28/78	CITY	24.5		243	226	20		8.0							9.2	15.7				2.7		0.3				12.2			16.8	
07/05/78	CITY	18.5		218	243	36		7.1							9.1	15.0	0.3			3.6		0.5				7.8			13.2	
07/12/78	CITY	22.3		250	231	48		7.7							9.9	17.3	0.5			3.4		0.5				7.3			12.0	
07/19/78	CITY	23.0		140	206	32		7.5							8.3	13.2	0.2			3.0		0.4				6.5			12.1	
07/26/78	CITY	25.5		237	230	44		7.6							10.4	14.2	0.2			2.6		0.4				8.1			14.6	
08/02/78	CITY	23.0		229	248	66		7.5							10.6	15.0	0.3			3.2		0.5				11.0			13.2	
08/09/78	CITY	27.0		255	257	52		7.6							10.6	16.4	0.4			3.3		0.6				9.8			12.4	
08/16/78	CITY	19.8		219	284	68		7.4							8.8	15.0	0.3			3.2		0.5				9.0			10.9	
08/23/78	CITY	17.5		191	234	34		7.0							7.4	13.7	0.2			3.3		0.4				5.1			10.9	
08/30/78	CITY	22.5		229	275	44		7.4							14.2	15.0	0.1			3.4		0.6				7.4			12.6	
09/06/78	CITY	18.9		213	233	26		7.4							10.2	14.7	0.2			3.7		0.4				6.5			12.8	
09/13/78	CITY			195	188	23		7.2							8.0	13.9	0.2			3.4		0.4				5.5			11.3	
09/20/78	CITY	19.0		204	213	20		7.6							9.4	16.5	0.2			3.5		0.3				8.4			13.6	
09/27/78	CITY	20.5		210	243	28		7.5							8.9	14.7	0.2			3.5		0.4				5.7			13.7	
10/04/78	CITY	19.0		210	223	28		8.0							9.7	16.0	0.1			3.7		0.4				6.0			14.1	
10/11/78	CITY	18.2		201	221	46		7.5							9.2	14.3	0.1			3.8		0.4				6.0			13.5	
10/25/78	CITY	13.2		201	240	46		7.2							9.2	16.5	0.4			4.8		0.4				4.8			11.1	
12/13/78	CITY	7.5		160	218	20		7.1							8.2	15.9	0.4			3.1		0.7				6.1			7.5	
01/24/79	CITY	5.5		217	209	22		6.9							11.8	15.9	0.7			3.6		0.6				4.6			8.6	

BLANK SPACES = NO SAMPLES; 0.0 VALUES = LESS THAN LOWER LIMIT OF DETECTION.

WATER QUALITY DATA 1979-1981 STATION B (STORET NO. STJOHN02).

DATE OF SAMPLE (m/d/y)	SAMPLERS	T (C)	COND. (FIELD) uhs/cm	COND. (LAB) uhs/cm	TDS mg/l	TSS mg/l	pH (FIELD)	pH (LAB)	ALK (LAB) mg/l CaCO3	HARD. (CALC. DISS.) mg/l	Ca (DISS.) mg/l	Mg (DISS.) mg/l	K mg/l	Na mg/l	Cl mg/l	SO4 mg/l	NH3-N mg/l	NO2-N mg/l	NO3-N mg/l	NO3+ NO2-N mg/l	KJELD. N (TOT) mg/l	PO4-P (TOT) mg/l	Fe (DISS.) mg/l	Mn (DISS.) mg/l	Zn mg/l	BOD mg/l	COD mg/l	C (TO OR) mg/l	O (DISS.) mg/l	COLOR PT-CO
01/31/79	CITY	2.5		238	239	32		7.1							11.4	15.9	0.8			3.9		0.6				5.8			12.0	
02/07/79	DEQ	4.0		126				7.3	42						7.0												19.0			
02/14/79	CITY	11.0		153	207	44		7.0							8.9	9.9	0.7			2.8		1.2				4.6			7.8	
02/21/79	CITY	8.5		192	216	34		7.0							7.8	15.2	0.3			3.1		0.7				2.5			8.4	
03/01/79	CITY	9.5		183	189	24		7.2							7.3	14.7	0.2			3.2		0.6				3.9			10.0	
03/06/79	DEQ	11.0		182				7.7	65						7.0												15.0			
03/07/79	CITY	14.0		171	181	36		7.1							6.7	12.1	0.4			2.8		0.7				3.9			9.1	
03/14/79	CITY	14.0		198	211	32		7.3							8.2	13.7	0.2			4.0		0.6				4.1			12.0	
03/21/79	CITY	14.5		198	220	34		7.6							8.3	15.1	0.2			3.4		0.5				6.9			16.3	
03/29/79	CITY	13.0		193	213	34		7.9							8.8	16.3	0.2			3.4		0.5				8.5			17.0	
04/04/79	CITY	14.0		214	230	42		7.4							8.8	15.0	0.3			3.5		0.6				5.9			13.0	
04/11/79	CITY	13.0		193	243	36		7.4							8.6	16.3	0.3			3.4		0.6				5.2			12.0	
04/18/79	CITY	14.0		198	640	350		7.3							8.8	15.5	0.2			3.0		0.2				3.0			7.2	
04/25/79	CITY	16.0		210	260	78		7.4							8.7	14.7	0.8			3.1		1.2				5.4			10.8	
05/02/79	CITY	18.0		211	230	58		7.3							8.8	15.2	0.7			3.3		0.9				3.0			7.3	
05/09/79	CITY	16.0		182	165	24		7.6							7.4	13.6	0.2			2.6		0.5				7.3			11.1	
05/16/79	CITY	21.0		210	204	42		7.9							8.0	14.2	0.2			3.2		0.6				6.9			13.4	
05/24/79	METRO	21.5		251	226	36		8.5							9.2	15.8	0.3			3.0		0.5				13.9			14.4	
05/30/79	METRO	21.5		223	232	36		8.6							9.8	15.3	0.2			3.2		0.4				12.0			15.7	
06/06/79	METRO	21.5		227	229	54		8.0							9.5	16.3	0.5			3.3		0.7				7.6			11.4	
06/13/79	METRO	21.5		250	248	48		8.8							9.1	19.8	0.2			3.5		0.6				12.0			15.0	
06/20/79	METRO	20.0		212	280	85		7.9							9.4	17.4	0.4			3.6		1.0				11.4			14.6	
06/27/79	METRO	25.0		254	276	80		8.5							9.6	17.5	0.5			3.4		1.0				9.5			13.7	
07/05/79	METRO	22.0		244	285	90		7.8							9.5	18.7	0.5			3.6		0.8				7.8			12.6	
07/11/79	METRO	22.0		252	260	76		8.0							11.0	19.4	0.4			3.5		0.8				6.4			11.7	
07/18/79	METRO	28.0		287	257	46		8.2							10.5	20.1	0.4			3.3		0.6				7.8			13.2	
07/21/79	DEQ	19.0		260				7.7	93						11.0												31.0			
07/25/79	METRO	25.0		242	275	52		8.1							10.2	18.2	0.3			3.4		0.6				5.4			11.8	
07/30/79	DEQ	22.0		265				7.6	84						10.0												20.0			
08/01/79	METRO	27.0		256	280	82		8.3							9.4	17.5	0.3			3.4		0.7				9.2			13.2	
08/08/79	METRO	25.0		248	248	66		8.9							10.9	18.8	0.2			2.9		0.6				10.4			16.8	
08/15/79	METRO	23.0		251	310	89		7.4							8.3	19.8	0.3			3.8		0.5				7.0			9.6	
08/22/79	METRO	24.0		220	273	54		7.9							12.1	16.0	0.3			2.9		0.5				12.4			13.8	
08/29/79	METRO	22.0		210	233	34		7.7							9.7	15.3	0.2			3.4		0.4				6.6			12.9	
09/05/79	METRO	20.0		180	207	38		7.1							11.0	13.3	0.6			2.9		0.5				6.8			6.7	
09/12/79	METRO	22.0		215	233	56		7.9							9.5	14.3	0.2			3.7		0.5				7.5			13.6	
09/19/79	METRO	22.0		191	241	66		7.9							9.7	14.7	0.2			3.2		0.7				6.2			14.2	
09/26/79	METRO	21.0		217				8.0							9.8	15.6	0.4			3.8		0.6							14.5	
10/18/79	METRO			230				7.8	73	85.0					9.6		0.3									5.7	11.0			
11/07/79	METRO			230				7.2	69	79.0					7.8		0.2									2.9	5.0			
01/23/80	METRO			230				7.9	77	94.0					8.9		0.2									2.2	5.0			
02/21/80	METRO			232				7.9	75	93.0					9.5		0.5									2.4	6.0			
03/11/80	METRO			222				7.3	71	82.0					8.6		0.2		3.5							2.7	8.0			
04/23/80	METRO			230				7.9	82	97.0					8.6		0.2		3.1							10.0	10.0			
05/28/80	METRO			260				7.6	77	177.0					8.9		0.1		3.2							8.5	11.0			
06/26/80	METRO			262				8.0	80	95.0					10.2		0.1		3.0							7.5	11.0			

BLANK SPACES = NO SAMPLES; 0.0 VALUES = LESS THAN LOWER LIMIT OF DETECTION.

WATER QUALITY DATA 1979-1981 STATION B (STORET NO. STJOHN02).

DATE OF SAMPLE (m/d/y)	SAMPLERS	T (C)	COND. (FIELD) uhs/cm	COND. (LAB) uhs/cm	TDS mg/l	TSS mg/l	pH (FIELD)	pH (LAB)	ALK (LAB) mg/l CaCO3	HARD. (CALC. DISS.) mg/l	Ca (DISS.) mg/l	Mg (DISS.) mg/l	K mg/l	Na mg/l	Cl mg/l	SO4 mg/l	NH3-N mg/l	NO2-N mg/l	NO3-N mg/l	NO3+ NO2-N mg/l	KJELD. N (TOT) mg/l	PO4-P (TOT) mg/l	Fe (DISS.) mg/l	Mn (DISS.) mg/l	Zn mg/l	BOD mg/l	COD mg/l	C (TO OR) mg/l	D (DISS.) mg/l	COLOR PT-CO
07/24/80	CITY			260				7.9	82	102.0					12.2		0.4		3.3							9.4	9.0			
11/18/80	METRO			250				8.3	77	96.0					8.7		0.3		4.5							2.7	10.0			
01/06/81	METRO			257				7.8	70	82.0					7.4		0.5									1.7	6.0			
02/03/81	METRO			280				7.4	77	94.0					8.2		0.2		4.2							1.5	4.0			
04/06/81	CITY			250	264	32																				4.7				
05/06/81	METRO			253	222	30		9.1	81	93.0					7.9		0.1		2.7							0.0	11.0			
06/01/81	METRO			265	226	16		8.3	84	9.7					8.0		0.0		3.1							7.2	6.9			
07/06/81	METRO			272	226	38		7.6	87	102.0					9.6		0.4		2.6							14.0	8.0			
08/12/81	METRO			270	246	86		8.0	82	96.0					11.8		0.4									8.5	22.0			
09/16/81	METRO			290	270	37		7.7	87	106.0					9.6		0.0									6.7	0.0			
10/14/81	METRO			260	230	36		7.2	73	94.0					8.4		0.1		3.6							5.1	8.0			
11/04/81	METRO			250	266	36		7.6	78	98.0					12.0		0.2		3.9							3.8	4.0			
12/08/81	METRO			145	180	46		7.1	53	65.0					12.8		0.4		1.9							1.1				
SAMPLES	ANALYZED	83	0	105	88	88	0	104	24	20	0	0	0	0	104	79	99	0	13	79	0	80	0	0	0	100	23	0	80	0
MEAN	VALUE	16.8		220	236	46		7.6	76	92.0					9.2	15.6	0.3		3.3	3.3		0.5				6.6	10.5		12.4	
MAXIMUM	VALUE	28.0		290	640	350		9.1	93	177.0					15.0	20.7	0.9		4.5	4.8		1.2				14.1	31.0		20.0	
MINIMUM	VALUE	2.5		126	165	7		6.9	42	9.7					5.8	7.6	0.0		1.9	1.8		0.0				0.0	0.0		6.7	
STANDARD	DEVIATION	6.4		32	51	37		0.5	11	28.0					1.5	2.5	0.2		0.7	0.5		0.2				3.2	6.8		2.9	

BLANK SPACES = NO SAMPLES; 0.0 VALUES = LESS THAN LOWER LIMIT OF DETECTION.

TABLE B - 4 Columbia Slough Station CA water quality data 1979 - 1986
(USEPA STORET No. STJOHN09)

DATE OF SAMPLE (m/d/y)	SAMPLERS	T (C)	COND. (FIELD) uhs/cm	COND. (LAB) uhs/cm	TDS mg/l	TSS mg/l	pH (FIELD)	pH (LAB)	ALK (LAB) mg/l CaCO3	HARD. (CALC. DISS.) mg/l	Ca (DISS.) mg/l	Mg (DISS.) mg/l	K mg/l	Na mg/l	Cl mg/l	SO4 mg/l	NH3-N mg/l	NO2-N mg/l	NO3-N mg/l	NO3+ NO2-N mg/l	KJELD. N (TOT) mg/l	PO4-P (TOT) mg/l	Fe (DISS.) mg/l	Mn (DISS.) mg/l	Zn mg/l	BOD mg/l	COD mg/l	C (TO OR) mg/l	O (DISS.) mg/l	COLOR PT-CO
10/18/79	METRO			220				7.8	66.0	80.0					9.0		0.30									4.4	7.0			
11/07/79	METRO			238				7.3	65.0	78.0					7.8		0.20									3.7	4.0			
01/23/80	METRO			230				7.9	79.0	93.0					9.0		0.40									1.6	6.0			
02/21/80	METRO			210				7.9	67.0	80.0					10.0		0.60									1.7	6.0			
03/11/80	METRO			225				7.4	74.0	85.0					9.4		0.20		3.2							2.3	8.0			
04/23/80	METRO			240				7.8	83.0	91.0					8.9		0.70		2.8							7.5	9.0			
05/28/80	METRO			261				7.6	68.0	176.0					9.3		0.10		3.0							9.5	12.0			
06/26/80	METRO			255				8.4	82.0	94.0					10.4		0.10		2.7							11.0	12.0			
07/24/80	CITY			260				8.1	80.0	100.0					12.5		0.40		3.4							11.0	9.0			
10/22/80	METRO			265				7.9	78.0	99.0					9.2		0.20		4.2							4.6	5.0			
11/18/80	METRO			266				8.2	74.0	94.0					8.7		0.30		4.5							2.4	11.0			
01/06/81	METRO			259				7.6	74.0	89.0					7.4		0.40									1.3	8.0			
02/03/81	METRO			280				7.7	74.0	93.0					8.0		0.20		4.1							2.2	5.0			
03/02/81	METRO			245				8.0	78.0	89.0					7.1		0.20										20.0			
04/06/81	CITY			252	270	32		7.7	76.0	90.0					8.4		0.20		3.4							5.9	13.0			
05/06/81	METRO			246	220	32		9.2	85.0	94.0					8.4		0.10		2.5							0.0	11.0			
06/01/81	METRO			240	208	28		7.7	78.0	9.1					7.6		0.10		2.4							5.9	5.8			
07/06/81	METRO			272	228	42		7.5	90.0	104.0					8.8		0.30		2.5							9.7	6.0			
08/12/81	METRO			275	300	110		7.9	87.0	101.0					11.5		0.50									7.9	22.0			
09/16/81	METRO			245	226	37		7.6	77.0	87.0					9.6		0.00									6.5	0.0			
10/14/81	METRO			250	246	52		7.4	70.0	89.0					8.0		0.10		3.2							7.6	10.0			
11/04/81	METRO			250	264	48		7.5	76.0	98.0					11.6		0.20		3.8							4.4	4.0			
12/08/81	METRO			150	192	44		7.1	52.0	60.0					10.1		0.30		2.0							0.8				
02/03/82	METRO			165				6.9	79.0	96.0					9.8		0.20													
03/02/82	METRO			220				7.2	76.0	86.0					8.6		0.10													
04/07/82	METRO			205				8.1	73.0	85.0					7.2		0.00									4.9				
05/05/82	METRO			240				7.5	89.0	101.0					8.2		0.00									5.1				
06/03/82	METRO			220				7.8	87.0	104.0					8.6		0.00									7.9				
07/14/82	METRO			225				7.5	83.0	99.0					8.0		0.00													
08/04/82	METRO			250				7.4	86.0	96.0					9.4		0.20													
09/01/82	METRO			200				6.9	65.0	73.0					10.4		0.40													
10/04/82	METRO			190				7.8	59.0	68.0					9.6		0.10													
01/06/83	METRO			186				7.6	65.0	76.0					8.0		0.90													
03/17/83	METRO			200				7.5	72.0	76.0					4.4		0.10													
04/12/83	DEQ	11.0	224	226			7.5	7.4	80.0	88.0	22	8.0			4.7	11	0.05			3.00			0.11				21.0	7		20
04/12/83	METRO			230				7.5	80.0	90.0					7.1		0.10													
05/11/83	METRO			215				7.6	78.0	93.0					13.1		0.10													
06/01/83	METRO			230				8.4	93.0	97.0					7.9		0.40													
07/20/83	METRO			215				7.9	74.0	88.0					7.2		0.00													
08/10/83	METRO			230				7.8	86.0	88.0					7.6		0.40													
09/07/83	METRO			145				8.2	59.0	60.0					10.5		0.00													
10/05/83	METRO			230				7.8	86.0	92.0					8.4		0.00													
11/02/83	METRO			230				7.6	79.0	89.0					7.6		0.20													
02/28/84	METRO			205				7.0	77.0	88.0					7.8		0.20													
05/15/84	DEQ	16.5	225	240			7.4	7.7	87.0	99.0	25	8.8			8.5	13	0.35			3.00			0.06				0.0	3		10
06/20/84	METRO			230				7.7	98.0	93.0					8.0		0.10													

BLANK SPACES = NO SAMPLES; 0.0 VALUES = LESS THAN LOWER LIMIT OF DETECTION.

WATER QUALITY DATA 1979-1985 STATION C-A (STORET NO. STJOHN09).

DATE OF SAMPLE (m/d/y)	SAMPLERS	T (C)	COND. (FIELD) uhs/cm	COND. (LAB) uhs/cm	TDS mg/l	TSS mg/l	pH (FIELD)	pH (LAB)	ALK (LAB) mg/l CaCO3	HARD. (CALC. DISS.) mg/l	Ca (DISS.) mg/l	Mg (DISS.) mg/l	K mg/l	Na mg/l	Cl mg/l	SO4 mg/l	NH3-N mg/l	NO2-N mg/l	NO3-N mg/l	NO3+ NO2-N mg/l	KJELD. N (TOT) mg/l	PO4-P (TOT) mg/l	Fe (DISS.) mg/l	Mn (DISS.) mg/l	Zn mg/l	BOD mg/l	COD mg/l	C (TO DR) mg/l	O (DISS.) mg/l	COLOR PT-CO
11/21/84	DEQ	8.5	199	246			7.4	7.2	67.0	86.0	22	7.6			13.0	14	0.28			3.10			0.00				0.0	2	7.1	20
05/15/85	DEQ	16.0	233	240			9.0	8.2	82.0	94.0	24	8.2			8.2	15	0.07			0.26			0.07				0.0	1	18.4	20
09/26/85	DEQ	18.0	224	230			8.2	8.1	81.0	93.0	24	8.0			8.4	15	0.08			3.40			0.05	0.09			0.0	2	17.1	15
01/02/86	METRO	0.8	224	240			6.9	7.3	75.2	105.0					7.1		0.42									5.0	14.0			
02/20/86	METRO	3.8	180	180			6.6	6.7	52.0	10.9					5.4		0.39									11.0	29.0			
05/29/86	DEQ	20.5	221	230	182	15	7.4	7.6	83.0	90.0	23	8.0	3	7.9	8.5	13	0.26			2.30	1	0.107	0.05	0.00		4.0	17.0	5	11.4	15
07/31/86	METRO	20.0	429	290			6.1	6.8	87.8	73.0					21.9		0.30									6.0	23.0			
08/28/86	METRO	22.5	175				6.2																							
SAMPLES	ANALYZED	10	10	53	10	10	10	53	53	53	6	6	1	1	53	6	53	0	15	6	1	1	6	2	0	29	31	6	4	6
MEAN	VALUE	13.8	233	231	234	44	7.3	7.7	76.8	87.7	23	8.1	3	7.9	8.9	14	0.22		3.2	2.51	1	0.107	0.06	0.05		5.4	9.6	3	13.5	17
MAXIMUM	VALUE	22.5	429	290	300	110	9.0	9.2	98.0	176.0	25	8.8	3	7.9	21.9	15	0.90		4.5	3.40	1	0.107	0.11	0.09		11.0	29.0	7	18.4	20
MINIMUM	VALUE	0.8	175	145	182	15	6.1	6.7	52.0	9.1	22	7.6	3	7.9	4.4	11	0.00		2.0	0.26	1	0.107	0.00	0.00		0.0	0.0	1	7.1	10
STANDARD	DEVIATION	7.0	68	30	35	24	0.8	0.4	9.5	21.8	1	0.4			2.5	1	0.19		0.7	1.06			0.03	0.05		3.1	7.4	2	4.5	4

BLANK SPACES = NO SAMPLES; 0.0 VALUES = LESS THAN LOWER LIMIT OF DETECTION.

TABLE B - 5 Columbia Slough Station C water quality data 1977 - 1986
(USEPA STORET No. STJOHNO3)

DATE OF SAMPLE (m/d/y)	SAMPLERS	T (C)	COND. (FIELD) uhs/cm	COND. (LAB) uhs/cm	TDS mg/l	TSS mg/l	pH (FIELD)	pH (LAB)	ALK (LAB) mg/l CaCO3	HARD. (CALC. DISS.) mg/l	Ca (DISS.) mg/l	Mg (DISS.) mg/l	K mg/l	Na mg/l	Cl mg/l	SO4 mg/l	NH3-N mg/l	NO2-N mg/l	NO3-N mg/l	NO3+ NO2-N mg/l	KJELD. N (TOT) mg/l	PO4-P (TOT) mg/l	Fe (DISS.) mg/l	Mn (DISS.) mg/l	Zn mg/l	BOD mg/l	COD mg/l	C (TO OR) mg/l	O (DISS.) mg/l	COLOR PT-CO
01/12/77	DEQ			150				7.6	70.0	77.0	22	5.5		5.5	1.9	13.2	0.110	0.02	0.28				0.00	0.00	0.02		0.0			0
01/19/77	CITY	10.0		219	212	31.0		7.1							12.2	16.7	0.600			4.20		0.30				3.9			7.3	
01/26/77	CITY	4.0		209	169	7.0		7.5							9.3	20.4	0.300			2.10		0.20				2.9			12.2	
02/02/77	CITY	6.0		222	224	30.0		7.5							10.5	17.4	0.100			4.10		0.20				5.4			13.5	
02/09/77	CITY	4.0		186	150	20.0		7.6							6.3	19.3	0.100			1.00		0.10				2.8			13.5	
02/16/77	CITY	9.5		220	250	46.0		7.4							10.2	30.0	0.300			4.30		0.30				8.4			10.7	
03/16/77	CITY	10.0		209	202	37.0		7.2							9.8	17.3	0.200			3.00		0.40				4.7			10.2	
04/06/77	CITY	17.0		242	246	45.0		7.5							11.0	8.4	0.300			3.50		0.40				5.8			12.2	
06/08/77	CITY	22.5		200	204	49.0		8.3							9.7	13.4	0.800			2.00		0.00				7.5			15.5	
06/15/77	CITY	22.0		221	243	76.0		8.1							9.6	18.9	1.700			8.20		0.80				7.0			14.6	
06/22/77	CITY	23.0		233	225	50.0		7.9							11.8	19.5	0.800			3.20		0.50				8.1			12.5	
06/30/77	CITY	23.0		185	227	74.0		8.7							14.8	18.0	0.400			2.10		0.40				8.1			15.1	
12/02/77	CITY	10.0		169	186	2.0		6.9							5.8		0.500					0.00				1.8			6.4	
01/18/78	CITY	7.0		180	168	35.0		7.1							8.3	11.2	0.400			1.60		0.50				4.9			9.0	
01/25/78	CITY	7.2		232	212	26.0		7.1							8.3	15.3	0.400			2.80		0.60				1.8			6.7	
02/02/78	CITY	7.0		205	199	36.0		7.1							8.7	13.3	0.600			2.50		0.60				3.7			8.4	
02/08/78	CITY	9.0		160	215	35.0		7.0							7.0	14.6	0.400			2.60		0.80				3.8			7.2	
02/23/78	CITY	11.0		234	237	50.0		7.2							7.0	15.7	0.200			3.10		0.50				3.6			8.8	
03/01/78	CITY	9.0		202	201	33.0		7.3							7.3	13.0	0.400			2.50		0.60				3.0			9.1	
03/09/78	CITY	10.5		210	228	43.0		7.4							7.4	13.8	0.200			3.60		0.30				6.2			10.7	
03/15/78	CITY	10.0		213	205	42.0		7.3							8.8	15.0	0.300			3.30		0.60				6.2			13.9	
03/22/78	CITY	15.0		230	272	80.0		7.7							8.8	13.8	0.200			3.40		0.80				7.2			17.2	
04/07/78	CITY	14.0		209	213	23.0		7.9							8.2	15.6	0.200			3.10		0.30				5.1			13.5	
04/12/78	CITY	15.0		212	201	17.0		7.5							8.6	16.3	0.200			3.40		0.40				5.5			12.4	
05/09/78	CITY	16.0		215	210	28.0		7.7							9.4	15.0	0.400			3.40		0.40				11.5			14.3	
05/17/78	CITY	17.0		171	165	16.0		7.3							6.7	11.7	0.200			2.30		0.30				7.6			12.0	
06/07/78	CITY	24.5		240	219	58.0		8.7							9.2	14.2	0.300			2.30		0.80				8.8			14.1	
06/21/78	CITY	21.0		203	208	63.0		7.3							8.8	13.2	0.400			2.50		0.60				7.8			10.1	
06/28/78	CITY	25.0		241	237	35.0		8.0							9.4	14.6				2.70		0.60				8.2			16.9	
07/05/78	CITY	19.0		225	256	55.0		7.1							9.8	16.1	0.600			3.20		0.60				6.3			10.2	
07/12/78	CITY	22.0		250	220	48.0		7.7							10.5	15.7	0.900			2.80		0.50				6.4			11.3	
07/19/78	CITY	22.0		210	205	50.0		7.7							8.8	12.1	0.400			2.40		0.60				6.6			10.6	
07/26/78	CITY	27.0		249	236	58.0		7.9							11.6	13.0	0.400			2.40		0.50				7.2			13.2	
08/02/78	CITY	23.0		230	265	74.0		7.8							11.4	16.0	0.500			3.00		0.60				7.9			11.9	
08/09/78	CITY	26.5		255	266	64.0		7.5							10.2	16.5	0.600			3.00		0.80				9.3			10.6	
08/16/78	CITY	20.0		223	275	76.0		7.5							9.5	14.1	0.400			3.00		0.60				8.1			9.8	
08/23/78	CITY	18.0		195	259	38.0		7.0							8.4	13.7	0.200			3.30		0.40				5.1			10.6	
08/30/78	CITY	22.5		212	218	54.0		7.5							9.7	14.3	0.200			3.30		0.60				5.8			11.4	
09/06/78	CITY	19.4		200	223	30.0		7.5							10.4	13.6	0.500			2.90		0.40				5.2			10.6	
09/13/78	CITY	15.0		202	203	26.0		7.3							7.9	13.6	0.100			3.20		0.40				5.8			11.6	
09/20/78	CITY	18.0		183	192	30.0		7.5							8.1	14.9	0.200			2.50		0.40				4.9			11.5	
09/27/78	CITY	20.5		212	251	30.0		7.7							9.0	14.3	0.100			2.50		0.40				7.6			14.6	
10/04/78	CITY	18.8		159	158	24.0		7.8							9.6	12.2	0.200			1.90		0.40				3.9			11.1	
10/11/78	CITY	18.8		209	230	46.0		7.5							10.2	15.2	0.200			3.70		0.40				6.1			12.8	
10/25/78	CITY	13.8		201	241	46.0		7.3							9.8	15.3	0.500			4.60		0.50				5.2			11.6	
12/13/78	CITY	7.0		164	214	16.0		7.1							8.8	15.3	0.400			3.00		0.60				3.8			7.8	
01/24/79	CITY	4.5		111	108	14.0		7.0							6.6	7.0	0.500			1.30		0.40				2.1			11.9	
01/31/79	CITY	2.5		216	212	24.0		7.1							10.9	14.1	0.800			3.30		0.60				4.2			11.9	
02/07/79	DEQ	5.0		193				7.3	66.0						11.0												23.0			
02/14/79	CITY	10.0		151	197	38.0		7.0							9.0	12.3	0.700			2.80		1.10				4.8			7.1	

BLANK SPACES = NO SAMPLES; 0.0 VALUES = LESS THAN LOWER LIMIT OF DETECTION.

WATER QUALITY DATA 1977-1985 STATION C (STORET NO. STJOHN03).

DATE OF SAMPLE (m/d/y)	SAMPLERS	T (C)	COND. (FIELD) uhs/cm	COND. (LAB) uhs/cm	TDS mg/l	TSS mg/l	pH (FIELD)	pH (LAB)	ALK (LAB) mg/l CaCO3	HARD. (CALC. DISS.) mg/l	Ca (DISS.) mg/l	Mg (DISS.) mg/l	K mg/l	Na mg/l	Cl mg/l	SO4 mg/l	NH3-N mg/l	NO2-N mg/l	NO3-N mg/l	NO3+ NO2-N mg/l	KJELD. N (TOT) mg/l	PO4-P (TOT) mg/l	Fe (DISS.) mg/l	Mn (DISS.) mg/l	Zn mg/l	BOD mg/l	COD mg/l	C (TO OR) mg/l	O (DISS.) mg/l	COLOR PT-CO
02/21/79	CITY	7.5		167	202	36.0		7.1							8.1	12.2	0.600			2.70		0.70				2.8			8.4	
03/01/79	CITY	9.0		180	192	30.0		7.2							7.9	14.1	0.200			3.10		0.60				3.1			9.5	
03/06/79	DEQ	11.5		186				7.6	65.0						8.0												12.0			
03/07/79	CITY	13.0		175	192	38.0		7.1							7.9	11.9	1.100			2.70		1.20				3.6			8.4	
03/14/79	CITY	13.0		200	221	46.0		7.3							8.2	14.4	0.200			3.70		0.60				3.6			10.3	
03/21/79	CITY	14.0		160	204	54.0		7.7							8.0	10.7	0.300			2.30		0.70				8.1			14.6	
03/29/79	CITY	14.0		195	215	36.0		7.9							9.1	17.0	0.200			3.20		0.50				5.8			15.5	
04/04/79	CITY	14.0		191	217	54.0		7.7							8.7	11.2	0.500			2.40		0.70				5.3			12.9	
04/11/79	CITY	13.5		185	247	54.0		7.3							8.7	15.8	0.600			3.20		0.80				3.9			9.4	
04/18/79	CITY	14.0		185	737	570.0		7.3							10.7	14.0	0.400			2.70		0.20				3.0			6.0	
04/25/79	CITY	18.5		202	280	100.0		7.4							9.7	13.8	1.500			3.10		1.70				4.6			8.6	
05/02/79	CITY	18.0		191	222	70.0		7.4							9.6	13.7	1.000			2.70		1.00				4.1			7.6	
05/09/79	CITY	16.0		179	164	18.0		7.5							8.1	13.7	0.300			2.70		0.40				5.7			9.6	
05/16/79	CITY	21.0		204	205	38.0		7.7							8.4	13.6	0.200			2.90		0.50				4.6			12.0	
05/24/79	METRO	23.0		246	229	36.0		8.9							9.4	14.8	0.400			2.40		0.70				12.3			17.2	
05/30/79	METRO	23.0		225	242	40.0		8.9							10.2	14.2	0.200			2.90		0.50				13.2			17.4	
06/06/79	METRO	21.5		168	174	60.0		8.2							7.6	11.0	0.500			1.20		0.90				7.9			10.9	
06/13/79	METRO	23.0		237	236	64.0		8.2							9.4	18.8	0.300			2.90		0.70				7.9			12.0	
06/20/79	METRO	20.0		219	281	83.0		7.7							10.5	17.3	0.800			3.50		1.00				7.3			12.1	
06/27/79	METRO	25.0		253	285	80.0		7.9							10.3	17.5	0.700			3.40		1.00				9.6			10.8	
07/05/79	METRO	22.5		245	276	86.0		7.8							10.7	17.6	0.700			3.50		0.90				10.0			10.8	
07/11/79	METRO	23.0		246	263	72.0		8.3							10.0	19.9	0.400			3.00		0.80				8.2			11.9	
07/18/79	METRO	28.5		285	251	48.0		8.2							10.4	21.3	0.400			3.40		0.70				6.1			13.2	
07/21/79	DEQ	18.0		267				7.6	83.0						10.0												29.0			
07/25/79	METRO	25.0		233	273	70.0		8.1							10.2	17.5	0.400			3.20		0.70				5.2			10.8	
07/30/79	DEQ	22.0		249				7.6	82.0						11.0												20.0			
08/01/79	METRO	26.5		253	272	60.0		8.2							9.7	18.9	0.300			3.30		0.70				7.0			12.2	
08/08/79	METRO	25.5		241	251	78.0		8.7							11.7	18.6	0.300			2.90		0.60				7.9			14.3	
08/15/79	METRO	23.0		258	268	65.0		7.5							9.2	19.4	0.400			3.70		0.50				6.6			9.6	
08/22/79	METRO	24.0		201	266	56.0		7.7							11.5	15.1	0.200			3.00		0.50				7.9			12.1	
08/29/79	METRO	23.0		215	231	32.0		8.1							10.2	15.8	0.700			3.20		0.40				6.6			13.2	
09/05/79	METRO	21.0		188	200	42.0		7.2							9.7	13.2	0.400			2.80		0.50				3.7			7.5	
09/12/79	METRO	22.7		211	216	36.0		8.1							9.7	14.7	0.200			3.30		0.50				8.4			14.6	
09/19/79	METRO	23.0		198	269	78.0		8.3							13.7	14.8	0.200			3.30		0.80				7.9			15.2	
09/26/79	METRO	21.0		216				8.2							10.3	14.6	0.300			3.60		0.60							14.9	
10/18/79	METRO			223				7.7	67.0	79.0					9.3		0.400									4.3	7.0			
11/07/79	METRO			223				6.8	63.0	74.0					8.0		0.200									2.9	5.0			
01/23/80	METRO			180				7.8	59.0	67.0					7.9		0.300									1.5	6.0			
02/21/80	METRO			212				8.0	68.0	80.0					9.8		0.600									2.8	5.0			
03/11/80	METRO			212				7.3	77.0	87.0					9.8		0.300		3.00							3.4	7.0			
04/23/80	METRO			230				7.7	79.0	86.0					9.3		0.800		2.60							7.3	9.0			
05/28/80	METRO			252				7.6	85.0	172.0					8.5		0.100		2.90							9.1	11.0			
06/26/80	METRO			251				8.2	80.0	93.0					10.4		0.200		2.70							15.0	13.0			
07/24/80	CITY			262				8.2	87.0	101.0					13.3		0.400		3.20							10.0	11.0			
10/22/80	METRO			263				7.5	78.0	99.0					8.8		0.200		5.00							4.2	5.0			
11/18/80	METRO			242				8.3	75.0	95.0					8.6		0.400		4.50							2.5	11.0			
01/06/81	METRO			252				7.6	73.0	86.0					7.4		0.400									1.6	8.0			
02/03/81	METRO			280				7.4	76.0	92.0					8.4		0.200		4.00							1.6	5.0			
03/02/81	METRO			245				8.2	76.0	92.0					7.1		0.200										11.0			
04/06/81	CITY			229	256	30.0		7.8	73.0	85.0					8.2		0.200		2.80							5.1	12.0			

BLANK SPACES = NO SAMPLES; 0.0 VALUES = LESS THAN LOWER LIMIT OF DETECTION.

WATER QUALITY DATA 1977-1985 STATION C (STORET NO. STJOHN03).

DATE OF SAMPLE (m/d/y)	SAMPLERS	T (C)	COND. (FIELD) uhs/cm	COND. (LAB) uhs/cm	TDS mg/l	TSS mg/l	pH (FIELD)	pH (LAB)	ALK (LAB) mg/l CaCO3	HARD. (CALC. DISS.) mg/l	Ca (DISS.) mg/l	Mg (DISS.) mg/l	K mg/l	Na mg/l	Cl mg/l	SO4 mg/l	NH3-N mg/l	NO2-N mg/l	NO3-N mg/l	NO3+ NO2-N mg/l	KJELD. N (TOT) mg/l	PO4-P (TOT) mg/l	Fe (DISS.) mg/l	Mn (DISS.) mg/l	Zn mg/l	BOD mg/l	COD mg/l	C (TO OR) mg/l	O (DISS.) mg/l	COLOR PT-CO
05/06/81	METRO			264	222	30.0		9.1	84.0	95.0					8.4		0.100		2.40							0.0	11.0			
06/01/81	METRO			232	200	32.0		7.9	76.0	8.6					7.6		0.000		2.00							4.9	4.6			
07/06/81	METRO			246	198	40.0		7.6	86.0	93.0					7.4		0.200		1.60							7.7	7.0			
08/12/81	METRO			270	288	110.0		7.9	88.0	104.0					11.0		0.600									8.6	22.0			
09/16/81	METRO			215	212	42.0		7.8	64.0	74.0					9.4		0.000		42.00							4.4	0.0			
10/14/81	METRO			245	242	58.0		7.5	69.0	84.0					8.0		0.100		3.40							6.2	8.0			
11/04/81	METRO			248	250	44.0		7.7	76.0	95.0					12.0		0.200		4.10							4.5	4.0			
12/08/81	METRO			155	186	42.0		7.2	54.0	60.0					10.4		0.400		1.90							0.7				
02/03/82	METRO			220				7.3	84.0	99.0					10.0		0.200													
03/02/82	METRO			230				7.1	76.0	86.0					8.6		0.100													
04/07/82	METRO			210				7.7	75.0	89.0					7.2		0.000									4.8				
05/05/82	METRO			245				7.4	88.0	100.0					8.4		0.000									4.5				
06/03/82	METRO			245				7.8	88.0	104.0					8.5		0.000									7.9				
07/14/82	METRO			250				7.6	85.0	98.0					8.0		0.000													
08/04/82	METRO			250				7.4	84.0	94.0					9.1		0.200													
09/01/82	METRO			170				7.1	58.0	61.0					8.1		0.200													
10/04/82	METRO			140				7.6	47.0	48.0					7.4		0.100													
01/06/83	METRO			192				7.7	67.0	75.0					8.3		0.800													
03/17/83	METRO			210				7.2	73.0	81.0					7.4		0.100													
04/12/83	DEQ	11.0	227	231			7.5	7.4	79.0	91.0	23	8.1			7.6	14.0	0.130			3.20			0.09				19.0	7		20
04/12/83	METRO			240				7.6	83.0	95.0					7.6		0.100													
05/11/83	METRO			220				7.6	79.0	93.0					13.4		0.100													
06/01/83	METRO			233				8.2	91.0	100.0					7.5		0.300													
07/20/83	METRO			220				8.2	76.0	86.0					7.2		0.000													
08/10/83	METRO			160				7.8	73.0	72.0					5.6		0.200													
09/07/83	METRO			140				8.0	60.0	58.0					8.1		0.000													
10/05/83	METRO							7.8	78.0	86.0					8.3		0.000													
11/02/83	METRO			230				7.7	78.0	89.0					7.6		0.200													
05/15/84	DEQ	16.5	236	240			7.4	7.4	87.0	100.0	26	8.5			11.0	14.0	0.370			2.90			0.05				0.0	3		10
06/20/84	METRO			240				7.6	90.0	94.0					8.2		0.100													
11/21/84	DEQ	8.5	204	253			7.4	7.3	67.0	88.0	23	7.4			15.0	14.0	0.310			2.90			0.08				7.0	2	6.7	20
05/15/85	DEQ	17.0	228	230			8.9	8.1	81.0	94.0	24	8.2			8.2	15.0	0.110			0.27			0.06				0.0	2		25
09/26/85	DEQ	18.0	238	230			8.2	8.2	77.0	90.0	23	7.8			11.0	15.0	0.090			3.40			0.09	0.19			0.0	2	17.2	15
11/13/85	SRI	6.5		162	158	23.0		7.3									0.830			0.66	0.83	0.26							9.5	
11/14/85	SRI	5.0		167	144	16.0		6.8									0.780			0.85	4.00	0.25							8.3	
12/16/85	SRI	3.0		172	208	8.8		7.3									0.176			2.51	2.06	0.46							9.5	
01/02/86	METRO	0.8	219	225			6.8	6.8	77.0	123.0					7.1		0.540									5.0	5.0			
02/20/86	METRO	3.7	170	178			6.6	6.6	58.7	72.5					5.5		0.380									8.0	29.0			
05/29/86	DEQ	20.5	203	210	183	29.0	7.4	7.3	79.0	88.0	23	8.1	2.9	7.7	7.9	14.0	0.390			2.10	1.40	0.14	0.00	0.00			.15.0	5	9.5	10
07/31/86	METRO	20.0	303	280			6.5	7.3	90.3	73.0					18.6		0.360									6.0	23.0			
08/28/86	METRO	22.3	225				6.6																							
SAMPLES	ANALYZED	97	10	139	92	92	10	140	57	53	7	7	1	2	137	86	135	1	17	88	4	84	7	3	1	107	36	6	86	7
MEAN	VALUE	16.1	225	214	227	50.7	7.3	7.6	75.6	86.9	23	7.7	2.9	6.6	9.2	15.1	0.355	0.02	5.20	2.90	2.07	0.56	0.05	0.06	0.02	5.8	10.1	4	11.4	14
MAXIMUM	VALUE	28.5	303	285	737	570.0	8.9	9.1	91.0	172.0	26	8.5	2.9	7.7	18.6	30.0	1.700	0.02	42.00	8.20	4.00	1.70	0.09	0.19	0.02	15.0	29.0	7	17.4	25
MINIMUM	VALUE	0.8	170	111	108	2.0	6.5	6.6	47.0	8.6	22	5.5	2.9	5.5	1.9	7.0	0.000	0.02	0.28	0.27	0.83	0.00	0.00	0.00	0.02	0.0	0.0	2	6.0	0
STANDARD	DEVIATION	6.9	32	33	64	58.3	0.7	0.5	9.8	20.6	1	0.9		1.1	1.9	3.0	0.276		9.27	0.94	1.19	0.26	0.04	0.09		2.6	7.8	2	2.7	8

BLANK SPACES = NO SAMPLES; 0.0 VALUES = LESS THAN LOWER LIMIT OF DETECTION.

TABLE B - 6 Columbia Slough Station CB water quality data 1979 - 1986
(USEPA STORET No. STJOHN10)

DATE OF SAMPLE (m/d/y)	SAMPLERS	T (C)	COND. (FIELD) uhs/cm	COND. (LAB) uhs/cm	TDS mg/l	TSS mg/l	pH (FIELD)	pH (LAB)	ALK (LAB) mg/l CaCO3	HARD. (CALC. DISS.) mg/l	Ca (DISS.) mg/l	Mg (DISS.) mg/l	K mg/l	Na mg/l	Cl mg/l	SO4 mg/l	NH3-N mg/l	NO2-N mg/l	NO3-N mg/l	NO3+ NO2-N mg/l	KJELD. N (TOT) mg/l	PO4-P (TOT) mg/l	Fe (DISS.) mg/l	Mn (DISS.) mg/l	Zn mg/l	BOD mg/l	COD mg/l	C (TO mg/l	D OR) (DISS.) mg/l	COLOR PT-CO
10/18/79	METRO			210				8.2	64.0	76.0					8.9		0.40									4.0	7.0			
11/07/79	METRO			220				7.5	62.0	71.0					8.0		0.20									3.1	5.0			
01/23/80	METRO			170				8.0	58.0	68.0					7.5		0.20									1.7	6.0			
02/21/80	METRO			211				8.1	67.0	79.0					9.6		0.60									2.7	5.0			
03/11/80	METRO			230				7.4	77.0	88.0					9.8		0.20		3.1							2.9	7.0			
04/23/80	METRO			230				7.7	79.0	86.0					9.5		0.80		2.5							5.8	9.0			
05/28/80	METRO			252				7.9	77.0	174.0					8.6		0.10		2.8							9.3	11.0			
06/26/80	METRO			250				8.3	81.0	92.0					10.6		0.20		2.7							12.0	13.0			
07/24/80	CITY			258				8.1	84.0	101.0					13.0		0.40		3.4							12.0	11.0			
10/22/80	METRO			265				7.9	78.0	99.0					9.2		0.20		4.2							4.3	5.0			
11/18/80	METRO			266				8.1	74.0	94.0					8.8		0.50		4.4							2.8	12.0			
01/06/81	METRO			260				7.7	74.0	89.0					7.4		0.60									1.6	8.0			
02/03/81	METRO			270				7.3	76.0	90.0					8.3		0.30		3.9							1.8	5.0			
03/02/81	METRO			245				8.0	75.0	91.0					7.1		0.20										10.0			
04/06/81	CITY			155	192	16		7.6	47.0	53.0					6.9		0.10		1.7							4.9	12.0			
05/06/81	METRO			250	238	22		9.0	80.0	88.0					8.0		0.10		2.0							0.0	9.0			
06/01/81	METRO			215	180	28		7.7	74.0	8.0					7.6		0.00		1.7							4.0	4.6			
07/06/81	METRO			230	182	46		8.0	84.0	87.0					7.0		0.20		1.2							7.6	8.0			
08/12/81	METRO			270	266	112		7.9	88.0	99.0					11.2		0.60									8.8	24.0			
09/16/81	METRO			175	160	28		7.6	54.0	61.0					8.8		0.00									2.9	0.0			
10/14/81	METRO			230	222	50		7.4	67.0	81.0					7.6		0.10		3.0							6.5	8.0			
11/04/81	METRO			248	256	36		7.5	77.0	97.0					12.0		0.20		3.7							4.4	4.0			
12/08/81	METRO			155	186	38		7.2	54.0	59.0					10.0		0.40		1.8							0.7				
02/03/82	METRO			230				7.2	84.0	99.0					10.4		0.30													
03/02/82	METRO			230				7.2	77.0	87.0					9.0		0.10													
04/07/82	METRO			210				7.8	76.0	88.0					7.2		0.00									5.3				
05/05/82	METRO			240				7.3	87.0	99.0					8.4		0.00									3.8				
06/03/82	METRO			250				7.8	90.0	104.0					8.6		0.00									7.6				
07/14/82	METRO			230				7.5	86.0	97.0					8.0		0.00													
08/04/82	METRO			240				7.5	83.0	90.0					8.8		0.20													
09/01/82	METRO			165				7.1	57.0	59.0					7.8		0.10													
10/04/82	METRO			140				7.8	51.0	51.0					4.9		0.10													
01/06/83	METRO			200				7.6	69.0	79.0					7.9		0.70													
03/17/83	METRO			210				7.2	73.0	81.0					7.2		0.10													
04/12/83	DEQ	11.0	227	228			7.5	7.5	69.0	91.0	23	8.2			7.6	14.0	0.19			3.00			0.10				25.0	8		20
04/12/83	METRO			235				7.5	80.0	90.0					7.8		0.10													
05/11/83	METRO			195				7.7	74.0	82.0					11.8		0.10													
06/01/83	METRO			230				8.1	91.0	98.0					7.4		0.20													
07/20/83	METRO			190				8.3	75.0	86.0					7.2		0.00													
08/10/83	METRO			150				8.0	65.0	65.0					4.3		0.20													
09/07/83	METRO			150				8.0	61.0	60.0					9.8		0.00													
10/05/83	METRO			190				7.9	73.0	75.0					8.0		0.00													
11/02/83	METRO			230				7.8	78.0	89.0					7.4		0.20													
02/28/84	METRO			220				7.4	66.0	93.0					6.7		0.10													
05/15/84	DEQ	17.0	234	240			7.3	7.4	86.0	97.0	25	8.5			9.6	14.0	0.27			2.90			0.06				0.0	3		10
06/20/84	METRO			240				7.2	88.0	94.0					8.2		0.20													

BLANK SPACES = NO SAMPLES; 0.0 VALUES = LESS THAN LOWER LIMIT OF DETECTION.

WATER QUALITY DATA 1979-1985 STATION C-B (STORET NO. STJOHN10).

DATE OF SAMPLE (m/d/y)	SAMPLERS	T (C)	COND. (FIELD) uhs/cm	COND. (LAB) uhs/cm	TDS mg/l	TSS mg/l	pH (FIELD)	pH (LAB)	ALK (LAB) mg/l CaCO3	HARD. (CALC. DISS.) mg/l	Ca (DISS.) mg/l	Mg (DISS.) mg/l	K mg/l	Na mg/l	Cl mg/l	SO4 mg/l	NH3-N mg/l	NO2-N mg/l	NO3-N mg/l	NO3+ NO2-N mg/l	KJELD. N (TOT) mg/l	PO4-P (TOT) mg/l	Fe (DISS.) mg/l	Mn (DISS.) mg/l	Zn mg/l	BOD mg/l	COD. mg/l	C (TO OR) mg/l	O (DISS.) mg/l	COLOR PT-CO
11/21/84	DEQ	8.5	209	235			7.4	7.3	68.0	87.0	22	7.7			10.0	14.0	0.31			3.00			0.05				6.0	1	7.0	20
05/15/85	DEQ	16.0	240	240			8.6	7.9	82.0	96.0	25	8.2			8.7	15.0	0.35			0.27			0.07				0.0	2	16.7	20
09/26/85	DEQ	18.5	234	230			8.5	8.3	80.0	93.0	24	8.1			8.5	15.0	0.06			3.40			0.06	0.09			0.0	2	17.3	20
01/02/86	METRO	0.8	228	240			6.7	6.9	78.9	103.0					6.8		0.50									5.0	8.0			
02/20/86	METRO	3.7	180	183			6.7	6.5	58.1	71.4					5.4		0.37									4.0	20.0			
05/29/86	DEQ	20.0	181	177	155	26	7.5	7.6	67.0	68.0	17	6.2	2.3	6.9	6.1	9.6	0.22			1.40	1	0.124	0.05	0.00		2.9	19.0	4	11.1	10
07/31/86	METRO	20.0	286	270			8.0	7.1	92.9	73.0					15.8		0.30									7.0	23.0			
08/28/86	METRO	22.4	210	260			6.7	6.8	113.0	109.0					1.8		0.41										18.0			
SAMPLES	ANALYZED	10	10	54	10	10	10	54	54	54	6	6	1	1	54	6	54	0	15	6	1	1	6	2	0	29	32	6	4	6
MEAN	VALUE	13.8	223	221	204	40	7.5	7.7	74.6	84.9	23	7.8	2.3	6.9	8.4	13.6	0.23		2.8	2.33	1	0.124	0.06	0.05		4.8	9.5	3	13.0	17
MAXIMUM	VALUE	22.4	286	270	266	112	8.6	9.0	113.0	174.0	25	8.5	2.3	6.9	15.8	15.0	0.80		4.4	3.40	1	0.124	0.10	0.09		12.0	25.0	8	17.3	20
MINIMUM	VALUE	0.8	180	140	155	16	6.7	6.5	47.0	8.0	17	6.2	2.3	6.9	1.8	9.6	0.00		1.2	0.27	1	0.124	0.05	0.00		0.0	0.0	1	7.0	10
STANDARD	DEVIATION	7.0	29	34	37	26	0.7	0.4	11.9	21.1	3	0.8			2.1	1.8	0.19		1.0	1.12			0.02	0.05		3.0	6.8	2	4.2	5

BLANK SPACES = NO SAMPLES; 0.0 VALUES = LESS THAN LOWER LIMIT OF DETECTION.

TABLE B - 7 Columbia Slough Station D water quality data 1977 - 1986
(USEPA STORET No. STJOHN04)

DATE OF SAMPLE	SAMPLERS	T	COND. (FIELD)	COND. (LAB)	TDS	TSS	pH (FIELD)	pH (LAB)	ALK (LAB) mg/l CaCO3	HARD. (CALC. DISS.)	Ca (DISS.)	Mg (DISS.)	K	Na	Cl	SO4	NH3-N	NO2-N	NO3-N	NO3+ NO2-N	KJELD. N (TOT)	PO4-P (TOT)	Fe (DISS.)	Mn (DISS.)	Zn	BOD	COD	C (TO OR)	D (DISS.)	COLOR
(m/d/y)		(C)	uhs/cm	uhs/cm	mg/l	mg/l				mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	PT-CO
01/12/77	DEQ			149				7.6	70.0	80.0	22	6.1	1.3	6.5	7.0	12.5	0.13	0.02	0.28				0.00	0.00	0.04		0.0			0
01/19/77	CITY	9.0		215	201	26		7.1							12.6	16.9	0.60			4.10		0.300				2.4			7.4	
01/26/77	CITY	3.5		183	133	4		7.6							6.3	19.3	0.10			0.80		0.100				1.5			12.9	
02/02/77	CITY	5.5		222	214	22		7.6							10.4	17.8	0.10			4.00		0.200				4.7			13.2	
02/09/77	CITY	4.0		172	125	12		7.8							5.5	18.7	0.00			0.30		0.100				1.5			13.1	
02/16/77	CITY	8.2		203	215	28		7.5							9.4	18.9	0.20			3.50		0.300				5.8			11.8	
03/16/77	CITY	10.0		210	205	35		7.2							10.1	17.2	0.20			2.80		0.400				4.4			10.1	
04/06/77	CITY	17.0		232	232	42		7.5							10.9	8.3	0.40			3.40		0.400				5.3			11.4	
06/08/77	CITY	22.0		182	188	50		8.3							7.7	14.0	0.70			1.30		0.000				7.6			14.3	
06/15/77	CITY	21.5		216	225	70		7.9							9.5	18.5	0.30			2.00		0.700				5.7			13.6	
06/22/77	CITY	21.0		162	143	46		8.4							10.3	12.8				0.90		0.400				6.4			9.7	
06/30/77	CITY	22.0		170	182	60		8.6							12.6	16.0				1.10		0.300				5.5			13.0	
04/07/78	CITY	13.8		213	211	20		7.7							8.7	15.6	0.20			3.10		0.200				4.8			12.4	
04/12/78	CITY	14.8		199	180	15		7.5							8.4	15.0	0.40			2.50		0.300				5.1			11.8	
06/07/78	CITY	23.5		210	190	60		8.3							7.7	10.7	0.40			1.40		0.600				4.6			10.7	
06/21/78	CITY	20.5		182	177	56		7.6							7.6	11.4	0.40			1.30		0.600				6.7			9.9	
07/12/78	CITY	22.5		185	150	38		7.7							7.2	11.7	0.50			1.40		0.400				4.1			10.2	
07/19/78	CITY	22.0		188	194	59		7.7							8.0	11.0	0.40			1.90		0.600				6.1			9.5	
07/26/78	CITY	27.0		198	172	38		8.0							7.9	10.0	0.20			1.40		0.500				6.0			11.0	
08/02/78	CITY	23.5		222	232	63		7.7							12.2	13.7	0.60			2.60		0.600				6.7			10.9	
03/06/79	DEQ	11.5		193				7.5	68.0						9.0												9.0			
04/04/79	CITY	14.0		172	197	44		7.7							8.9	12.5	0.70			2.00		0.600				5.0			12.9	
07/21/79	DEQ	18.5		262				8.0	85.0						10.0												18.0			
07/30/79	DEQ	21.5		265				7.6	85.0						9.0												16.0			
10/18/79	METRO			222				7.9	66.0	78.0					9.1		0.50									3.0	6.0			
11/07/79	METRO			218				7.2	61.0	70.0					8.0		0.20									2.6	4.0			
01/23/80	METRO			190				7.9	64.0	75.0					7.7		0.30									1.4	6.0			
02/21/80	METRO			160				8.1	48.0	55.0					9.4		0.50									2.1	4.0			
03/11/80	METRO			214				7.4	74.0	85.0					9.8		0.40		2.90							3.2	8.0			
04/23/80	METRO			180				7.7	61.0	60.0					8.3		0.70		1.60							3.2	8.0			
05/28/80	METRO			249				7.7	77.0	167.0					8.1		0.20		2.30							5.6	12.0			
06/26/80	METRO			258				7.9	82.0	94.0					10.8		0.30		2.70							10.0	13.0			
07/24/80	CITY			265				8.1	81.0	102.0					13.3		0.40		3.50							11.0	12.0			
10/22/80	METRO			270				7.6	78.0	101.0					9.2		0.20		4.10							4.1	3.0			
11/18/80	METRO			270				8.2	75.0	95.0					8.8		0.40		4.40							2.5	10.0			
01/06/81	METRO			198				7.7	59.0	64.0					9.2		1.40									1.4	8.0			
02/03/81	METRO			230				7.7	70.0	79.0					7.6		0.50		2.40							1.4	4.0			
03/02/81	METRO			250				8.2	75.0	90.0					7.8		0.40		0.40								10.0			
04/06/81	CITY			90	158	12		7.6	34.0	36.0					6.1		0.10		1.10							2.6	10.0			
05/06/81	METRO			241	212	36		8.8	80.0	93.0					8.5		0.10		2.00							6.1	8.0			
06/01/81	METRO			185	150	24		8.0	64.0	7.1					4.8		0.00		0.70							3.6	3.4			
07/06/81	METRO			220	164	36		7.9	81.0	83.0					6.8		0.10		1.20							7.8	8.0			
08/12/81	METRO			260	254	104		7.9	83.0	93.0					11.0		0.80									7.6	44.0			
09/16/81	METRO			160	142	37		7.5	50.0	61.0					7.2		0.00									2.1	0.0			
10/14/81	METRO			230	208	50		7.5	65.0	79.0					7.6		0.10		2.80							4.9	5.0			
11/04/81	METRO			232	240	44		8.0	76.0	94.0					11.8		0.20		2.80							4.2	4.0			

BLANK SPACES = NO SAMPLES; 0.0 VALUES = LESS THAN LOWER LIMIT OF DETECTION.

WATER QUALITY DATA 1977-1985 STATION D (STORET NO. STJOHN04).

DATE OF SAMPLE (m/d/y)	SAMPLERS	T (C)	COND. (FIELD) uhs/cm	COND. (LAB) uhs/cm	TDS mg/l	TSS mg/l	pH (FIELD)	pH (LAB)	ALK (LAB) mg/l CaCO3	HARD. (CALC. DISS.) mg/l	Ca (DISS.) mg/l	Mg (DISS.) mg/l	K mg/l	Na mg/l	Cl mg/l	SO4 mg/l	NH3-N mg/l	NO2-N mg/l	NO3-N mg/l	NO3+ NO2-N mg/l	KJELD. N (TOT) mg/l	PO4-P (TOT) mg/l	Fe (DISS.) mg/l	Mn (DISS.) mg/l	Zn mg/l	BOD mg/l	COD mg/l	C (TO DR) mg/l	O (DISS.) mg/l	COLOR PT-CO
12/08/81	METRO			155	212	88		7.3	59.0	63.0					10.8		0.60		1.30							1.0				
02/03/82	METRO			115				7.3	44.0	45.0					6.0		0.10													
03/02/82	METRO			170				7.0	59.0	64.0					7.2		0.10													
04/07/82	METRO			210				7.8	77.0	88.0					7.3		0.00									4.1				
05/05/82	METRO			145				7.6	54.0	57.0					5.2		0.00									1.8				
06/03/82	METRO			205				7.8	92.0	103.0					9.1		0.00									7.8				
07/14/82	METRO			235				7.6	88.0	99.0					8.4		0.00													
08/04/82	METRO			190				7.5	66.0	73.0					7.7		0.20													
09/01/82	METRO			140				7.4	55.0	54.0					4.4		0.10													
10/04/82	METRO			150				7.8	54.0	54.0					3.9		0.10													
01/06/83	METRO			202				7.3	71.0	81.0					7.9		0.60													
03/17/83	METRO			210				7.0	73.0	81.0					6.8		0.10													
04/12/83	DEQ	10.5	196	196			7.5	7.4	68.0	75.0	19	6.7			6.8	11.0	0.18			1.70			0.09				18.0	7		20
04/12/83	METRO			205				7.6	71.0	78.0					8.2		0.10													
05/11/83	METRO			160				7.8	64.0	65.0					10.0		0.00													
06/01/83	METRO			230				8.1	93.0	90.0					7.3		0.30													
07/20/83	METRO			225				7.9	78.0	87.0					7.6		0.00													
08/10/83	METRO			140				8.0	62.0	62.0					3.3		0.10													
09/07/83	METRO			140				8.2	61.0	57.0					7.0		0.00													
10/05/83	METRO							8.0	61.0	56.0					7.0		0.00													
11/02/83	METRO			230				8.0	80.0	90.0					7.7		0.30													
02/28/84	METRO			220				7.4	88.0	89.0					7.2		0.30													
05/15/84	DEQ	16.5	225	230			7.3	7.5	85.0	94.0	24	8.3			9.6	13.0	0.25			2.60			0.18				0.0	2		15
06/28/84	METRO			245				7.1	86.0	95.0					8.4		0.20													
11/21/84	DEQ	8.5	209	238			7.4	7.3	69.0	87.0	22	7.9			11.0	14.0	0.45			3.00			0.04				5.0	3	6.9	20
05/15/85	DEQ	15.5	248	240			8.6	7.9	82.0	96.0	25	8.1			8.7	15.0	0.24			0.27			0.06				0.0	1	16.0	20
09/26/85	DEQ	18.5	237	230			8.3	8.4	81.0	90.0	23	7.8			9.6	15.0	0.14			3.40			0.13	0.07			0.0	2	17.4	15
01/02/86	METRO	0.8	110	98			6.7	6.9	29.6	34.3					5.8		0.14									0.0	5.0			
02/20/86	METRO	3.8	185	180			6.6	6.6	60.2	77.5					5.6		0.43									5.0	21.0			
05/29/86	DEQ	18.0	136	137	111	18	7.8	7.6	52.0	54.0	14	4.6	1.6	5.8	6.3	8.0	0.05			0.69	0.6	0.093	0.05	0.00		3.3	10.0	4	11.8	5
07/31/86	METRO	20.0	275	270			7.5	7.2	89.0	73.0					13.8		0.41									6.0	23.0			
08/28/86	METRO	22.5	225				6.9																							
SAMPLES	ANALYZED	33	10	76	30	30	10	77	57	54	7	7	2	2	77	27	72	1	17	26	1	21	7	3	1	49	35	6	24	7
MEAN	VALUE	15.5	205	202	187	41	7.5	7.7	69.5	76.9	21	7.1	1.5	6.2	8.4	14.0	0.28	0.02	2.15	2.06	0.6	0.366	0.08	0.02	0.04	4.5	9.0	3	11.7	14
MAXIMUM	VALUE	27.0	275	270	254	104	8.6	8.8	93.0	167.0	25	8.3	1.6	6.5	13.8	19.3	1.40	0.02	4.40	4.10	0.6	0.700	0.18	0.07	0.04	11.0	44.0	7	17.4	20
MINIMUM	VALUE	0.8	110	90	111	4	6.6	6.6	29.6	7.1	14	4.6	1.3	5.8	3.3	8.0	0.00	0.02	0.28	0.27	0.6	0.000	0.00	0.00	0.04	0.0	0.0	1	6.9	0
STANDARD	DEVIATION	7.0	48	41	36	22	0.6	0.4	13.8	22.9	3	1.3	0.2	0.3	2.1	3.2	0.25		1.19	1.10		0.199	0.06	0.03		2.3	8.4	2	2.3	7

BLANK SPACES = NO SAMPLES; 0.0 VALUES = LESS THAN LOWER LIMIT OF DETECTION.

TABLE B - 8 North Slough Station H water quality data 1978 - 1983
(USEPA STORET No. STJOHN08)

DATE OF SAMPLE (m/d/y)	SAMPLERS	T (C)	COND. (FIELD) uhs/cm	COND. (LAB) uhs/cm	TDS mg/l	TSS mg/l	pH (FIELD)	pH (LAB)	ALK (LAB) mg/l CaCO3	HARD. (CALC. DISS.) mg/l	Ca (DISS.) mg/l	Mg (DISS.) mg/l	K mg/l	Na mg/l	Cl mg/l	SO4 mg/l	NH3-N mg/l	NO2-N mg/l	NO3-N mg/l	NO3+ NO2-N mg/l	KJELD. N (TOT) mg/l	PO4-P (TOT) mg/l	Fe (DISS.) mg/l	Mn (DISS.) mg/l	Zn mg/l	BOD mg/l	COD mg/l	C (TO DR) mg/l	O (DISS.) mg/l	COLOR PT-CO
04/07/78	CITY			880	796	180		7.6							58.0	0.0	6.2			1.1		5.2				104.0				
02/07/79	DEQ	6.5		209				7.1	69						16.0												25.0			
03/06/79	DEQ	11.0		189				7.4	63						9.0												14.0			
07/21/79	DEQ	18.0		261				7.9	81						10.0												21.0			
07/30/79	DEQ	21.5		243				7.5	86						10.0												21.0			
10/22/80	METRO			260				8.0	100	97.0					9.6		0.3		0.0							5.2	11.0			
11/18/80	METRO			218				8.1	64	74.0					8.2		0.3		0.4							3.2	16.0			
01/06/81	METRO			120				7.4	34	39.0					5.2		0.4									2.3	13.0			
02/03/81	METRO			200				7.2	63	71.0					7.1		0.5		1.7							2.1	6.0			
03/02/81	METRO			135				8.0	42	44.0					4.4		0.1										12.0			
04/06/81	CITY			148	202	38		7.9	46	48.0					9.1		0.1		1.2							6.5	18.0			
05/06/81	METRO			192	152	18		8.1	64	65.0					5.3		0.1		0.8							1.4	3.0			
06/01/81	METRO			160	124	24		8.0	60	6.5					3.2		0.0		0.0							1.2	2.3			
07/06/81	METRO			221	210	80		7.8	81	84.0					9.8		0.2		1.1							7.3	7.0			
08/12/81	METRO			180	226	120		7.9	85	78.0					7.0		0.5									7.7	40.0			
09/16/81	METRO			255	264	85		7.8	83	91.0					12.2		0.0									5.4	0.0			
10/14/81	METRO			170	192	60		7.5	55	63.0					6.4		0.1		1.0							4.9	5.0			
11/04/81	METRO			175	156	28		7.5	67	73.0					9.2		0.0		0.0							4.2	6.0			
12/08/81	METRO			94	122	40		7.1	34	40.0					7.9		0.4		1.2							0.5				
02/03/82	METRO			110				7.2	41	40.0					7.0		0.1													
03/02/82	METRO			110				7.7	170	40.0					5.6		0.1													
04/07/82	METRO			152				7.8	50	61.0					6.6		0.0									4.0				
05/05/82	METRO			150				7.9	60	60.0					4.2		0.0									1.7				
06/03/82	METRO			185				7.8	72	76.0					6.6		0.0									3.1				
07/14/82	METRO			165				7.6	67	69.0					6.4		0.0													
01/06/83	METRO			192				7.7	62	65.0					9.9		1.9													
03/17/83	METRO			140				7.1	50	52.0					6.6		0.1													
06/01/83	METRO			170				8.0	77	71.0					5.5		0.1													
SAMPLES	ANALYZED	4	0	28	10	10	0	28	27	23	0	0	0	0	28	1	24	0	10	1	0	1	0	0	0	17	17	0	0	0
MEAN	VALUE	14.3		203	244	67		7.7	68	61.2					9.5	0.0	0.5		0.7	1.1		5.2				9.7	13.0			
MAXIMUM	VALUE	21.5		880	796	180		8.1	170	97.0					58.0	0.0	6.2		1.7	1.1		5.2				104.0	40.0			
MINIMUM	VALUE	6.5		94	122	18		7.1	34	6.5					3.2	0.0	0.0		0.0	1.1		5.2				0.5	0.0			
STANDARD	DEVIATION	5.9		138	189	48		0.3	26	20.0					9.7	0.0	1.3		0.6			0.0				23.7	9.8			

BLANK SPACES = NO SAMPLES; 0.0 VALUES = LESS THAN LOWER LIMIT OF DETECTION.

TABLE B - 9 North Slough Station G water quality data 1977 - 1986
(USEPA STORET No. STJOHN07)

DATE OF SAMPLE (m/d/y)	SAMPLERS	T (C)	COND. (FIELD) uhs/cm	COND. (LAB) uhs/cm	TDS mg/l	TSS mg/l	pH (FIELD)	pH (LAB)	ALK (LAB) mg/l CaCO3	HARD. (CALC. DISS.) mg/l	Ca (DISS.) mg/l	Mg (DISS.) mg/l	K mg/l	Na mg/l	Cl mg/l	SO4 mg/l	NH3-N mg/l	NO2-N mg/l	NO3-N mg/l	NO3+ NO2-N mg/l	KJELD. N (TOT) mg/l	PO4-P (TOT) mg/l	Fe (DISS.) mg/l	Mn (DISS.) mg/l	Zn mg/l	BOD mg/l	COD mg/l	C (TO DR) mg/l	O (DISS.) mg/l	COLOR PT-CO
01/12/77	DEQ			150				7.7	70.0	78.0	22	5.6	1.1	5.6	4.6	13.0	0.20	0.02	0.44				0.00	0.00	0.02		0.0			0
04/07/78	CITY			445	331	43		7.5							34.0	20.2	5.00			3.10		0.300				11.1				
02/07/79	DEQ	11.0		196				7.0	74.0						12.0												29.0			
03/06/79	DEQ	11.0		196				7.6	68.0						9.0												12.0			
07/21/79	DEQ	16.0		250				7.7	88.0						9.0												14.0			
07/30/79	DEQ	21.5		254				7.5	85.0						10.0												23.0			
11/07/79	METRO			180				7.6	52.0	58.0					19.2		1.60									3.3	6.0			
01/23/80	METRO			110				7.7	36.0	39.0					5.6		0.20									2.5	3.0			
02/21/80	METRO			113				7.9	32.0	36.0					9.5		0.20									2.0	4.0			
03/11/80	METRO			150				7.4	49.0	55.0					9.2		0.20		1.80							4.4	8.0			
04/23/80	METRO			80				7.5	26.0	26.0					5.4		0.10		0.60							1.4	5.0			
05/28/80	METRO			185				7.8	59.0	119.0					5.5		0.10		1.20							3.6	12.0			
06/26/80	METRO			200				8.0	68.0	77.0					7.8		0.20		1.00							4.9	13.0			
07/24/80	CITY			215				9.1	79.0	86.0					12.6		0.90		1.00							0.0	51.0			
10/22/80	METRO			280				7.9	95.0	100.0					11.9		0.50		3.20							5.3	9.0			
11/18/80	METRO			210				8.1	59.0	70.0					8.7		0.40		0.70							3.0	16.0			
01/06/81	METRO			120				7.1	37.0	38.0					5.2		0.40									2.0	13.0			
02/03/81	METRO			180				7.3	61.0	69.0					6.1		0.50		0.70							2.1	7.0			
03/02/81	METRO			140				8.1	48.0	47.0					4.2		0.20										11.0			
04/06/81	CITY			169	224	48		7.8	52.0	56.0					8.6		0.10		1.30							7.0	14.0			
05/06/81	METRO			198	158	20		8.2	63.0	67.0					5.4		0.10		1.30							2.4	4.0			
06/01/81	METRO			165	124	22		8.0	58.0	6.3					3.4		0.00		0.20							1.5	2.3			
07/06/81	METRO			214	180	58		7.9	79.0	81.0					8.5		0.20		1.00							7.0	7.0			
08/12/81	METRO			160	200	122		7.9	61.0	6.3					5.6		0.30									2.7	18.0			
09/16/81	METRO			215	176	30		7.8	65.0	75.0					9.6		0.00									3.5	0.0			
10/14/81	METRO			210	204	62		7.6	61.0	72.0					7.6		0.10		2.00							4.7	5.0			
11/04/81	METRO			195	182	32		7.6	72.0	79.0					10.2		0.10		0.20							4.9	6.0			
12/08/81	METRO			84	114	46		7.1	30.0	34.0					8.5		0.40		1.20							0.6				
02/03/82	METRO			100				7.3	41.0	41.0					6.7		0.10													
03/02/82	METRO			130				7.7	130.0	45.0					6.4		0.10													
04/07/82	METRO			140				7.8	52.0	56.0					6.4		0.00									3.1				
05/05/82	METRO			150				8.0	60.0	60.0					4.2		0.00									2.0				
06/03/82	METRO			190				7.8	73.0	77.0					6.6		0.00									3.2				
07/14/82	METRO			180				7.3	75.0	72.0					6.2		0.00													
08/04/82	METRO			150				7.7	56.0	56.0					4.7		0.10													
01/06/83	METRO			220				7.6	73.0	79.0					10.3		1.50													
03/17/83	METRO			175				6.8	60.0	67.0					6.0		0.10													
04/12/83	DEQ	10.5	141	139			7.7	7.5	50.0	51.0	13	4.6			9.8	6.0	0.00			0.02			0.10				19.0	5		15
04/12/83	METRO			145				7.7	54.0	50.0					9.4		0.00													
05/11/83	METRO			210				7.4	77.0	88.0					12.8		0.00													
06/01/83	METRO			195				8.0	81.0	80.0					6.0		0.10													
07/20/83	METRO			190				8.1	79.0	75.0					7.4		0.00													
08/10/83	METRO			250				8.0	100.0	91.0					12.0		0.70													
09/07/83	METRO			220				8.4	93.0	85.0					18.3		0.00													
10/05/83	METRO							8.3	109.0	106.0					13.3		0.60													
11/02/83	METRO			290				7.4	108.0	105.0					17.2		1.20													

BLANK SPACES = NO SAMPLES; 0.0 VALUES = LESS THAN LOWER LIMIT OF DETECTION.

WATER QUALITY DATA 1977-1985 STATION 6 (STORET NO. STJOHN07).

DATE OF SAMPLE (m/d/y)	SAMPLERS	T (C)	COND. (FIELD) uhs/cm	COND. (LAB) uhs/cm	TDS mg/l	TSS mg/l	pH (FIELD)	pH (LAB)	ALK (LAB) mg/l CaCO3	HARD. (CALC. DISS.) mg/l	Ca (DISS.) mg/l	Mg (DISS.) mg/l	K mg/l	Na mg/l
02/28/84	METRO			250				7.6	84.0	86.0				
05/15/84	DER	17.0	177	180			7.3	7.4	73.0	75.0	19	6.7		
06/20/84	METRO			240				7.4	93.0	93.0				
11/21/84	DER	8.0	197	209			7.4	7.5	82.0	82.0	21	7.3		
05/15/85	DER	16.4	214	200			7.6	7.3	83.0	78.0	20	6.9		
09/26/85	DER	19.0	238	260			8.4	7.7	103.0	96.0	24	8.7		
01/02/86	METRO	0.8	238	250			6.7	7.0	102.0	106.0				
02/20/86	METRO	3.8	210	230			6.6	6.5	77.5	81.1				
05/29/86	DER	22.5	181	180	136	30	7.7	7.3	71.0	68.0	17	6.3	2.7	8.2
07/31/86	METRO	21.0	227	220			7.6	7.2	89.5	59.0				
08/28/86	METRO	23.4	225	225			6.9	6.8	125.0	101.0				
SAMPLES	ANALYZED	14	10	56	11	11	10	57	56	52	7	7	2	2
MEAN	VALUE	14.4	205	193	186	47	7.4	7.6	71.1	68.9	19	6.6	1.9	6.9
MAXIMUM	VALUE	23.4	238	445	351	122	8.4	9.1	130.0	119.0	24	8.7	2.7	8.2
MINIMUM	VALUE	0.8	141	80	114	20	6.6	6.5	26.0	6.3	13	4.6	1.1	5.6
STANDARD	DEVIATION	6.8	29	58	62	27	0.5	0.4	22.3	24.1	3	1.2	0.8	1.3

DATE OF SAMPLE (m/d/y)	SAMPLERS	Cl mg/l	SO4 mg/l	NH3-N mg/l	NO2-N mg/l	NO3-N mg/l	NO3+ NO2-N mg/l	KJELD. N (TOT) mg/l	PO4-P (TOT) mg/l	Fe (DISS.) mg/l	Mn (DISS.) mg/l	Zn mg/l	BOD mg/l	COD mg/l	C (TO OR) mg/l	O (DISS.) mg/l	COLOR PT-CO
02/28/84	METRO	11.0		2.60													
05/15/84	DER	9.6	7.7	0.02			0.67			0.05				13.0	6		15
06/20/84	METRO	8.4		0.20													
11/21/84	DER	10.0	2.8	0.02			0.00			0.07				18.0	6	7.7	20
05/15/85	DER	12.0	3.0	0.02			0.00			0.04				0.0	4	6.5	10
09/26/85	DER	23.0	2.4	0.02			0.00			0.00	0.08			29.0	12	17.2	30
01/02/86	METRO	12.2		0.34	0.01	0.10			0.290				8.0	26.0		10.0	
02/20/86	METRO	10.5		2.20	2.01	0.02			0.170				6.0	25.0		10.8	
05/29/86	DER	9.0	6.4	0.20			0.55	1.4	0.178		0.00		10.0	18.0	6	11.0	20
07/31/86	METRO	11.8		0.00	0.00	0.00			0.137				5.0	36.0		7.1	
08/28/86	METRO	14.5		0.29	0.00	0.00			0.180				11.0	43.0		5.5	
SAMPLES	ANALYZED	57	8	53	5	20	7	1	6	6	3	1	30	36	6	8	7
MEAN	VALUE	9.7	7.7	0.42	0.41	0.90	0.62	1.4	0.209	0.04	0.03	0.02	4.3	14.4	7	9.5	16
MAXIMUM	VALUE	34.0	20.2	5.00	2.01	3.20	3.10	1.4	0.300	0.10	0.08	0.02	11.1	51.0	12	17.2	30
MINIMUM	VALUE	3.4	2.4	0.00	0.00	0.00	0.00	1.4	0.137	0.00	0.00	0.02	0.0	0.0	4	5.5	0
STANDARD	DEVIATION	5.0	5.7	0.83	0.80	0.78	1.05		0.062	0.04	0.04		2.8	11.9	3	3.5	9

BLANK SPACES = NO SAMPLES; 0.0 VALUES = LESS THAN LOWER LIMIT OF DETECTION.

TABLE B - 10 North Slough Station F water quality data 1977 - 1986
(USEPA STORET No. STJOHN06)

DATE OF SAMPLE (m/d/y)	SAMPLERS	T (C)	COND. (FIELD) uhs/cm	COND. (LAB) uhs/cm	TDS mg/l	TSS mg/l	pH (FIELD)	pH (LAB)	ALK (LAB) mg/l CaCO3	HARD. (CALC. DISS.) mg/l	Ca (DISS.) mg/l	Mg (DISS.) mg/l	K mg/l	Na mg/l	Cl mg/l	SO4 mg/l	NH3-N mg/l	NO2-N mg/l	NO3-N mg/l	NO3+ NO2-N mg/l	KJELD. N (TOT) mg/l	PO4-P (TOT) mg/l	Fe (DISS.) mg/l	Mn (DISS.) mg/l	Zn mg/l	BOD mg/l	COD mg/l	C (TO OR) mg/l	O (DISS.) mg/l	COLOR PT-CO
01/12/77	DEQ			157				7.1	63.0	78.0	22	5.7	1.2	5.6	5.4	19.3	0.160	0.03	0.67				0.00	0.00	0.02		5.0			0
01/19/77	CITY	7.0		175	157	40.0		7.2							14.1	18.0	0.300			1.40		0.300				2.2			7.5	
01/26/77	CITY	3.0		180	123	7.0		7.8							5.6	19.6	0.100			0.50		0.200				1.7			13.3	
02/02/77	CITY	4.0		175	187	60.0		7.7							9.0	21.7	0.400			0.90		0.500				3.1			10.2	
02/09/77	CITY	5.0		190	164	30.0		7.9							7.3	18.4	0.100			1.50		0.200				2.8			14.0	
02/16/77	CITY	8.0		170	216	76.0		7.5							10.1	10.8	0.400			0.90		0.600				6.5			8.4	
03/16/77	CITY	8.5		142	249	73.0		7.4							8.8	21.7	0.600			0.50		0.800				5.1			11.3	
04/06/77	CITY	18.0		236	255	65.0		7.6							12.4	11.0	0.800			3.10		0.800				5.6			9.4	
06/08/77	CITY	22.0		161	251	132.0		7.5							8.1	11.7	0.500			0.30		0.100				8.8			7.0	
06/15/77	CITY	22.5		211	256	96.0		7.7							10.0	18.4	0.400			1.60		10.000				7.6			11.6	
06/22/77	CITY	25.0		265	254	72.0		8.0							14.6	20.1	1.100			1.60		0.800				4.3			11.1	
06/30/77	CITY	25.0			149	50.0		8.3							10.1	14.5	0.400			1.00		0.200				6.2			12.0	
04/07/78	CITY	13.4		197	192	16.0		7.8							8.1	14.5	0.200			1.90		0.200				4.0			11.6	
04/12/78	CITY	13.8		160	145	29.0		8.1							7.0	13.3	0.200			0.60		0.400				5.5			12.6	
06/07/78	CITY	19.0		182	114	34.0		8.5							3.4	9.5	0.200			0.30		0.700				3.0			11.6	
06/21/78	CITY	19.5		131	142	55.0		7.6							4.4	8.6	0.100			0.30		0.500				5.8			10.8	
07/12/78	CITY	21.0		180	156	50.0		7.8							7.0	10.3	0.600			1.30		0.600				4.9			10.0	
07/19/78	CITY	23.0		118	121	49.0		7.8							3.4	7.1	0.200			0.30		0.500				3.2			9.2	
07/26/78	CITY	27.3		172	220	102.0		8.0							7.4	6.0	0.200			0.50		1.000				11.7			8.8	
08/02/78	CITY	23.5		122				7.7							5.0	8.4	0.400			0.40		0.700				4.6			9.9	
02/07/79	DEQ	6.0		136				7.4	69.0						16.0												31.0			
03/06/79	DEQ	11.0		196				7.4	65.0						9.0												11.0			
07/21/79	DEQ	18.5		257				7.5	84.0						10.0												31.0			
07/30/79	DEQ	22.0		260				7.6	75.0						10.0												19.0			
10/18/79	METRO			282				7.9	85.0	92.0					14.9		1.900									1.6	8.0			
11/07/79	METRO			212				7.5	59.0	66.0					8.6		0.300									3.2	5.0			
01/23/80	METRO			150				7.9	41.0	59.0					6.6		0.200									1.8	4.0			
02/21/80	METRO			120				7.9	35.0	39.0					9.0		0.200									2.3	3.0			
03/11/80	METRO			162				7.4	55.0	61.0					8.8		0.300		2.20							4.1	8.0			
04/23/80	METRO			80				7.5	28.0	32.0					5.2		0.100		0.60							2.0	5.0			
05/28/80	METRO			195				7.6	62.0	127.0					5.7		0.200		1.40							3.7	11.0			
06/26/80	METRO			201				8.0	68.0	72.0					8.6		0.300		1.10							4.2	13.0			
07/24/80	CITY			225				8.6	78.0	86.0					12.0		0.700		1.60							0.0	38.0			
10/22/80	METRO			295				7.7	89.0	101.0					12.7		1.100		3.40							4.3	5.0			
11/18/80	METRO			261				8.3	76.0	86.0					10.8		1.000		2.90							2.5	13.0			
01/06/81	METRO			130				7.6	37.0	42.0					5.6		0.600									1.4	13.0			
02/03/81	METRO			190				7.4	53.0	58.0					7.2		0.400		1.80							1.3	5.0			
03/02/81	METRO			160				8.1	47.0	54.0					6.2		0.300										9.0			
04/06/81	CITY			109	162	12.0		7.8	34.0	33.0					5.8		0.100		0.70							2.5	9.0			
05/06/81	METRO			200	174	24.0		8.5	70.0	74.0					6.8		0.100		2.00							3.1	5.0			
06/01/81	METRO			170	136	22.0		8.1	58.0	6.1					3.6		0.000		0.00							1.9	2.3			
07/06/81	METRO			190	134	48.0		7.8	71.0	73.0					5.0		0.100		0.50							5.8	5.0			
08/12/81	METRO			150	150	90.0		7.9	56.0	59.0					4.3		0.200									1.4	13.0			
09/16/81	METRO			160	140	27.0		7.8	52.0	58.0					6.0		0.000									1.3	0.0			
10/14/81	METRO			150	170	54.0		7.6	42.0	47.0					8.0		0.100		1.40							2.6	5.0			
11/04/81	METRO			250	242	28.0		7.5	78.0	95.0					13.0		0.200		3.70							4.2	4.0			

BLANK SPACES = NO SAMPLES; 0.0 VALUES = LESS THAN LOWER LIMIT OF DETECTION.

. WATER QUALITY DATA 1977-1985 STATION F (STORET NO. STJOHN06).

DATE OF SAMPLE (m/d/y)	SAMPLERS	T (C)	COND. (FIELD) uhs/cm	COND. (LAB) uhs/cm	TDS mg/l	TSS mg/l	pH (FIELD)	pH (LAB)	ALK (LAB) mg/l CaCO3	HARD. (CALC. DISS.) mg/l	Ca (DISS.) mg/l	Mg (DISS.) mg/l	K mg/l	Na mg/l	Cl mg/l	SO4 mg/l	NH3-N mg/l	NO2-N mg/l	NO3-N mg/l	NO3+ NO2-N mg/l	KJELD. N (TOT) mg/l	PO4-P (TOT) mg/l	Fe (DISS.) mg/l	Mn (DISS.) mg/l	Zn mg/l	BOD mg/l	COD mg/l	C (TO OR) mg/l	O (DISS.) mg/l	COLOR PT-CO
12/08/81	METRO			82	128	54.0		7.2	29.0	36.0					8.4		0.400		1.20							0.6				
02/03/82	METRO			95				7.2	41.0	42.0					6.1		0.100													
03/02/82	METRO			150				7.1	55.0	54.0					6.2		0.100													
04/07/82	METRO			150				7.4	55.0	61.0					6.6		0.000									3.3				
05/05/82	METRO			150				7.9	60.0	62.0					4.2		0.000									2.2				
06/03/82	METRO			160				7.7	70.0	76.0					5.8		0.000									3.1				
07/14/82	METRO			185				7.6	73.0	71.0					6.2		0.000													
08/04/82	METRO			130				7.7	53.0	52.0					4.2		0.100													
09/01/82	METRO			135				7.5	58.0	53.0					3.1		0.100													
10/04/82	METRO			230				7.7	77.0	88.0					8.8		0.100													
01/06/83	METRO			204				7.3	70.0	80.0					8.2		0.600													
03/17/83	METRO			185				6.8	66.0	71.0					6.0		0.100													
04/12/83	DEQ	10.5	142	142			7.6	7.5	49.0	50.0	13	4.3			11.0	5.9	0.000			0.00			0.08				17.0	5		15
04/12/83	METRO			150				7.7	54.0	54.0					9.3		0.000													
05/11/83	METRO			130				7.7	53.0	49.0					8.4		0.000													
06/01/83	METRO			220				8.0	89.0	88.0					6.9		0.300													
07/20/83	METRO			210				8.0	81.0	78.0					8.2		0.000													
08/10/83	METRO			240				7.8	58.0	92.0					8.0		0.300													
09/07/83	METRO			195				8.3	87.0	95.0					16.9		0.200													
10/05/83	METRO							7.5	92.0	100.0					7.4		0.400													
11/02/83	METRO			270				7.4	90.0	96.0					11.9		1.300													
02/28/84	METRO			300				7.3	99.0	91.0					15.4		4.500													
05/15/84	DEQ	16.5	230	240			7.3	7.6	85.0	77.0	24	4.2			9.6	13.0	0.260			2.70			0.18				5.0	3		10
06/20/84	METRO			245				7.4	85.0	94.0					8.4		0.300													
11/21/84	DEQ	8.5	291	311			7.2	7.2	101.0	96.0	24	8.7			20.0	14.0	3.900			1.50			0.05				21.0	8	5.9	29
05/15/85	DEQ	16.0	250	240			8.6	7.7	86.0	90.0	23	7.8			12.0	8.6	0.780			1.50			0.00				0.0	3		15
09/26/85	DEQ	18.5	236	230			8.4	8.3	80.0	93.0	24	8.0			12.0	15.0	0.080			0.33			0.05	0.08			0.0	2	17.1	15
11/13/85	SRI	6.5		235	179	21.5		6.7									0.760			1.80	3.70	0.120							12.0	
11/14/85	SRI	5.0		248	175	22.5		6.9									0.630			0.80	3.60	0.160							7.0	
12/16/85	SRI	4.0		205	186	7.9		6.7									0.238			1.26	3.46	0.020							12.0	
01/02/86	METRO	0.8	286	300			6.9	7.1	108.0	110.0					15.8		1.860									6.0	28.0			
02/20/86	METRO	3.8	175	180			6.5	6.6	64.3	76.4					5.3		0.690									3.0	21.0			
05/29/86	DEQ	21.5	175	187	143	22.0	7.9	7.8	70.0	70.0	18	6.2	3.1	8.4	10.0	8.2	0.440			1.20	1.40	0.117	0.05	0.00		5.4	24.0	5	11.7	15
07/31/86	METRO	21.0	238	230			7.7	7.2	94.1	63.0					13.4		0.040									6.0	38.0			
08/28/86	METRO	23.5	225				6.9																							
SAMPLES	ANALYZED	36	10	78	31	31	10	80	58	54	7	7	2	2	77	26	76	1	16	28	4	23	7	3	1	48	36	6	25	7
MEAN	VALUE	14.5	225	189	176	47.4	7.5	7.6	66.6	70.5	21	6.4	2.2	7.0	8.6	13.4	0.452	0.03	1.57	1.07	3.04	0.849	0.06	0.03	0.02	3.8	12.1	4	10.6	13
MAXIMUM	VALUE	27.3	291	311	256	132.0	8.6	8.6	108.0	127.0	24	8.7	3.1	8.4	20.0	21.7	4.500	0.03	3.70	3.10	3.70	10.000	0.18	0.08	0.02	11.7	38.0	8	17.1	29
MINIMUM	VALUE	0.8	142	80	114	7.0	6.5	6.6	28.0	6.1	13	4.2	1.2	5.6	3.1	5.9	0.000	0.03	0.00	0.00	1.40	0.020	0.00	0.00	0.02	0.0	0.0	2	5.9	8
STANDARD	DEVIATION	7.8	46	52	44	29.6	0.6	0.4	18.7	22.7	4	1.7	1.0	1.4	3.5	4.9	0.725		1.03	0.74	0.95	1.970	0.06	0.04		2.2	10.5	2	2.4	6

BLANK SPACES = NO SAMPLES; 0.0 VALUES = LESS THAN LOWER LIMIT OF DETECTION.

TABLE B - 11 Columbia Slough Station E water quality data 1977 - 1986
(USEPA STORET No. STJOHN05)

DATE OF SAMPLE (m/d/y)	SAMPLERS	T (C)	COND. (FIELD) uhs/cm	COND. (LAB) uhs/cm	TDS mg/l	TSS mg/l	pH (FIELD)	pH (LAB)	ALK (LAB) mg/l CaCO3	HARD. (CALC. DISS.) mg/l	Ca (DISS.) mg/l	Mg (DISS.) mg/l	K mg/l	Na mg/l	Cl mg/l	SO4 mg/l	NH3-N mg/l	NO2-N mg/l	NO3-N mg/l	NO3+ NO2-N mg/l	KJELD. N (TOT) mg/l	PO4-P (TOT) mg/l	Fe (DISS.) mg/l	Mn (DISS.) mg/l	Zn mg/l	BOD mg/l	COD mg/l	C (TO OR) mg/l	O (DISS.) mg/l	COLOR PT-CO
01/12/77	DEQ			148				7.1	67.0	77.0	22	5.5	1.0	5.5	4.6	11.5	0.13	0.02	34.0				0.00	0.00	0.02		5.0			0
01/19/77	CITY	9.0		218	201	30		7.2							12.7	16.9	0.70			3.80		0.30				3.2			7.5	
01/26/77	CITY	3.0		173				7.7							5.0	19.3	0.10			0.30		0.10				1.4			13.4	
02/02/77	CITY	5.5		222	220	30		7.6							10.4	17.9	0.20			3.90		0.20				4.9			13.3	
02/09/77	CITY	4.0		170	125	14		7.8							5.3	18.6	0.00			0.30		0.10				2.0			13.1	
02/16/77	CITY	8.0		200	204	26		7.5							9.0	19.3	0.20			3.00		0.20				4.5			11.9	
03/16/77	CITY	9.5		200	211	52		7.3							10.1	18.4	0.30			2.50		0.50				4.0			10.2	
04/06/77	CITY	17.0		228	225	33		7.6							10.8	8.4	0.40			3.30		0.40				4.2			11.3	
06/08/77	CITY	22.0		182	187	50		8.2							6.9	13.5	0.70			1.20		0.00				7.0			14.3	
06/15/77	CITY	21.2		214	223	66		7.7							9.3	18.0	0.30			1.80		0.60				6.9			13.5	
06/22/77	CITY	21.0		140	128	34		8.1							9.9	11.2	0.30			0.60		0.30				4.5			9.3	
06/30/77	CITY	22.0		160	170	54		8.6							11.9	15.5	0.30			0.90		0.20				5.3			12.7	
04/07/78	CITY	13.5		191	210	17		7.7							8.7	16.0	0.20			3.00		0.20				4.2			12.1	
04/12/78	CITY	13.8		190	170	21		7.6							8.0	14.2	0.30			2.00		0.30				4.7			11.7	
06/07/78	CITY	23.5		200	179	56		8.3							7.2	10.4	0.40			1.30		0.80				4.2			11.1	
06/21/78	CITY	19.5		147	157	58		7.5							5.2	8.8	0.30			0.90		0.50				4.6			10.0	
07/12/78	CITY	22.0		180	143	40		7.8							7.0	10.0	0.50			1.30		0.50				4.6			10.7	
07/19/78	CITY	22.5		175	178	56		7.7							6.7	9.8	0.40			1.60		0.50				4.8			9.4	
07/26/78	CITY	26.0		195	172	34		8.1							7.4	10.3	0.10			1.50		0.40				5.7			11.3	
08/02/78	CITY	23.5		215	234	68		7.7							12.2	14.1	0.50			2.40		0.60				6.7			10.7	
02/07/79	DEQ	6.0		264				7.2	92.0						18.0												32.0			
03/06/79	DEQ	7.6		219				7.6	74.0						11.0												15.0			
04/04/79	CITY	12.0		93	107	14		7.6							6.7	7.3	0.20			0.90		0.30				1.8			11.5	
07/21/79	DEQ	18.5		262				7.7	84.0						10.0												13.0			
07/30/79	DEQ	22.5		257				7.6	86.0						11.0												19.0			
10/18/79	METRO			216				7.9	68.0	80.0					9.5		0.50									3.2	6.0			
11/07/79	METRO			190				7.4	52.0	57.0					8.0		0.20									2.5	4.0			
01/23/80	METRO			100				7.8	36.0	40.0					5.6		0.20									1.9	3.0			
02/21/80	METRO			138				8.0	41.0	47.0					9.0		0.30									1.7	3.0			
03/11/80	METRO			158				7.4	53.0	63.0					8.7		0.30		2.0							2.9	7.0			
04/23/80	METRO			80				7.5	26.0	30.0					5.2		0.10		0.6							1.5	5.0			
05/28/80	METRO			249				7.7	77.0	166.0					8.0		0.30		2.2							5.7	13.0			
06/26/80	METRO			219				8.1	72.0	77.0					8.8		0.20		1.6							4.6	12.0			
07/24/80	CITY			270				8.1	82.0	101.0					13.2		0.40		3.2							14.0	14.0			
10/22/80	METRO			270				7.9	80.0	99.0					9.3		0.20		4.1							5.0	3.0			
11/18/80	METRO			270				8.2	77.0	96.0					8.9		0.40		4.4							2.3	10.0			
01/06/81	METRO			200				7.6	60.0	65.0					8.2		1.00									1.4	10.0			
02/03/81	METRO			180				7.3	51.0	59.0					7.4		0.40		1.9							3.0	4.0			
03/02/81	METRO			230				8.2	71.0	82.0					7.2		0.40										9.0			
04/06/81	CITY			101	158	12		7.8	35.0	37.0					5.4		0.10		0.9							2.4	13.0			
05/06/81	METRO			174	138	8		8.1	63.0	64.0					7.0		0.10		0.7							1.6	3.0			
06/01/81	METRO			160	120	18		8.0	59.0	6.1					3.2		0.00		0.0							1.7	2.3			
07/06/81	METRO			165	118	26		7.9	62.0	63.0					3.8		0.10		0.2							4.2	4.0			
08/12/81	METRO			240	210	76		7.9	78.0	84.0					8.8		0.40									6.0	21.0			
09/16/81	METRO			160	142	30		7.8	52.0	59.0					7.0		0.00									2.0	0.0			
10/14/81	METRO			205	188	44		7.6	59.0	69.0					7.2		0.10		1.7							3.6	5.0			

BLANK SPACES = NO SAMPLES; 0.0 VALUES = LESS THAN LOWER LIMIT OF DETECTION.

WATER QUALITY DATA 1977-1985 STATION E (STORET NO. STJOHN05).

DATE OF SAMPLE (m/d/y)	SAMPLERS	T (C)	COND. (FIELD) uhs/cm	COND. (LAB) uhs/cm	TDS mg/l	TSS mg/l	pH (FIELD)	pH (LAB)	ALK (LAB) mg/l CaCO3	HARD. (CALC. DISS.) mg/l	Ca (DISS.) mg/l	Mg (DISS.) mg/l	K mg/l	Na mg/l	Cl mg/l	SO4 mg/l	NH3-N mg/l	NO2-N mg/l	NO3-N mg/l	NO3+ NO2-N mg/l	KJELD. N (TOT) mg/l	PO4-P (TOT) mg/l	Fe (DISS.) mg/l	Mn (DISS.) mg/l	Zn mg/l	BOD mg/l	COD mg/l	C (TO OR) mg/l	O (DISS.) mg/l	COLOR PT-CO
11/04/81	METRO			232	230	40		7.5	74.0	89.0					12.1		0.20		3.0							5.1	4.0			
12/08/81	METRO			100	140	60		7.2	36.0	40.0					8.8		0.40		1.3							1.0				
02/03/82	METRO			100				7.3	41.0	41.0					6.7		0.10													
03/02/82	METRO			160				7.0	55.0	60.0					6.6		0.10													
04/07/82	METRO			170				7.3	62.0	70.0					6.8		0.00									3.7				
05/05/82	METRO			150				8.0	64.0	67.0					4.2		0.00									1.9				
06/03/82	METRO			185				7.8	74.0	82.0					6.0		0.00									3.1				
07/14/82	METRO			200				7.3	79.0	82.0					6.8		0.00													
08/04/82	METRO			170				7.6	59.0	62.0					6.5		0.10													
09/01/82	METRO			135				7.5	54.0	54.0					3.6		0.10													
10/04/82	METRO			145				7.8	55.0	58.0					3.3		0.10													
01/06/83	METRO			210				7.6	72.0	84.0					8.2		0.60													
03/17/83	METRO			175				6.9	60.0	66.0					6.0		0.10													
04/12/83	DEQ	10.5	173	174			7.5	7.5	62.0	67.0	17	6.0			8.4	8.7	0.08			1.20			0.10				28.0	5		15
04/12/83	METRO			180				7.7	63.0	74.0					8.2		0.10													
05/11/83	METRO			130				7.9	57.0	56.0					7.0		0.00													
06/01/83	METRO			205				8.1	82.0	90.0					6.3		0.20													
07/20/83	METRO			225				7.9	78.0	88.0					7.6		0.00													
08/10/83	METRO			140				8.1	61.0	57.0					3.4		0.10													
09/07/83	METRO			140				8.3	61.0	57.0					6.8		0.00													
10/05/83	METRO			140				8.0	60.0	54.0					6.9		0.00													
11/02/83	METRO			230				7.4	81.0	90.0					7.7		0.30													
02/28/84	METRO			220				7.4	78.0	89.0					7.3		0.40													
05/15/84	DEQ	15.5	216	220			7.3	7.5	84.0	90.0	23	7.9			9.6	13.0	0.22			2.20			0.33				0.0	11		20
06/20/84	METRO			240				7.2	85.0	96.0					8.4		0.30													
11/21/84	DEQ	8.5	219	233			7.3	7.4	70.0	87.0	22	7.8			8.5	14.0	0.59			3.00			0.26				10.0	2	6.8	20
05/15/85	DEQ	15.0	256	240			8.2	7.8	84.0	96.0	25	8.1			9.5	15.0	0.35			0.28			0.06				0.0	1	15.0	15
09/26/85	DEQ	18.5	237	230			8.3	8.5	81.0	90.0	23	7.8			11.0	15.0	0.08			0.33			0.05	0.08			0.0	2	17.3	20
01/02/86	METRO	0.8	101	90			6.6	6.8	32.7	32.3					5.8		0.09									0.0	8.0			
02/20/86	METRO	3.7	185	187			6.6	6.6	61.7	74.2					4.3		0.42									3.0	19.0			
05/29/86	DEQ	18.0	122	124	98	28	8.1	7.9	49.0	46.0	12	3.8	1.2	5.3	3.3	7.5	0.02			0.30	0.7	0.06	0.05	0.00		2.4	8.0	2	11.8	5
07/31/86	METRO	20.0	286	270			7.8	7.2	92.4	72.0					11.8		0.64									7.0	25.0			
08/28/86	METRO	22.4	205				6.9																							
SAMPLES	ANALYZED	34	10	78	29	29	10	78	58	54	7	7	2	2	78	27	74	1	16	26	1	21	7	3	1	49	36	6	24	7
MEAN	VALUE	14.9	200	187	172	38	7.5	7.7	64.9	70.0	21	6.7	1.1	5.4	7.8	13.4	0.24	0.02	3.9	1.69	0.7	0.34	0.12	0.03	0.02	3.8	9.4	4	11.7	14
MAXIMUM	VALUE	26.0	286	270	234	76	8.3	8.6	92.4	166.0	25	8.1	1.2	5.5	18.0	19.3	1.00	0.02	34.0	3.90	0.7	0.80	0.33	0.08	0.02	14.0	32.0	11	17.3	20
MINIMUM	VALUE	0.8	101	80	98	8	6.6	6.6	26.0	6.1	12	3.8	1.0	5.3	3.2	7.3	0.00	0.02	0.0	0.28	0.7	0.00	0.00	0.00	0.02	0.0	0.0	1	6.8	0
STANDARD	DEVIATION	7.2	54	47	40	18	0.6	0.4	15.5	23.9	4	1.5	0.1	0.1	2.6	3.8	0.20		7.9	1.11		0.20	0.11	0.04		2.3	8.0	3	2.2	7

BLANK SPACES = NO SAMPLES; 0.0 VALUES = LESS THAN LOWER LIMIT OF DETECTION.

TABLE B - 12 Smith and Bybee Lakes water quality stations summary values

DATE OF SAMPLE (m/d/y)	SAMPLERS	T (C)	COND. (FIELD) uhs/cm	COND. (LAB) uhs/cm	TDS mg/l	TSS mg/l	pH (FIELD)	pH (LAB)	ALK (LAB) mg/l CaCO3	HARD. (CALC. DISS.) mg/l	Ca (DISS.) mg/l	Mg (DISS.) mg/l	K mg/l	Na mg/l	Cl mg/l	SO4 mg/l	NH3-N mg/l	NO2-N mg/l	NO3-N mg/l	NO3+ NO2-N mg/l	KJELD. N (TOT) mg/l	PO4-P (TOT) mg/l	Fe (DISS.) mg/l	Mn (DISS.) mg/l	BOD mg/l	COD mg/l	C (TO OR) mg/l	O (DISS.) mg/l	COLOR PT-CO
STATION SLA (STORET NO. STJOHN13) DATES SAMPLED 1980 - 1986																													
SAMPLES	ANALYZED	9	8	29	5	5	9	28	29	29	5	5	0	0	29	5	29	4	11	5	0	4	5	1	15	17	5	7	5
MEAN	VALUE	14.5	209	183	140	24	7.4	7.5	66.1	65.5	20	8.0			11.0	4.9	0.18	0.01	0.10	0.00		0.227	0.12	0.2	6.6	24.9	9	9.5	28
MAXIMUM	VALUE	24.0	246	320	224	32	8.3	8.4	112.0	126.0	26	9.4			26.5	7.8	2.30	0.01	0.30	0.02		0.390	0.22	0.2	12.0	54.0	13	17.0	50
MINIMUM	VALUE	0.8	137	100	90	14	6.7	6.6	34.0	5.6	12	6.6			5.2	2.2	0.00	0.00	0.00	0.00		0.098	0.00	0.2	1.4	0.0	6	5.3	15
STANDARD	DEVIATION	8.1	33	53	45	7	0.5	0.5	20.8	23.5	5	1.0			4.7	1.9	0.42	0.01	0.13	0.01		0.113	0.08		3.2	13.6	3	3.7	14
LOW WATER VALUES	JULY - SEPT																												
SAMPLES	ANALYZED	3	2	4	1	1	3	4	4	4	1	1	0	0	4	1	4	2	3	1	0	2	1	1	3	4	1	3	1
MEAN	VALUE	23.0	224	218	136	32	7.6	7.5	93.4	79.0	26	9.4			11.5	2.2	0.05	0.00	0.00	0.00		0.18	0.00	0.2	7.2	33.5	13	10.3	50
MAXIMUM	VALUE	24.0	237	280	136	32	8.3	7.9	112.0	100.0	26	9.4			13.1	2.2	0.10	0.00	0.00	0.00		0.27	0.00	0.2	11.0	54.0	13	17.0	50
MINIMUM	VALUE	22.0	210	190	136	32	7.2	6.6	73.0	53.0	26	9.4			7.7	2.2	0.00	0.00	0.00	0.00		0.10	0.00	0.2	4.6	10.0	13	6.2	50
STANDARD	DEVIATION	0.8	14	36			0.5	0.5	16.9	18.1					2.2		0.04					0.09			2.7	16.0		4.8	
STATION SLB (STORET NO. STJOHN14) DATES SAMPLED 1981 - 1986																													
SAMPLES	ANALYZED	2	0	17	11	7	0	17	19	15	0	0	0	0	15	0	21	0	6	2	6	6	0	0	10	7	4	2	0
MEAN	VALUE	4		185	148	30.1		7.5	63	66.0					7.5		0.101		0.3	0.0	1.03	0.10			5.7	21	6.5	9.3	
MAXIMUM	VALUE	4		340	268	58.0		8.4	94	138.0					15.1		0.400		0.6	0.0	1.90	0.17			12.0	33	8.1	12.0	
MINIMUM	VALUE	4		94	100	7.3		6.6	32	5.4					4.0		0.000		0.1	0.0	0.00	0.05			2.2	8	4.6	6.5	
STANDARD	DEVIATION	0		69	49	19.8		0.5	17	32.2					2.8		0.098		0.2	0.0	0.58	0.05			3.3	8	1.3	2.7	
LOW WATER VALUES	JULY - SEPT																												
SAMPLES	ANALYZED	0	0	1	4	1	0	1	4	1	0	0	0	0	1	0	4	0	1	0	3	3	0	0	1	1	3	0	0
MEAN	VALUE			200	122	12.0		7.7	70	77.0					5.2		0.105		0.2		1.10	0.08			5.0	15	6.4		
MAXIMUM	VALUE			200	170	12.0		7.7	87	77.0					5.2		0.200		0.2		1.40	0.13			5.0	15	8.1		
MINIMUM	VALUE			200	100	12.0		7.7	45	77.0					5.2		0.000		0.2		0.80	0.05			5.0	15	4.6		
STANDARD	DEVIATION				28				16								0.071				0.24	0.04					1.4		
STATION SLC (STORET NO. STJOHN54) DATES SAMPLED 1986																													
SAMPLES	ANALYZED	4	3	4	1	1	4	4	4	4	1	1	1	1	4	1	3	3	3	0	1	4	1	1	4	4	1	4	1
MEAN	VALUE	18.3	184	201	110	14	7.3	7.3	85.5	74	15	5.4	2.1	9.1	14.0	3	0.02	0.00	0.00		0.8	0.132	0.05	0.0	5.4	32	8	8.3	20
MAXIMUM	VALUE	24.0	205	225	110	14	7.9	7.8	112.0	92	15	5.4	2.1	9.1	15.0	3	0.03	0.01	0.01		0.8	0.190	0.05	0.0	8.0	37	8	10.9	20
MINIMUM	VALUE	3.8	157	160	110	14	6.7	6.8	61.0	56	15	5.4	2.1	9.1	12.0	3	0.00	0.00	0.00		0.8	0.108	0.05	0.0	3.5	26	8	7.0	20
STANDARD	DEVIATION	8.4	20	25			0.4	0.4	18.1	16					1.2		0.01				0.0	0.034			1.6	5		1.5	

TABLE B - 14 Smith Lake Station SLB water quality data 1981 - 1985
(USEPA STORET No. STJOHN14)

DATE OF SAMPLE (m/d/y)	SAMPLERS	T (C)	COND. (FIELD) uhs/cm	COND. (LAB) uhs/cm	TDS mg/l	TSS mg/l	pH (FIELD)	pH (LAB)	ALK (LAB) mg/l CaCO3	HARD. (CALC. DISS.) mg/l	Ca (DISS.) mg/l	Mg (DISS.) mg/l	K mg/l	Na mg/l	Cl mg/l	SO4 mg/l	NH3-N mg/l	NO2-N mg/l	NO3-N mg/l	NO3+ NO2-N mg/l	KJELD. N (TOT) mg/l	PO4-P (TOT) mg/l	Fe (DISS.) mg/l	Mn (DISS.) mg/l	BOD mg/l	COD mg/l	C (TO OR) mg/l	O (DISS.) mg/l	COLOR PT-CO
01/06/81	METRO			115				7.2	32	37.0					5.0		0.400								5.1	18			
02/03/81	METRO			290				7.0	73	110.0					6.6		0.200		0.2						4.5	17			
03/02/81	METRO			340				8.2	94	138.0					4.0		0.200									24			
04/06/81	CITY			306	268	58.0		7.9	32	106.0					15.1		0.100		0.3						12.0	31			
05/06/81	METRO			230	192	42.0		7.6	60	70.0					11.7		0.100		0.6						9.4	33			
06/01/81	METRO			145	106	14.0		7.3	55	5.4					5.4		0.000		0.3						2.2	8			
07/06/81	METRO			200	170	12.0		7.7	79	77.0					5.2		0.200		0.2						5.0	15			
12/08/81	METRO			125	130	22.0		7.2	42	55.0					10.5		0.200		0.1						9.5				
02/03/82	METRO			170				7.2	72	70.0					8.6		0.100												
03/02/82	METRO			94				8.4	74	32.0					6.0		0.100												
04/07/82	METRO			125				7.7	54	49.0					6.9		0.000								4.3				
05/05/82	METRO			135				7.4	51	50.0					8.2		0.000								2.3				
06/03/82	METRO			180				7.8	79	72.0					7.2		0.000								2.4				
07/21/82	USGS				100				69								0.108				1.10	0.05					4.6		
08/19/82	USGS				111				87								0.110				0.80	0.05					6.4		
09/16/82	USGS				108				45								0.000				1.40	0.13					8.1		
10/12/82	USGS				110				77								0.070				1.90	0.06					7.0		
03/17/83	METRO			135				7.1	55	49.0					6.6		0.000												
06/01/83	METRO			165				7.8	74	69.0					5.8		0.100												
11/13/85	SRI	4		205	175	53.5		6.7									0.000			0.0	0.00	0.17						12.0	
12/16/85	SRI	4		187	153	7.3		6.6									0.138			0.0	1.01	0.14						6.5	
SAMPLES	ANALYZED	2	0	17	11	7	0	17	19	15	0	0	0	0	15	0	21	0	6	2	6	6	0	0	10	7	4	2	0
MEAN	VALUE	4		185	148	30.1		7.5	63	66.0					7.5		0.101		0.3	0.0	1.03	0.10			5.7	21	6.5	9.3	
MAXIMUM	VALUE	4		340	268	58.0		8.4	94	138.0					15.1		0.400		0.6	0.0	1.90	0.17			12.0	33	8.1	12.0	
MINIMUM	VALUE	4		94	100	7.3		6.6	32	5.4					4.0		0.000		0.1	0.0	0.00	0.05			2.2	8	4.6	6.5	
STANDARD	DEVIATION	0		69	49	19.8		0.5	17	32.2					2.8		0.098		0.2	0.0	0.58	0.05			3.3	8	1.3	2.7	

BLANK SPACES = NO SAMPLES; 0.0 VALUES = LESS THAN LOWER LIMIT OF DETECTION.

TABLE B - 15 Smith Lake Station SLC water quality data 1986 (USEPA STORET No. STJOHN54)

DATE OF SAMPLE (m/d/y)	SAMPLERS	T (C)	COND. (FIELD) uhs/cm	COND. (LAB) uhs/cm	TDS mg/l	TSS mg/l	pH (FIELD)	pH (LAB)	ALK (LAB) mg/l CaCO3	HARD. (CALC. DISS.) mg/l	Ca (DISS.) mg/l	Mg (DISS.) mg/l	K mg/l	Na mg/l
02/20/86	METRO	3.8	190	210			6.7	6.8	83.7	92				
05/29/86	DEQ	22.0	157	160	110	14	7.9	7.5	61.0	60	15	5.4	2.1	9.1
07/31/86	METRO	24.0		210			7.2	7.8	85.2	56				
08/28/86	METRO	23.5	205	225			7.2	7.2	112.0	89				
SAMPLES	ANALYZED	4	3	4	1	1	4	4	4	4	1	1	1	1
MEAN	VALUE	18.3	184	201	110	14	7.3	7.3	85.5	74	15	5.4	2.1	9.1
MAXIMUM	VALUE	24.0	205	225	110	14	7.9	7.8	112.0	92	15	5.4	2.1	9.1
MINIMUM	VALUE	3.8	157	160	110	14	6.7	6.8	61.0	56	15	5.4	2.1	9.1
STANDARD	DEVIATION	8.4	20	25			0.4	0.4	18.1	16				

DATE OF SAMPLE (m/d/y)	SAMPLERS	Cl mg/l	SO4 mg/l	NH3-N mg/l	NO2-N mg/l	NO3-N mg/l	NO3+ NO2-N mg/l	KJELD. N (TOT) mg/l	PO4-P (TOT) mg/l	Fe (DISS.) mg/l	Mn (DISS.) mg/l	BOD mg/l	COD mg/l	C (TO OR) mg/l	O (DISS.) mg/l	COLOR PT-CO
02/20/86	METRO	15.0		0.03	0.01	0.01			0.120			5.0	28		10.9	
05/29/86	DEQ	12.0	3					0.8	0.109	0.05	0.0	3.5	26	8	7.7	20
07/31/86	METRO	14.2		0.00	0.00	0.00			0.108			5.0	37		7.0	
08/28/86	METRO	14.9		0.03	0.00	0.00			0.190			8.0	37		7.5	
SAMPLES	ANALYZED	4	1	3	3	3	0	1	4	1	1	4	4	1	4	1
MEAN	VALUE	14.0	3	0.02	0.00	0.00		0.8	0.132	0.05	0.0	5.4	32	8	8.3	20
MAXIMUM	VALUE	15.0	3	0.03	0.01	0.01		0.8	0.190	0.05	0.0	8.0	37	8	10.9	20
MINIMUM	VALUE	12.0	3	0.00	0.00	0.00		0.8	0.108	0.05	0.0	3.5	26	8	7.0	20
STANDARD	DEVIATION	1.2		0.01				0.0	0.034			1.6	5		1.5	

BLANK SPACES = NO SAMPLES; 0.0 VALUES = LESS THAN LOWER LIMIT OF DETECTION.

TABLE B – 16 Bybee Lake Station BLA water quality data 1982 – 1986
(USEPA STORET No. STJOHN53)

DATE OF SAMPLE (m/d/y)	SAMPLERS	T (C)	COND. (FIELD) uhs/cm	COND. (LAB) uhs/cm	TDS mg/l	TSS mg/l	pH (FIELD)	pH (LAB)	ALK (LAB) mg/l CaCO3	HARD. (CALC. DISS.) mg/l	Ca (DISS.) mg/l	Mg (DISS.) mg/l	K mg/l	Na mg/l	Cl mg/l	SO4 mg/l	NH3-N mg/l	NO2-N mg/l	NO3-N mg/l	NO3+ NO2-N mg/l	KJELD. N (TOT) mg/l	PO4-P (TOT) mg/l	Fe (DISS.) mg/l	Mn (DISS.) mg/l	BOD mg/l	COD mg/l	C (TO OR) mg/l	O (DISS.) mg/l	COLOR PT-CO
07/21/82	USGS				109				65.0								0.090				1.00	0.030					3.4		
08/20/82	USGS				81				54.0								0.140				0.70	0.070					2.3		
09/16/82	USGS				166				64.0								0.012				1.50	0.100					8.2		
10/12/82	USGS				140				97.0								0.100				0.90	0.070					7.4		
11/13/85	SRI	4.0		195	160	13.5		6.8									0.350			0.00	3.80	0.000						12.6	
12/16/85	SRI	2.0		192	152	9.6		6.3									0.265			0.18	0.91	0.080						12.4	
02/20/86	METRO	3.8	190	194			7.1	7.3	77.5	79.8					9.2		0.060	0.01	0.01			0.050			3	19		11.4	
05/29/86	DEQ	23.0	142	148	113	25.0	7.9	7.3	63.0	57.0	14	5.4	2	7	7.0	4				0.03	0.90	0.149	0.08	0.0	5	23	10.0	7.8	25
07/31/86	METRO	22.0		200			6.7	7.3	85.6	57.0					10.2		0.090	0.00	0.00			0.153			5	36		6.2	
08/28/86	METRO	23.0	200	200			7.3	7.4	113.0	92.0					11.1		0.040	0.00	0.00			0.230			10			7.0	
SAMPLES	ANALYZED	6	3	6	7	3	4	6	8	4	1	1	1	1	4	1	9	3	3	3	7	10	1	1	4	3	5	6	1
MEAN	VALUE	13.0	177	188	132	16.0	7.3	7.1	77.4	71.5	14	5.4	2	7	9.4	4	0.127	0.00	0.00	0.07	1.39	0.093	0.08	0.0	6	26	6.3	9.6	25
MAXIMUM	VALUE	23.0	200	200	166	25.0	7.9	7.4	113.0	92.0	14	5.4	2	7	11.1	4	0.350	0.01	0.01	0.18	3.80	0.230	0.08	0.0	10	36	10.0	12.6	25
MINIMUM	VALUE	2.0	142	148	81	9.6	6.7	6.3	54.0	57.0	14	5.4	2	7	7.0	4	0.012	0.00	0.00	0.00	0.70	0.000	0.08	0.0	3	19	2.3	6.2	25
STANDARD	DEVIATION	9.7	25	18	29	6.5	0.4	0.4	18.7	15.1					1.5		0.104			0.08	1.01	0.064			3	7	2.9	2.6	

BLANK SPACES = NO SAMPLES; 0.0 VALUES = LESS THAN LOWER LIMIT OF DETECTION.

TABLE B - 17. Columbia Slough and Smith and Bybee Lakes fecal coliform and enterococcus bacteria density (No. Col./100 ml).

LOCATION/DATE	SAMPLERS	FECAL COLIFORM #COL/100ML	ENTERO-COCCUS #COL/100ML
COLUMBIA SLOUGH STATIONS			
CA			
11/21/84	DEQ	24000	
05/15/85	DEQ	460	
05/29/86	DEQ	93	12
C			
11/21/84	DEQ	2400	
05/15/85	DEQ	460	
11/13/85	SRI	16000	
11/14/85	SRI	9000	
12/16/85	SRI	5000	
05/29/86	DEQ	23	24
CB			
11/21/84	DEQ	2400	
05/15/85	DEQ	2400	
05/29/86	DEQ	43	16
D			
11/21/84	DEQ	4600	
05/15/85	DEQ	2400	
05/29/86	DEQ	23	4
G			
11/21/84	DEQ	30	
05/15/85	DEQ	240	
01/02/86	METRO	124	POS.
02/20/86	METRO	1400	244
05/29/86	DEQ	23	16
07/31/86	METRO	204	103
08/28/86	METRO	308	654
F			
11/21/84	DEQ	150	
05/15/85	DEQ	2400	
11/13/85	SRI	27	
11/14/85	SRI	23	
12/16/85	SRI	4	8
05/29/86	DEQ	43	28
E			
11/21/84	DEQ	2100	
05/15/85	DEQ	2400	
05/29/86	DEQ	43	24

LOCATION/DATE	SAMPLERS	FECAL COLIFORM #COL/100ML	ENTERO-COCCUS #COL/100ML
LAKE STATIONS			
BYBEE BLA			
09/10/74	USGS	640	
11/13/85	SRI	80	
12/16/85	SRI	70	
02/20/86	METRO	2	6
05/29/86	DEQ	4	4
07/31/86	METRO	256	119
08/28/86	METRO	68	106
09/27/86	SRI	110	
SMITH SLA			
11/21/84	DEQ	150	
05/15/85	DEQ	240	
01/02/86	METRO	14	POS.
02/20/86	METRO	134	482
07/31/86	METRO	64	8
08/28/86	METRO	24	161
SMITH SLB			
09/09/74	USGS	420	
11/13/85	SRI	4	
12/16/85	SRI	2	
SMITH SLC			
02/20/86	METRO	8	24
05/29/86	DEQ	4	4
07/31/86	METRO	4	3
08/28/86	METRO	140	0
09/27/86	SRI	70	

Station ID 142117.20

Station Location WILLAMETTE RIVER AT PORTLAND, OREG.

Common Quality Constituents (sampled monthly)	N	Concentration MEAN (mg/l)	STANDARD DEVIATION
Temperature (degrees C)	70	12.4	5.5
Conductivity (um/cm)	70	75.6	13.9
Turbidity (JTU)	33	7.2	4.3
pH(std units;transport as H)	70	7.2	0.5
Alkalinity as CaCO3	61	22.3	3.9
Sulfate as SO4	70	5.3	2.3
Chloride	71	4.7	1.5
Silica	71	15.1	2.2
Calcium	71	6.8	1.1
Magnesium	70	2.2	0.4
Sodium	71	4.8	1.0
Potassium	71	0.8	0.2
Dissolved Solids	69	54.2	7.4
Suspended Sediment	58	20.4	23.5
Phosphorus, total as P	71	0.09	0.03
Nitrate-Nitrite, total as N	71	0.57	0.46
Ammonia, total as N	45	0.10	0.05
Organic Carbon, total as C	43	3.1	1.0
Dissolved Oxygen	62	10.9	2.1
Fecal Coliform (col/100 ml)	45	424.0	576.0
Fecal Strep. (col/100 ml)	45	148.0	197.0
Phytoplankton (cells/ml)	45	5103.0	11180.0

TABLE B-18 Statistical summary of water quality data 1974 - 1981 from NASQAN Station 142117.20 Willamette River at Portland, Oregon (Smith and Alexander 1983)

Station ID 141289.10 — Station Location COLUMBIA RIVER AT WARRENDALE,OREG.

Common Quality Constituents (sampled monthly)	N	Concentration MEAN (mg/l)	STANDARD DEVIATION
Temperature (degrees C)	70	11.5	5.8
Conductivity (um/cm)	68	161.6	33.7
Turbidity (JTU)	35	5.8	3.6
pH(std units;transport as H)	69	7.8	0.3
Alkalinity as CaCO3	61	61.2	10.1
Sulfate as SO4	69	13.6	4.0
Chloride	68	3.4	1.1
Silica	70	9.2	2.5
Calcium	70	18.7	2.8
Magnesium	70	5.2	1.1
Sodium	70	6.4	1.6
Potassium	70	1.4	0.3
Dissolved Solids	69	95.2	16.2
Suspended Sediment	60	17.8	15.0
Phosphorus, total as P	69	0.04	0.03
Nitrate-Nitrite, total as N	67	0.25	0.58
Ammonia, total as N	46	0.04	0.03
Organic Carbon, total as C	46	3.1	1.6
Dissolved Oxygen	67	11.5	1.8
Fecal Coliform (col/100 ml)	42	5.0	7.0
Fecal Strep. (col/100 ml)	43	25.0	48.0
Phytoplankton (cells/ml)	43	5973.0	7052.0

TABLE B-19 Statistical summary of water quality data 1974 - 1981 from NASQAN Station 141289.10 Columbia River at Warrendale, Oregon (Smith and Alexander 1983)

TABLE B - 20. USEPA-listed priority pollutants detected in Columbia Slough at two locations 30 August 1982 (ODEQ 1984) (out of a total of 129 pollutants tested).

PARAMETER	STATIONS (microgram/l) Denver Ave.	Landfill Bridge (STA C)
Pesticide:		
BHC;Alpha -	0.006	0.0
+ DDE, 4,4'	0.002	0.0
Metals:		
Antimony	0.0	0.0
+ Arsenic	0.0	0.0
+ Beryllium	0.0	0.0
+ Cadmium	0.3	0.3
+ Chromium	1.4	1.4
+*Copper	5.0	9.0
+ Lead	15.6	22.8
+ Mercury	0.0	0.0
+ Nickel	29.0	11.0
Selenium	0.0	0.0
# Silver	0.0	0.0
# Thallium	0.0	0.0
+*Zinc	16.0	31.0
PCB's:		
+ PCB - 1254 (Arochlor)	0.028	0.037
Halogenated Aliphatics:		
Ethylene, Tetrachloro-	18.000	6.400
Ethylene, 1,1,2-Trichl.	4.800	3.900
Pthalate Esters:		
Phthalate, Bis (2-Ethyl-hexyl)	2.0	54.0
Phthalate, Di-N-Butyl-	0.2	0.2
Phthalate, Di-N-Octyl-	0.0	0.9
Phthalate, N-Butyl Benzyl	0.24	0.0
Polycyclic Aromatics:		
Fluroanthene	0.11	0.0

* = exceeds state water quality standards
+ = present also in sediment and crayfish tissue from station
# = found also in sediment from station

LEGEND

DATUM — ALL ELEVATIONS = USGS.

- LANDFILL DIKE
- CONTROL STRUCTURE
- TREE / SHRUB LINE-SMITH & BYBEE LAKES, SHORELINE-COLUMBIA SLOUGH
- STUDY AREA BOUNDARY / TOP OF BANK (APPROX. 30 FT.)
- APPROX. LAKE SHORE LINE (10.5 FT. CONTOUR)
- VALUES ARE MICROMHOS / Cm

Port of Portland

GRAPHIC SCALE IN FEET

500 0 500 1000 1500 2000 2500

DECEMBER, 1986

SMITH AND BYBEE LAKES

MANAGEMENT PLAN ENVIRONMENTAL STUDIES

CONDUCTANCE SURVEY; JUNE 20, 1986

SUBMITTED BY:

SENIOR PLANNER, LAND DEVELOPMENT

DRAWING NO.: RG 86-511 14/23 (C-14)

MAP C-1

D

WETLAND SEDIMENTS

FISHMAN ENVIRONMENTAL SERVICES
P.O. BOX 19023 PORTLAND, OR 97219

SMITH AND BYBEE LAKES ENVIRONMENTAL STUDIES

TECHNICAL APPENDIX D: WETLAND SEDIMENTS

Project Sponsored By:

Port of Portland

and

City of Portland, Bureau of Environmental Services

Prepared by:
Fishman Environmental Services
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NATIONAL ASSOCIATION OF ENVIRONMENTAL PROFESSIONALS
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DECEMBER, 1986

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1 BACKGROUND AND OBJECTIVES

A low-level sampling and analysis program was designed to characterize sediments in the Smith/Bybee Lakes study area by broad grain size categories. This information will provide a limited baseline for possible future investigations. Sediment data will provide insights into sediment dynamics, including sources, deposition and scouring.

Previous knowledge of the study area sediments is limited to samples collected from Columbia Slough during 1971-1973 (ODEQ 1974) and lake sediment samples collected during 1982 (Clifton 1983). The DEQ also sampled Columbia Slough sediments for toxic chemicals (priority pollutants) during 1982 as part of the Portland Area Water Quality Toxics Investigation study (ODEQ 1984).

2 METHODS

Sediment samples were collected on September 18 and October 25, 1986. Sediments were collected with a 234 sq cm (36 sq in) Ekman sampler. Samples for grain size analysis were taken from the contents of the Ekman sampler using a 3.6 cm (1.4 in) diameter plastic tube. Sediment volume in the tube was calculated, and the sample was extruded into a labeled plastic bag and frozen.

Sediment samples were thawed in the laboratory and oven-dried in pre-weighed aluminum foil dishes. Dry samples were screened, using a vibrating table, through a number 10 (2 mm or 0.08 in) and a number 200 (0.074 mm or 0.0029 in) standard sieve. Gravel consists of mineral sediments larger than 2 mm, sand is mineral sediment smaller than 2 mm and larger than 0.074 mm, clay and silt is mineral sediment smaller than 0.074 mm (Cowardin et al. 1979).

The material retained on each screen and passed through the number 200 screen was weighed. Samples containing clay/silt fractions were lightly pulverized using a mortar and pestle before screening to break up large clods formed in the drying process.

Sediment size classes were expressed as percent dry weight. Each size class was also examined using a microscope to provide a visual characterization. The total dry weight of each sample per original wet sample volume was also calculated. No attempt was made to determine organic content of the samples; drying temperatures were not high enough to volatilize these materials.

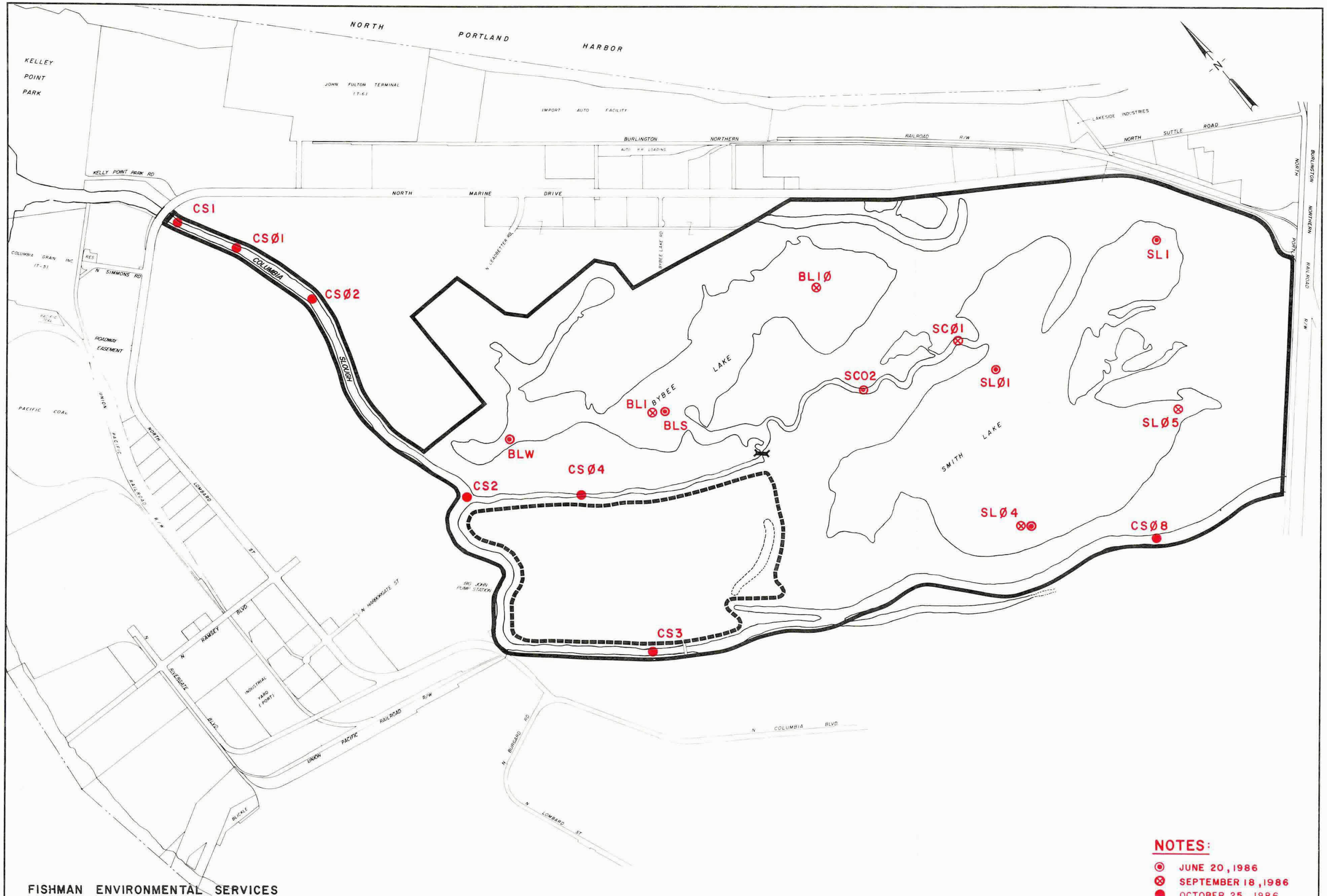
The percent volume of detritus (decaying organic material) was measured for sediment samples that were analysed for invertebrate composition and abundance. Sediments remaining in the Ekman sampler after removal of the sediment core were field screened through a 1.0 mm mesh, material remaining on the screen was preserved for lab analysis (see Fishman Environmental Services 1986). The material remaining after removal of benthic organisms, in the laboratory, was measured for volume using a water displacement method. This volume was compared to the original sample volume.

3 RESULTS

Sampling locations are shown in Figure D-1; lake stations were sampled on September 18, Columbia Slough stations were sampled on October 25. Many of the stations correspond to sampling sites for fish and water quality.

Slough samples were taken in mid-channel with the exception of October sample number 02 at station CS01. Sample 02 was taken from the mouth of a small embayment on the east shore of the slough that receives fill overflow from Rivergate Industrial District fill activity.

The results of sediment analyses are presented in Table D-1. Grain size distributions at each sampling station are indicated on Figure D-2. Columbia Slough sediment samples generally contained a high percentage (80% or greater, with one exception) of larger size grains. These larger size particles were generally sand, but often were mixed with aggregations of silt and/or organic materials. The percentage of larger particles decreased with distance from the mouth of the Slough. The weight to volume ratio of the samples also generally decreased with distance from the mouth. The samples from stations CS3 and CS08 had more plant debris than slough stations downstream. The sample from North Slough had a lower percentage of sand-size particles than Columbia Slough proper (27.7%); this sample was more similar to the uppermost Columbia Slough station (CS08) than to the lower slough stations.



NOTES:

- ◉ JUNE 20, 1986
- ⊗ SEPTEMBER 18, 1986
- ● OCTOBER 25, 1986

LEGEND

DATUM	ALL ELEVATIONS = USGS.
▬ ▬ ▬	LANDFILL DIKE
⋈	CONTROL STRUCTURE
———	TREE / SHRUB LINE - SMITH & BYBEE LAKES, SHORELINE - COLUMBIA SLOUGH
▬▬▬	STUDY AREA BOUNDARY / TOP OF BANK (APPROX. 30 FT.)

Port of Portland

GRAPHIC SCALE IN FEET

500 0 500 1000 1500 2000 2500

DECEMBER, 1986

SMITH AND BYBEE LAKES
MANAGEMENT PLAN
ENVIRONMENTAL STUDIES
SEDIMENT SAMPLING STATIONS

SENIOR PLANNER, LAND DEVELOPMENT

RG 86-511 15/23 (C-15)

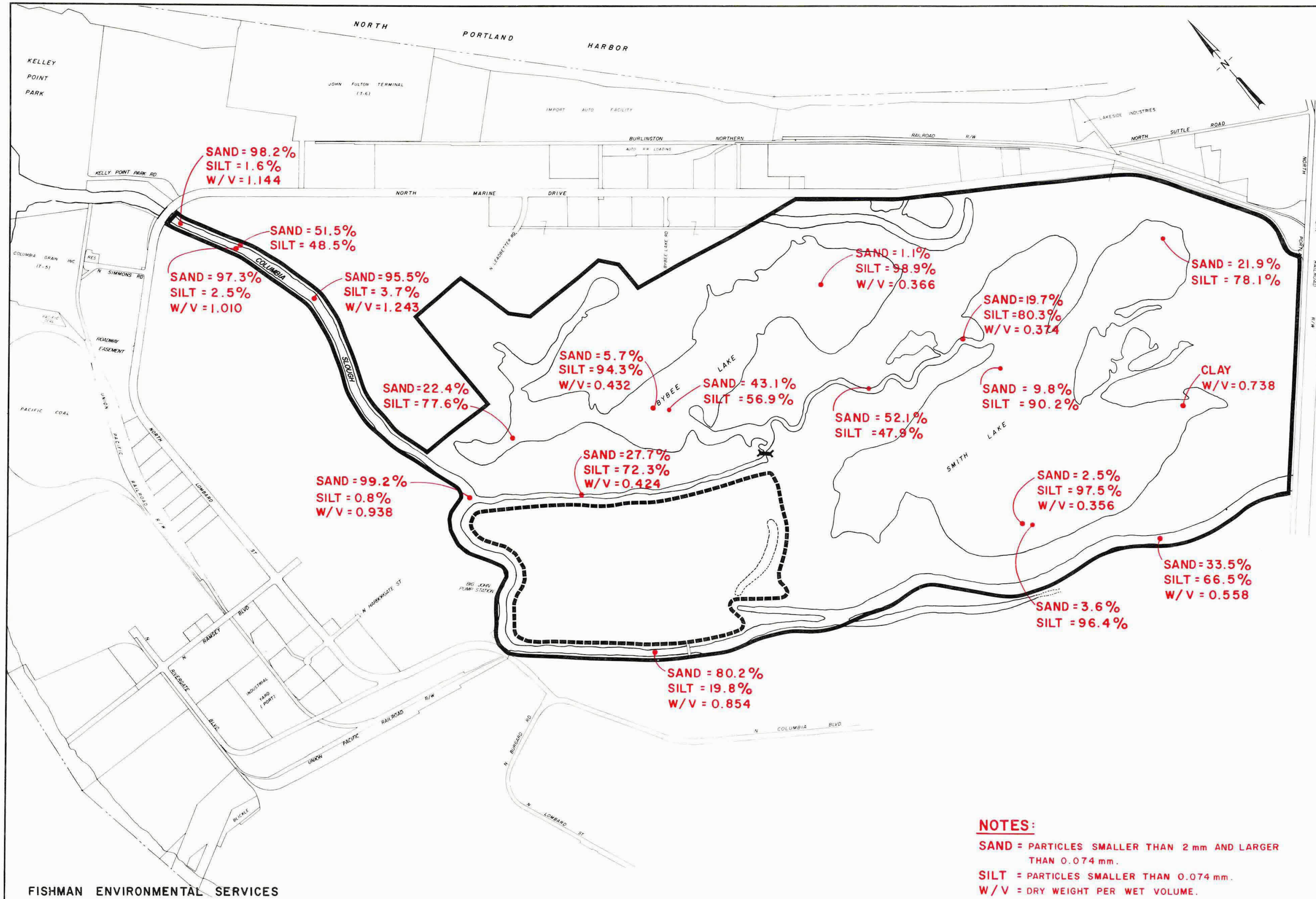
FIGURE D - 1

TABLE D-1
SEDIMENT DATA: SMITH AND BYBEE LAKES STUDY AREA

DATE	SAMPLE NUMBER	STATION	LOCATION	SAMPLE VOLUME (CC)	% DRY WT. BY PARTICLE SIZE (MM) >2	<2>0.074	<0.074	WT./VOL. (g/cc) *	REMARKS
20JUN86		SL1	SMITH L.			21.9	78.1		
20JUN86		SL04	SMITH L.			3.6	96.4		
18SEP86	1	SL04	SMITH L.	103.4	0	9.8	90.2	0.356	(a)
18SEP86	2	SL05	SMITH L.	97.0	0	42.0	58.0	0.738	(b)
20JUN86		SC02	SMITH CH.			52.1	47.9		
18SEP86	3	SC01	SMITH Ch.	103.4	0	19.7	80.3	0.374	(c)
18SEP86	4	BL10	BYBEE L.	77.6	0	1.1	98.9	0.366	(d)
18SEP86	5	BL1	BYBEE L.	77.6	0	5.7	94.3	0.432	(e)
20JUN86		BLS	BYBEE L.			43.1	56.9		
20JUN86		BLW	BYBEE L.			22.4	77.6		
25OCT86	01	CS1	COL. Sl.	43.8	0.2	98.2	1.6	1.144	(f)
25OCT86	02	CS01	COL. Sl.	N/A	0	51.5	48.5	N/A	(g)
25OCT86	03	CS01	COL. Sl.	51.9	0.2	97.3	2.5	1.010	(h)
25OCT86	04	CS02	COL. Sl.	30.5	0.8	95.5	3.7	1.243	(i)
25OCT86	05	CS2	COL. Sl.	56.0	0	99.2	0.8	0.938	(j)
25OCT86	06	CS04	NORTH Sl.	82.4	0	27.7	72.3	0.424	(k)
25OCT86	07	CS3	COL. Sl.	45.8	0	80.2	19.8	0.854	(l)
25OCT86	08	CS08	COL. Sl.	38.7	0	33.5	66.5	0.558	(m)

* Dry weight per wet volume

(a) Material >0.074mm = mix of fine light brown sand and aggregated silt particles
Material <0.074mm= gray silt
(b) Gray clay, hard lumps, very difficult to sieve.
(c) Material >0.074mm= mix of fine gray sand and particles.
Material <0.074mm= gray silt.
(d) Material >0.074mm= fine sand; material <0.074mm= gray silt.
(e) Material >0.074mm= fine sand; material <0.074mm= gray silt.
(f) Material >0.074mm= fine brown sand; material <0.074mm= superfine sand with some other material.
(g) Material >0.074mm= brown mix of fine sand and small aggregate particles.
Material <0.074mm= tan silt.
(h) Material >0.074mm= brown fine sand; material <0.074mm= superfine sand.
(i) Material >2mm= wood debris; material >0.074mm= fine sand, some plant debris.
Material <0.074mm= superfine sand.
(j) Dark brown sand with mica flecks.
(k) Material >0.074mm= gray-brown fine sand; material <0.074mm= gray-brown silt. Some plant debris.
(l) Material >0.074mm= brown fine sand, fair amount of plant debris.
Material <0.074mm= superfine sand and silt.
(m) Material >0.074mm= brown fine sand with mica flecks, plant debris, and silt particles.
Material <0.074mm= brown silt, some fine sand.



NOTES:

SAND = PARTICLES SMALLER THAN 2 mm AND LARGER THAN 0.074 mm.

SILT = PARTICLES SMALLER THAN 0.074 mm.

W/V = DRY WEIGHT PER WET VOLUME.

LEGEND

DATUM — ALL ELEVATIONS = USGS.

LANDFILL DIKE

CONTROL STRUCTURE

TREE / SHRUB LINE - SMITH & BYBEE LAKES, SHORELINE - COLUMBIA SLOUGH

STUDY AREA BOUNDARY / TOP OF BANK (APPROX. 30 FT.)

Port of Portland

GRAPHIC SCALE IN FEET

500 0 500 1000 1500 2000 2500

DECEMBER, 1986

SMITH AND BYBEE LAKES
MANAGEMENT PLAN
ENVIRONMENTAL STUDIES
SEDIMENT DISTRIBUTION

SENIOR PLANNER, LAND DEVELOPMENT

RG 86-511 16/23 (C-16)

FIGURE D - 2

Lake sediment samples were generally less sandy than slough samples (52% or less). Several of the lake samples were more than 90% silt. The samples with the highest sand content were along a line from the eastern end of Smith Lake, near Marine Drive, through Smith Channel, to the northwest corner of Bybee Lake.

The volume of benthic samples represented by detritus is presented below:

STATION NO.	% DETRITUS (volume)
CS1	0.0
CS02	5.0
CS04	2.1
CS08	11.2
SC01	1.5
BL1	1.1
BL10	0.3
SL04	0.2 - 0.4

Bottom elevations in the study area, derived from field measurements during 1986, are shown on Figure D-3. The bottom of Columbia Slough, from the landfill bridge to the mouth, is generally below sea-level, with the exception of a shoaled area just off the mouth of North Slough. The slough bottom is slightly above sea-level near the North Portland Road bridge.

The lowest measured bottom elevations in the lakes were in Smith Channel, on both sides of a sill that is a remnant of a previous dike across the channel (the remnant dike is shown as elevation 5.2 ft). Measured elevation in Smith Lake ranged from 3.7 ft MSL to 5.7 ft MSL; a shallow clay sill in the SE corner of the lake rises to 8.3 ft MSL. Smith Lake elevations are generally 4 to 5 ft MSL in the portion west of the Smith Channel entrance, and between 5 and 6 ft MSL in the eastern portion.

Measured elevations in Bybee Lake ranged from 2.8 ft MSL to 6.1 ft MSL; the highest elevations were found in the central body and NW arm of the lake. The elevations in the SE arm of the lake are between 4.0 and 4.5 ft MSL, with the exception of a high spot near the west central portion (5.3 ft on the Figure). The bottoms of the northern arms of the lake are generally higher than 5.0 ft MSL.

LEGEND

DATUM

ALL ELEVATIONS = USGS.

LANDFILL DIKE

CONTROL STRUCTURE

TREE / SHRUB LINE-SMITH & BYBEE LAKES ; SHORELINE-COLUMBIA SLOUGH

STUDY AREA BOUNDARY / TOP OF BANK (APPROX. 30 FT.)

APPROX. LAKE SHORE LINE (10.5 FT. CONTOUR)

APPROX. BOTTOM ELEVATIONS (MSL) BASED ON FIELD MEASUREMENTS

Port of Portland

GRAPHIC SCALE IN FEET

500 0 500 1000 1500 2000 2500

DECEMBER , 1986

SMITH AND BYBEE LAKES

MANAGEMENT PLAN ENVIRONMENTAL STUDIES

STUDY AREA BOTTOM ELEVATIONS

SUBMITTED BY

SENIOR PLANNER , LAND DEVELOPMENT

DRAWING NO.

RG 86-511 17/23 (C-17)

FIGURE D - 3

4 CONCLUSIONS

The sediments from Smith and Bybee Lakes are indicative of the low-energy, enriched nature of these lakes. The gray silt-size sediments reflect minimal scouring and a deposition environment influenced by organic materials. The lower stations of Columbia Slough are influenced by one or more of the following factors: (1) greater current velocities, mostly tidal; (2) deposition of sand from inflowing Willamette River water; (3) influx of sand from filling activity in the Rivergate Industrial District. The lower percentages of sand at stations upstream reflect a decreasing influence of the factor or factors listed above. The sediments from North Slough and Smith Channel indicate areas that have minimal flows, or perhaps only seasonal flows.

Data for sediment samples taken by the U.S. Geological Survey (USGS) during 1982 were presented as percent (by weight) coarser than 0.053 mm sieve size (Clifton 1983). These data are not directly comparable to the data for the 0.074 mm sieve used in the present study; however, an assumption can be made that the coarser grain sizes in both studies represent sand-size particles. Results for the top 10 cm of sediment at USGS station 2 in Smith Lake, near station SL04 in this study, had sand-size particles at 2%, by weight. Results for USGS station 3 in Bybee Lake, near station BL1 in this study, had 4% sand-size particles. The sediment at USGS station 8, near our station BL10, had 2% sand-size particles. These results are very similar to those obtained for the present study, suggesting little change over the past 4 years.

Lake and slough bottom sediment data collected by DEQ during 1971-72 are presented in Appendix D-A to this report. In Columbia Slough, from Union Pacific RR Bridge above Portland Road to the mouth, measures of organic content (volatile solids, COD, organic carbon) showed decreasing levels from the upper to lower stations. The Organic Sediment Index (OSI) values derived in the study indicated that Columbia Slough sediments were in a state of active decomposition during the sampling period. The organic nature of slough sediments was attributed to annual leaf fall and storm sewer runoff, with accumulation resulting from poor flushing in the slough. The organic nature of deeper sediments was attributed to many years of meat packing and other organic effluents discharged to the slough (these types of effluents are no longer discharged to Columbia Slough).

Data for 6 metals are also presented in the slough data table for 1972. The metals include iron (Fe),manganese (Mn), zinc (Zn), lead (Pb), chromium (Cr), and copper (Cu). Levels of iron were highest between Portland Road and the landfill and at the mouth, manganese generally increased from upper to lower stations, and zinc, lead, chromium and copper were highest between Portland Road and the landfill.

Data for stations in Smith Lake and Bybee Lake collected during the 1971 DEQ study showed lower levels than slough stations for all parameters measured except for iron and manganese.

The more recent DEQ sediment data (1982) were collected as part of a toxics screening survey designed to provide general information on the classes of compounds found in water, sediment and tissues of aquatic organisms (ODEQ 1984). Data tables from the DEQ Draft Report are included as Appendix D-B. The EPA lists 129 toxic chemicals as "priority pollutants"; 10 of these were found in sediment samples in the Portland area study. Samples from the two Columbia Slough stations (below Denver Avenue and below Landfill bridge) contained pesticides, heavy metals, PCB's, monocyclic aromatics, phthalate esters, and PAH's. [1] These slough stations were similar to other urban-industrial areas sampled in the Portland area.

No criteria presently exist relating priority pollutant levels in sediments with effects on aquatic life or human health. Research and environmental monitoring in this technical area are on-going at both the EPA and DEQ. Columbia Slough is one of several areas identified in the Portland area (Beaverton Creek and Willamette River near Doane Lake) that shows sediment contamination typical and expected in a heavily urbanized-industrialized setting.

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1. PCB's are polychlorinated biphenols, primarily used, until recently, in electrical transformers and capacitors. Monocyclic aromatics are chemicals generally used for industrial purposes. Phthalate esters are primarily used as plasticizers in the production of polyvinyl chloride. PAH's, or polycyclic aromatic hydrocarbons, are present in creosote and petroleum products, and generally result from incomplete combustion processes.

5_REFERENCES

Clifton, D.G. 1983. Water-quality data for Smith and Bybee Lakes, Portland, Oregon: June to November 1982. U.S. Geological Survey. Open-file Rept. 83-204.

Cowardin, L.M., V. Carter, F.C.Golet and E.T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. U.S. Fish & Wildlife Service. FWS/OBS-79/31.

Fishman Environmental Services. 1986. Smith and Bybee Lakes Environmental Studies. Technical Appendix F: Invertebrates. Port of Portland and City of Portland Bureau of Environmental Services.

ODEQ (Oregon Dept. of Environm. Quality) 1974. Water quality in Columbia SLough, Oregon.

_____. 1984. Oregon ambient water quality toxics data summary - 1979 to 1983. DRAFT, November, 1984.

APPENDIX D-A

SEDIMENT DATA FROM ODEQ (1974)

TABLE II

Smith and Bybee Lakes

Summarized Bottom Sediment Data

December 29, 1971

Lakes	% Total Volatile Solids	mg/kg (dry weight)										
		BOD	COD	NO_3-N	$PO_4^{\equiv}$	Fe	Mn	Zn	Pb	Cr	Cu	Hg
Smith	6.3-6.7	<3,000	53,000-56,200	47-73	1,760-1,880	37,100-41,800	653-907	144-193	<20	20-28	40-47	0.56-0.65
Bybee	6.3-6.5	<4,000	51,300-55,600	29-137	1,760-1,820	33,200-40,600	532-635	153-182	<14	23-24	33-46	0.47-0.53

TABLE 1

LOWER COLUMBIA SLOUGH

Sediment Composition, Core Samples

June 19, 1972

Sampling Description	Core Length, Inches	% VS	COD mg/kg	% Organic Carbon	Total Kjeldahl Nitrogen mg/kg	% K-N	% Organic Nitrogen	OSI	mg/kg: PO_4 as P	mg/kg: Fe	mg/kg: Mn	mg/kg: Zn	mg/kg: Pb	mg/kg: Cr	mg/kg: Cu	pH
1. Union Pacific Railroad Bridge	10															
a. Top 1"		17.7	244,300	9.2	41,000	4.1	2.9	26.7	328	31,200	312	328	164	54	53	7.7
b. Bottom 1"		15.7	203,400	7.6	32,000	3.2	2.2	16.7	377	36,100	320	448	91.5	60	62	7.6
2. North Portland Rd. Bridge	14															
a. Top 1"		12.2	112,000	4.2	30,000	3.0	1.6	6.7	404	31,600	378	353	182	63	51	7.3
b. Bottom 1"		16.1	176,000	6.6	43,000	4.3	2.3	15.2	414	38,900	420	423	147	66	65	7.7
3. Old Radio Tower	4.25															
a. Top 1"		12.6	151,300	5.7	42,000	4.2	2.2	12.5	600	45,200	597	440	295	84	80	7.2
b. Bottom 1"		8.2	70,000	2.6	20,000	2.0	1.1	2.9	215	18,500	351	363	14	77	41	7.4
4. Landfill Access Road	11															
a. Top 1"		11.9	134,000	5.0	30,000	3.0	1.1	5.5	386	43,200	694	468	159	73	86	7.2
b. Bottom 1"		9.8	55,900	2.1	8,620	0.8	0.45	0.95	328	28,400	476	153	39	33	33	7.2
5. North Slough near Head	10.5															
a. Top 1"		8.9	92,900	3.5	14,000	1.4	1.0	3.5	253	23,400	972	299	86	72	54	7.2
b. Bottom 1"		18.4	244,200	9.1	16,000	1.6	1.2	10.9	55	31,600	322	72	24	67	38	7.1
6. 1/8 Mile above Sand Plug	10.5															
a. Top 1"		7.6	72,600	2.7	12,000	1.2	1.3	3.51	355	48,300	1,090	300	51	65	56	7.2
b. Bottom 1"		7.4	81,900	3.1	22,000	2.2	1.0	3.1	181	30,300	494	295	72	80	45	7.2

Notes: mg/kg is expressed on a dry weight basis
OSI = organic sediment index

APPENDIX D-B

DATA FROM DEQ DRAFT REPORT, 1984

Table 3.1 Portland Area Water Quality Toxics Investigation Site Locations

Station Name	STORET ID	River Mile	Number of Samples +				Characteristic Land Use Influencing Site
			Water	Sed.	Fish	Cray-fish	
Willamette River above Wilsonville	09AT24	39.0	2	1	1	2	A (I,M)
Tualatin River above Gaston	09CT90	66.3				17	A,F
Tualatin River near Hillsboro (Hwy 219)	09CT40	45.0				12	A (I,M,R)
Cedar Mill Creek at 145th Ave.	09CTM4	2.6	1	1		15	R
Beaverton Creek below Tektronix	09C008	5.5	1	1		3-4	I,R
Fanno Creek near mouth	09C003	1.2	1	1		10	R
Tualatin River below Durham STP	09CT10	8.7	2	1	3**	8-10	M,R (A,I)
Deep Creek near mouth	09BTD2	0.7	1*				A,R (I)
Clackamas River above Carver	09BT15	9.2	1*				F (I,R)
Clackamas River near mouth	09BT00	0.3	2	1			R,F (A,I,
Willamette River above Sellwood Bridge	09AT17	16.6	1	1		1	I,U (R)
Willamette River at SP&S Bridge	09AT12	7.0	3				I,U
Willamette River near Doane Lake area	09AT11	7.1		1	4	7	I,U
Storm Drain near Doane Lake area	09ATS1	7.1	1				I,U
Willamette River below SP&S (east bank)	09AT10	6.8		1		18	I,U
Multnomah Channel near Rafton	09ATC4	19.0				16	I,U
Willamette River 1.5 mile above mouth	09AT02	1.5				1	I,U
Columbia Slough below Denver Ave.	09ATA6	5.7	1	1	4	1	I,S (U)
Columbia Slough below Landfill Bridge	09ATA3	4.0	1	1		11	I,S (U)

* Metals only
** Suckers substituted for carp

\+ Fish and Crayfish samples were composited at each site

Land Use Codes:
A = Agricultural
F = Forestry
I = Industrial
M = Municipal
R = Residential
S = Solid Waste/Landfill
U = Urban
() => potential secondary impacts

Table 4.2 Geographic Summary f 1982 Portland Survey

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Station Name	Pest.	Metals	PCB's	Halog. Aliph.	Ethers	Monocyclic Aromatics	Phenols & Cresols	Phthalate Esters	PAH's	Other Compounds
Willamette River above Wilsonville	- S T	W S -	- - -	W - .	- - -	- - -	- - -	W S T	- S	- - -
Tualatin River above Gaston	. . T	. . .	. . T	. . -	. . -	. . T	. . -	. . T	. . -	. . -
Tualatin River near Hillsboro (Hwy 219)	. . T	. . .	. . -	. . T	. . -	. . T	. . -	. . T	. . -	. . -
Cedar Mill Creek at 145th Ave.	- S T	W S T	- - T	- - -	- - -	- - T	- - -	W S T	- S -	- - -
Beaverton Creek below Tektronix	W S T	W S T	- - T	W - -	- - -	W - T	- - -	W S T	- S -	- - -
Fanno Creek near mouth	W S T	W S .	W - T	- - -	- - -	- - -	- - -	W S T	- S	- - -
Tualatin River below Durham STP	W S T	W S .	- S T	W - .	- - -	W - -	- - -	W S T	- S -	- - -
Clackamas River near mouth	- S .	W S .	- - .	- - .	- - .	- - .	- - .	W S .	- - .	- - .
Willamette River above Sellwood Bridge	- S -	W S .	- S -	- - .	- - -	- - -	- S -	W S T	- S -	- - -
Willamette River at SP&S Bridge	- S T	W S T	- S T	W - -	- - -	- S T	W S -	W S T	W S -	- - -
Multnomah Channel near Rafton	. . T	. . T	. . -	. . -	. . -	. . T	. . -	. . T	. . -	. . -
Willamette River 1.5 mile above mouth	. . -	. . .	. . -	. . .	. . -	. . -	. . -	. . T	. . -	. . -
Columbia Slough below Denver Ave.	W S T	W S .	W S T	W - .	- - -	W S -	- - -	W S T	W S -	- - -
Columbia Slough below Landfill Bridge	W S T	W S T	W S T	W - .	W - -	W S -	W - -	W S T	- S -	- - -

Legend:

. = no analysis of chemical group at station
\- = chemical group not detected at station

Media identified by position
W = chemical group detected in water at station (left)
S = chemical group detected in sediment at station (center)
T = chemical group detected in crayfish tissue at station (right)

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Table 4-4 Geographic Summary for 1979 - 1982 Fish Tissue Data

Station Name	As	Cd	Cr	Cu	Hg	Pb	DDD op	DDD pp	DDE op	DDE pp	DDT op	DDT pp	Aldrin	Dieldrin	Endrin	BHC a	BHC b	BHC g	Heptachlr	HexBenzen	Chlordane	PCB	Total Fish*	Total Liver*
Umpqua R @ Scottsburg	-.	-.	T.	T.	T.	-.	-.	-.	-.	T.	-.	-.	-.	-.	-.	-.	..	-.	-.	-.	-.	T.	5/21	.
Upper Coos Bay	T.	T.	T.	T.	T.	T.	T.	-.	T.	-.	-.	-.	-.	-.	-.	T.	-.	-.	-.	-.	-.	-.	9/22	.
Coos Bay @ Catching Sl	-.	T.	-.	T.	T.	-.	.-	.-	.-	.L	.-	.-	.-	.-	.-	.-	..	.-	.-	.-	.-	.-	3/6	1/15
Isthmus Slough	-.	-.	T.	T.	T.	-.	-.	-.	-.	-.	-.	-.	-.	-.	-.	-.	..	-.	-.	-.	-.	-.	3/21	.
Lower Coos Bay-Clam Area	T.	T.	T.	T.	-.	T.	-.	-.	-.	-.	-.	-.	-.	-.	-.	-.	..	-.	-.	-.	-.	-.	5/21	.
South Slough	T.	T.	T.	T.	T.	T.	T.	-.	T.	-.	-.	-.	-.	-.	-.	T.	-.	-.	-.	-.	-.	T.	10/22	.
Rogue R @ Robertson Br	-.	-.	-.	T.	T.	-.	T.	T.	T.	T.	T.	T.	-.	T.	-.	T.	T.	T.	-.	T.	-.	T.	14/22	.
Rogue R ab Agness	T-	-L	TL	TL	TL	—	—	—	—	-L	—	—	—	—	—	—	..	—	-L	—	—	-L	4/21	7/21
Illinois R @ mouth	.-	.L	.L	.L	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	..	.-	.-	.-	.-	.-	.	3/21
Rogue R @ Lobster Ck	-.	T.	-.	T.	T.	-.	.-	.-	.L	.L	.-	.-	.L	.-	.-	.-	..	.-	.-	.-	.-	.-	3/21	3/15
Dexter Reservoir	-.	-.	T.	T.	T.	-.	T.	-.	T.	T.	-.	-.	-.	T.	-.	T.	-.	-.	-.	T.	-.	T.	10/22	.
Cottage Grove Reservoir	-.	-.	T.	T.	T.	-.	-.	-.	T.	-.	-.	-.	T.	T.	-.	T.	-.	-.	-.	-.	-.	-.	7/22	.
Dorena Reservoir	-.	-.	T.	T.	T.	-.	T.	-.	T.	-.	-.	-.	T.	-.	-.	T.	-.	-.	-.	T.	-.	T.	9/22	.
Willamette R @ Springfld	T.	-.	T.	T.	T.	-.	-.	-.	-.	-.	-.	-.	-.	-.	-.	-.	..	-.	-.	-.	-.	-.	4/21	.
McKenzie R @ Coburg Br	T.	-.	T.	T.	T.	T.	—	—	TL	TL	—	T-	TL	—	—	T-	-.	—	—	—	—	TL	11/22	4/15
Fern Ridge Reservoir	-.	-.	T.	T.	T.	-.	T.	-.	T.	-.	-.	-.	T.	T.	-.	T.	-.	-.	-.	T.	-.	T.	10/22	.
Conser Slough	-.	T.	T.	T.	T.	-.	—	-L	TL	TL	TL	TL	-L	TL	—	—	—	TL	-L	TL	—	TL	12/22	11/16
Santiam R @ mouth	T.	T.	T.	T.	T.	T.	T-	T-	TL	TL	—	T-	-L	TL	—	TL	T.	T-	—	TL	—	TL	17/22	7/15
Willamette R @ Wheatland	T.	-.	T.	T.	T.	T.	—	—	TL	TL	—	—	TL	—	—	—	..	—	—	-L	—	TL	9/21	5/15
Yamhill R @ Dayton	-.	-.	T.	T.	T.	-.	T.	T.	T.	T.	T.	T.	T.	T.	-.	-.	-.	T.	T.	T.	-.	T.	15/22	.
Willamette R nr Wilsonvil	..	..	..	..	..	..	..	.L	..	.L	..	.L	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.	3/13
Hagg Lake	T.	T.	T.	T.	T.	-.	-L	T-	—	TL	—	—	—	-L	—	TL	..	—	—	-L	—	T-	9/21	5/15
Tualatin R below Durham	..	..	..	..	..	..	..	.L	..	.L	..	.L	.-	.-	.-	.-	.-	.-	.-	.-	.-	.-	.	3/13
North Fork Reservoir	T.	T.	T.	T.	T.	T.	.-	.-	.-	.L	.-	.-	.-	.-	.-	.L	..	.-	.-	.-	.-	.-	6/6	2/15
Willamette R @ SP&S Br	T.	-.	T.	T.	T.	T.	T-	TL	TL	TL	—	-L	TL	-L	—	T-	.-	—	—	-L	T-	TL	13/21	8/16
Columbia Slough @ Dump Br	T.	-.	T.	T.	T.	T.	TL	TL	TL	TL	—	-L	TL	TL	-L	T-	.-	—	—	TL	T-	TL	15/21	10/16
N Portland Harbor-Col R	-.	T.	T.	T.	T.	-.	-.	T.	T.	T.	-.	-.	-.	T.	-.	T.	-.	-.	-.	T.	-.	T.	11/22	.
Deschutes R @ mouth	T.	T.	T.	T.	T.	T.	TL	T-	TL	TL	T-	T-	—	T-	—	TL	-.	—	—	T-	T-	TL	17/22	5/15
Klamath R @ Keno	-.	T.	T.	T.	T.	T.	—	—	T-	T-	—	—	—	—	—	TL	T.	—	—	T-	—	TL	11/22	2/15

Legend:

. = no analysis of chemical group at station
– = chemical group not detected at station

* number of chemicals detected / number of chemicals analyzed

Tissue type identified by position
T = edible portion of fish tissue (left side)
L = liver sample (right side)

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Table B.1 Pesticides

Station	Date/Time	Depth	CAS # 107-02-8	CAS # 309-00-2	CAS # 319-84-6	CAS # 319-85-7	CAS # 319-86-8	CAS # 58-89-9	CAS # 57-74-9	CAS # 72-54-8	CAS # 72-55-9	CAS # 50-29-3
WATER (ug/l)												
09AT24	8/31 17:00		-	-	-	-	-	-	-	-	-	-
"	9/01 10:40		-	-	-	-	-	-	-	-	-	-
09CTM4	9/01 7:55		-	-	-	-	-	-	-	-	-	-
09C008	9/01 8:35		-	-	0.005	-	-	-	-	-	-	-
09C003	8/31 12:10		-	-	0.007	-	-	-	-	-	-	-
09CT10	8/31 13:10		-	-	0.002	-	-	-	-	-	-	-
"	9/01 9:55		-	-	-	-	-	-	-	-	-	-
09BT00	8/31 8:40		-	-	-	-	-	-	-	-	-	-
"	9/01 11:50		-	-	-	-	-	-	-	-	-	-
09AT17	8/30 15:20		-	-	-	-	-	-	-	-	-	-
09ATS1	9/01 15:45		-	-	-	-	-	-	-	-	-	-
09AT12	8/30 16:20		-	-	-	-	-	-	-	-	-	-
"	9/01 14:55		-	-	-	-	-	-	-	-	-	-
"	9/01 15:00		-	-	-	-	-	-	-	-	-	-
09ATA6	8/30 18:30		-	-	0.006	-	-	-	-	-	0.002	-
09ATA3	8/30 17:40		-	-	-	-	-	-	-	-	0.002	-
SEDIMENT (ug/kg)												
09AT24	8/31 16:30	020B	-	-	-	-	-	-	-	1	3	6
09CTM4	9/01 7:45	003B	-	-	-	-	-	-	-	3	3	-
09C008	9/01 9:00	001B	-	-	1.0	-	-	-	-	140	24	3
09C003	8/31 12:00	002B	-	-	-	-	-	-	-	2	3	6
09CT10	8/31 12:55	006B	-	-	-	-	-	-	-	4	4	-
09BT00	8/31 9:40	006B	-	-	-	-	-	-	-	-	3	-
09AT17	8/30 15:45	020B	-	-	-	-	-	-	-	1	3	-
09AT11	8/30 16:40	015B	-	-	-	-	-	-	-	613	100	2700
09AT10	8/30 16:50	020B	-	-	-	-	-	-	-	6	8	-
09ATA6	8/30 18:45	005B	-	-	-	-	-	-	-	20	17	-
09ATA3	8/30 17:50	010B	-	-	-	-	-	-	-	7	6	-
TISSUE (mg/kg)												
09AT24	7/29	Crayfish		-	-	-	-	-	-	-	0.020	-
09CT90	7/28	Crayfish	-	-	-	-	-	-	-	0.002	0.001	-
09CT40	7/28	Crayfish	-	-	-	-	-	-	-	-	0.004	-
09CTM4	7/28	Crayfish	-	-	-	-	-	-	-	0.002	0.003	-
09C003	7/29	Crayfish	-	-	-	-	-	-	-	-	0.001	-
09CT10	7/29	Crayfish	-	-	-	-	-	-	-	-	0.004	-
09AT17	7/30	Crayfish		-	-	-	-	-	-	-	-	-
09AT11	7/27	Crayfish	-	-	-	-	-	-	-	0.002	0.003	-
09AT10	7/27	Crayfish	-	-	-	-	-	-	-	0.002	0.003	0.002
09ATC4	7/27	Crayfish	-	-	-	-	-	-	-	-	0.003	-
09AT02	7/28	Crayfish		-	-	-	-	-	-	-	-	-
09ATA6	7/27	Crayfish		-	-	-	-	-	-	-	0.024	-
09ATA3	7/27	Crayfish		-	-	-	-	-	-	0.002	0.004	-

Compounds:

107-02-8 Acrolein
309-00-2 Aldrin
319-84-6 BHC, Alpha-
319-85-7 BHC, Beta-
319-86-8 BHC, Delta-
58-89-9 BHC, Gamma-
57-74-9 Chlordane
72-54-8 DDD, 4,4'-
72-55-9 DDE, 4,4'-
50-29-3 DDT, 4,4'-

Codes:

- : analyzed, but not detected
* : detected, but below limit of quantification
blank : insufficient sample, not analyzed

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Table 9.2 .esu.ilts

Station	Date/Time	Depth	CAS # 60-57-1	CAS # 1031-07-8	CAS # 959-98-8	CAS # 33213-659	CAS 72-.-8	CAS # 7421-93-4	CAS # 76-44-8	CAS # 1024-57-3	CAS # 78-59-1	CAS # 1746-01
WATER (ug/l)												
09AT24	8/31 17:00		-	-	-	-	-	-	-	-	-	-
"	9/01 10:40		-	-	-	-	-	-	-	-	-	-
09CTM4	9/01 7:55		-	-	-	-	-	-	-	-	-	-
09C008	9/01 8:35		-	-	-	-	-	-	-	-	-	-
09C003	8/31 12:10		-	-	-	-	-	-	-	-	-	-
09CT10	8/31 13:10		-	-	-	-	-	-	-	-	-	-
"	9/01 9:55		-	-	-	-	-	-	-	-	-	-
09BT00	8/31 8:40		-	-	-	-	-	-	-	-	-	-
"	9/01 11:50		-	-	-	-	-	-	-	-	-	-
09AT17	8/30 15:20		-	-	-	-	-	-	-	-	-	-
09ATS1	9/01 15:45		-	-	-	-	-	-	-	-	-	-
09AT12	8/30 16:20		-	-	-	-	-	-	-	-	-	-
"	9/01 14:55		-	-	-	-	-	-	-	-	-	-
"	9/01 15:00		-	-	-	-	-	-	-	-	-	-
◀ 09ATA6	8/30 18:30		-	-	-	-	-	-	-	-	-	-
09ATA3	8/30 17:40		-	-	-	-	-	-	-	-	-	-
SEDIMENT (ug/kg)												
09AT24	8/31 16:30	020B	-	-	-	-	-	-	-	-	-	-
09CTM4	9/01 7:45	003B	-	-	-	-	-	-	-	-	-	-
09C008	9/01 9:00	001B	-	-	-	-	-	-	-	-	-	-
09C003	8/31 12:00	002B	-	-	-	-	-	-	-	-	-	-
09CT10	8/31 12:55	006B	-	-	-	-	-	-	-	-	-	-
09BT00	8/31 9:40	006B	-	-	-	-	-	-	-	-	3	-
09AT17	8/30 15:45	020B	-	-	-	-	-	-	-	-	-	-
09AT11	8/30 16:40	015B	-	-	-	-	-	-	-	-	-	-
09AT10	8/30 16:50	020B	-	-	-	-	-	-	-	-	-	-
◀ 09ATA6	8/30 18:45	005B	-	-	-	-	-	-	-	-	-	-
09ATA3	8/30 17:50	010B	-	-	-	-	-	-	-	-	3	-
TISSUE (mg/kg)												
09AT24	7/29	Crayfish	-	-	-	-	-	-	-	-	-	
09CT90	7/28	Crayfish	-	-	-	-	-	-	-	-	-	
09CT40	7/28	Crayfish	-	-	-	-	-	-	-	-	-	
09CTM4	7/28	Crayfish	-	-	-	-	-	-	-	-	-	
09C003	7/29	Crayfish	-	-	-	-	-	-	-	-	-	
09CT10	7/29	Crayfish	-	-	-	-	-	-	-	-	-	
09AT17	7/30	Crayfish	-	-	-	-	-	-	-	-	-	
09AT11	7/27	Crayfish	-	-	-	-	-	-	-	-	-	
09AT10	7/27	Crayfish	-	-	-	-	-	-	-	-	-	
09ATC4	7/27	Crayfish	-	-	-	-	-	-	-	-	-	
09AT02	7/28	Crayfish	-	-	-	-	-	-	-	-	-	
◀ 09ATA6	7/27	Crayfish	-	-	-	-	-	-	-	-	-	
09ATA3	7/27	Crayfish	-	-	-	-	-	-	-	-	-	

Compounds:

60-57-1 Dieldrin
1031-07-8 Endosulfan Sulfate
959-98-8 Endosulfan, Alpha-
33213-65-9 Endosulfan, Beta-
72-20-8 Endrin
7421-93-4 Endrin Aldehyde
76-44-8 Heptachlor
1024-57-3 Heptachlor Epoxide
78-59-1 Isophorone
1746-01-6 2,4,7,8-Tetrachlorodibenzo-P-Dioxin (

Codes:

- : analyzed, but not detected
* : detected, but below limit of quantification
blank : insufficient sample, not analyzed

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Table B.3 Pesticides and Metals

Location	Date/Time	Depth	CAS # 8001-35-2	CAS # 7440-36-0	CAS # 7400-38-2	CAS # 7440-41-7	CAS # 7400-43-9	CAS # 7400-47-3	CAS # 7400-50-8	CAS # 7439-92-1	CAS # 7439-97-6	CAS # 7440-02-0
WATER (ug/l)												
09AT24	8/31 17:00		-	-	-	-	0.2	-	1.0	-	-	5
*	9/01 10:40		-	-	-	-	0.2	-	2.0	-	-	5
09CTM4	9/01 7:55		-	-	-	-	-	0.7	6.0	6.0	-	29
09C008	9/01 8:35		-	-	-	-	0.6	5.6	15.0	13.2	-	20
09C003	8/31 12:10		-	-	-	-	0.5	0.7	4.5	13.2	-	17
09CT10	8/31 13:10		-	-	-	-	0.5	-	3.0	1.8	-	17
*	9/01 9:55		-	-	-	-	0.2	-	3.0	1.8	-	10
09BTD2	8/31 10:05			-	-	-	0.2	-	1.5	-	-	5
09BT15	8/31 10:30			-	-	-	-	-	1.5	-	-	7
09BT00	8/31 8:40		-	-	-	-	0.6	-	1.0	1.2	-	6
*	9/01 11:50		-	-	-	-	0.8	-	2.0	-	-	15
09AT17	8/30 15:20		-	-	-	-	-	-	1.0	1.8	-	3
09ATS1	9/01 15:45		-	-	12.5	1.1	0.2	0.7	8.0	14.4	-	83
09AT12	8/30 16:20		-	-	-	-	-	-	5.5	1.8	-	8
*	9/01 14:55		-	-	-	-	0.6	-	3.0	-	-	23
*	9/01 15:00		-	-	-	-	0.2	-	2.0	-	-	14
09ATA6	8/30 18:30		-	-	-	-	0.3	1.4	5.0	15.6	-	29
09ATA3	8/30 17:40		-	-	-	-	0.3	1.4	9.0	22.8	-	11

Location	Date/Time	Depth	CAS # 8001-35-2	CAS # 7440-36-0	CAS # 7400-38-2	CAS # 7440-41-7	CAS # 7400-43-9	CAS # 7400-47-3	CAS # 7400-50-8	CAS # 7439-92-1	CAS # 7439-97-6	CAS # 7440-02-0
SEDIMENT (ug/kg)												
09AT24	8/31 16:30	020B	-	-	4000	740	200	19600	28000	1200	30	31000
09CTM4	9/01 7:45	003B	-	-	3500	710	100	15400	19000	5000	40	15000
09C008	9/01 9:00	001B	-	-	4800	620	1900	49700	115000	113000	160	52000
09C003	8/31 12:00	002B	-	-	3300	580	-	14000	14000	3400	10	16000
09CT10	8/31 12:55	006B	-	-	3300	680	200	44800	20000	210000	30	17000
09BT00	8/31 9:40	006B	-	-	2300	490	-	10500	14500	700	30	15000
09AT17	8/30 15:45	020B	-	-	4000	700	-	20300	27500	1300	30	26000
09AT11	8/30 16:40	015B	-	-	5000	730	-	18900	26500	3200	80	22000
09AT10	8/30 16:50	020B	-	-	5500	990	100	26600	54000	2800	70	33000
09ATA6	8/30 18:45	005B	-	-	9000	1180	1500	44100	82000	204000	120	32000
09ATA3	8/30 17:50	010B	-	-	4800	660	1500	16100	27500	5500	80	15000

Location	Date/Time	Depth	CAS # 8001-35-2	CAS # 7440-36-0	CAS # 7400-38-2	CAS # 7440-41-7	CAS # 7400-43-9	CAS # 7400-47-3	CAS # 7400-50-8	CAS # 7439-92-1	CAS # 7439-97-6	CAS # 7440-02-0
TISSUE (mg/kg)												
09AT24	7/29	Crayfish	-									
09CT90	7/28	Crayfish	-									
09CT40	7/28	Crayfish	-									
09CTM4	7/28	Crayfish	-	-	0.11	0.008	0.035	0.47	14.5	0.92		0.07
09C003	7/29	Crayfish	-									
09CT10	7/29	Crayfish	-									
09AT17	7/30	Crayfish	-									
09AT11	7/27	Crayfish	-									
09AT10	7/27	Crayfish	-	-	0.12	0.005	-	0.29	26.5	0.68		0.50
09ATC4	7/27	Crayfish	-	-	0.12	0.002	0.004	0.20	21.7	0.59		-
09AT02	7/28	Crayfish	-									
09ATA6	7/27	Crayfish	-									
09ATA3	7/27	Crayfish	-	-	0.14	0.005	-	0.23	13.5	0.55		-

Compounds:

8001-35-2	Toxaphene
7440-36-0	Antimony
7440-38-2	Arsenic
7440-41-7	Beryllium
7440-43-9	Cadmium
7440-47-3	Chromium
7440-50-8	Copper
7439-92-1	Lead
7439-97-6	Mercury
7440-02-0	Nickel

Codes:

- : analyzed, but not detected
* : detected, but below limit of quantification
blank : insufficient sample, not analyzed

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Table B.4 Metals and PCB's

Station	Date/Time	Depth	CAS # 7782-49-2	CAS # 7440-22-4	CAS # 7440-28-0	CAS # 7440-66-6	CAS # 91-58-7	CAS # 12674-112	CAS # 11104-282	CAS # 11141-165	CAS # 53469-219	CAS # 12672-296
WATER (ug/l)												
09AT24	8/31 17:00		-	-	-	-	-	-	-	-	-	-
"	9/01 10:40		-	-	-	-	-	-	-	-	-	-
09CTM4	9/01 7:55		-	-	-	6	-	-	-	-	-	-
09C008	9/01 8:35		-	-	-	29	-	-	-	-	-	-
09C003	8/31 12:10		-	-	-	15	-	-	-	-	-	-
09CT10	8/31 13:10		-	-	-	-	-	-	-	-	-	-
"	9/01 9:55		-	-	-	-	-	-	-	-	-	-
09BTD2	8/31 10:05		-	-	-	-						
09BT15	8/31 10:30		-	-	-	-						
09BT00	8/31 8:40		-	-	-	-	-	-	-	-	-	-
"	9/01 11:50		-	-	-	-	-	-	-	-	-	-
09AT17	8/30 15:20		-	-	-	-	-	-	-	-	-	-
09ATS1	9/01 15:45		-	-	-	-	-	-	-	-	-	-
09AT12	8/30 16:20		-	-	-	-	-	-	-	-	-	-
"	9/01 14:55		-	-	-	-	-	-	-	-	-	-
"	9/01 15:00		-	-	-	4	-	-	-	-	-	-
09ATA6	8/30 18:30		-	-	-	16	-	-	-	-	-	-
09ATA3	8/30 17:40		-	-	-	31	-	-	-	-	-	-
SEDIMENT (ug/kg)												
09AT24	8/31 16:30	020B	-	130	-	79000	-	-	-	-	-	-
09CTM4	9/01 7:45	003B	-	60	100	109000	-	-	-	-	-	-
09C008	9/01 9:00	001B	-	1600	-	237000	-	-	-	-	-	-
09C003	8/31 12:00	002B	-	180	-	145000	-	-	-	-	-	-
09CT10	8/31 12:55	006B	-	130	-	121000	-	-	-	-	-	-
09BT00	8/31 9:40	006B	-	50	100	45000	-	-	-	-	-	-
09AT17	8/30 15:45	020B	-	130	-	85000	-	-	-	-	-	-
09AT11	8/30 16:40	015B	-	150	100	147000	-	-	-	-	-	-
09AT10	8/30 16:50	020B	-	230	-	126000	-	-	-	-	-	-
09ATA6	8/30 18:45	005B	-	1200	100	357000	-	-	-	-	-	-
09ATA3	8/30 17:50	010B	-	200	-	148000	-	-	-	-	-	-
TISSUE (mg/kg)												
09AT24	7/29	Crayfish					-	-	-	-	-	-
09CT90	7/28	Crayfish					-	-	-	-	-	-
09CT40	7/28	Crayfish					-	-	-	-	-	-
09CTM4	7/28	Crayfish	0.08	0.085	-	15.70	-	-	-	-	-	-
09C003	7/29	Crayfish					-	-	-	-	-	-
09CT10	7/29	Crayfish					-	-	-	-	-	-
09AT17	7/30	Crayfish					-	-	-	-	-	-
09AT11	7/27	Crayfish					-	-	-	-	-	-
09AT10	7/27	Crayfish	0.03	-	-	17.10	-	-	-	-	-	-
09ATC4	7/27	Crayfish	0.04	-	-	17.00	-	-	-	-	-	-
09AT02	7/28	Crayfish					-	-	-	-	-	-
09ATA6	7/27	Crayfish					-	-	-	-	-	-
09ATA3	7/27	Crayfish	0.05	0.032	-	17.50	-	-	-	-	-	-

Compounds:

7782-49-2 Selenium
7440-22-4 Silver
7440-28-0 Thallium
7440-66-6 Zinc
91-58-7 Napthalene, 2-Chloro-

12674-11-2 PCB-1016 (Arochlor 1016)
11104-28-2 PCB-1221 (Arochlor 1221)
11141-16-5 PCB-1232 (Arochlor 1232)
53469-21-9 PCB-1242 (Arochlor 1242)
12672-29-6 PCB-1248 (Arochlor 1248)

Codes:

- : analyzed, but not detected
* : detected, but below limit of quantification
blank : insufficient sample, not analyzed

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Table B.5 PCB's and Halogenated Aliphatics

Station	Date/Time	Depth	CAS # 11097-691	CAS # 11096-825	CAS # 87-68-3	CAS # 77-47-4	CAS # 71-55-6	CAS # 79-34-5	CAS # 79-00-5	CAS # 75-34-3	CAS # 107-06-2	CAS # 75-00-3
WATER (ug/l)												
09AT24	8/31 17:)		-	-	-	-	-	-	-	-	-	-
"	9/01 10:10		-	-	-	-	-	-	-	-	-	-
09CTM4	9/01 7:55		-	-	-	-	-	-	-	-	-	-
09C008	9/01 8:35		-	-	-	-	1.200	-	-	-	-	-
09C003	8/31 12:10		0.020	-	-	-	-	-	-	-	-	-
09CT10	8/31 13:10		-	-	-	-	-	-	-	-	-	-
"	9/01 9:55		-	-	-	-	-	-	-	-	-	-
09BT00	8/31 8:40		-	-	-	-	-	-	-	-	-	-
"	9/01 11:50		-	-	-	-	-	-	-	-	-	-
09AT17	8/30 15:20		-	-	-	-	-	-	-	-	-	-
09ATS1	9/01 15:45		0.085	-	-	-	-	-	-	-	-	-
09AT12	8/30 16:20		-	-	-	-	-	-	-	-	-	-
"	9/01 14:55		-	-	-	-	-	-	-	-	-	-
"	9/01 15:00		-	-	-	-	-	-	-	-	-	-
09ATA6	8/30 18:30		0.028	-	-	-	*	-	-	-	-	-
09ATA3	8/30 17:40		0.037	-	-	-	*	-	-	-	-	-
SEDIMENT (ug/kg)												
09AT24	8/31 16:30	020B	28.00	-	-	-	-	-	-	-	-	-
09CTM4	9/01 7:45	003B	-	-	-	-	-	-	-	-	-	-
09C008	9/01 9:00	001B	-	-	-	-	-	-	-	-	-	-
09C003	8/31 12:00	002B	-	-	-	-	-	-	-	-	-	-
09CT10	8/31 12:55	006B	64.00	-	-	-	-	-	-	-	-	-
09BT00	8/31 9:40	006B	-	-	-	-	-	-	-	-	-	-
09AT17	8/30 15:45	020B	15.00	-	-	-	-	-	-	-	-	-
09AT11	8/30 16:40	015B	314.00	-	-	-	-	-	-	-	-	-
09AT10	8/30 16:50	020B	76.00	-	-	-	-	-	-	-	-	-
09ATA6	8/30 18:45	005B	115.00	-	-	-	-	-	-	-	-	-
09ATA3	8/30 17:50	010B	57.00	-	-	-	-	-	-	-	-	-
TISSUE (mg/kg)												
09AT24	7/29	Crayfish	-	-	-	-						
09CT90	7/28	Crayfish	0.055	-	-	-	-	-	-	-	-	-
09CT40	7/28	Crayfish	-	-	-	-	-	-	-	-	-	-
09CTM4	7/28	Crayfish	0.021	-	-	-	-	-	-	-	-	-
09C003	7/29	Crayfish	0.025	-	-	-	-	-	-	-	-	-
09CT10	7/29	Crayfish	0.102	-	-	-	-	-	-	-	-	-
09AT17	7/30	Crayfish	-	-	-	-						
09AT11	7/27	Crayfish	0.058	-	-	-	-	-	-	-	-	-
"	7/28	Crayfish			-	-						
09AT10	7/27	Crayfish	-	-	-	-	-	-	-	-	-	-
09ATC4	7/27	Crayfish	-	-	-	-	-	-	-	-	-	-
09AT02	7/28	Crayfish	-	-	-	-						
09ATA6	7/27	Crayfish	0.187	-	-	-						
09ATA3	7/27	Crayfish	0.016	-	-	-						

Compounds:

11097-69-1 PCB-1254 (Arochlor 1254)
11096-82-5 PCB-1260 (Arochlor 1260)
87-68-3 Butadiene, Hexachloro-
77-47-4 Cyclopentadiene, Hexachloro-
71-55-6 Ethane, 1,1,1-Trichloro-
79-34-5 Ethane, 1,1,2,2-Tetrachloro-
79-00-5 Ethane, 1,1,2-Trichloro-
75-34-3 Ethane, 1,1-Dichloro-
107-06-2 Ethane, 1,2-Dichloro-
75-00-3 Ethane, Chloro-

Codes:

- : analyzed, but not detected
* : detected, but below limit of quantification
blank : insufficient sample, not analyzed

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Table B.6 Hal·gen ·· Aliphatics

Station	Date/Time	Depth	CAS # 67-72-1	CAS # 75-35-4	CAS # 75-01-4	CAS # 127-18-4	CAS # 156-60-5	CAS # 79-01-6	CAS # 74-83-9	CAS # 74-87-3	CAS # 124-48-1	CAS # 75-09-2
WATER (ug/l)												
09AT24	8/31 17:00		-	-	-	-	-	-	-	-	-	-
"	9/01 10:40		-	-	-	-	-	*	-	-	-	-
09CTM4	9/01 7:55		-	-	-	-	-	-	-	-	-	-
09C008	9/01 8:35		-	-	-	-	39.000	36.000	-	-	-	-
09C003	8/31 12:10		-	-	-	-	-	*	-	-	-	-
09CT10	8/31 13:10		-	-	-	*	-	-	-	-	-	-
"	9/01 9:55		-	-	-	-	-	*	-	-	-	-
09BT00	8/31 8:40		-	-	-	-	-	-	-	-	-	-
"	9/01 11:50		-	-	-	-	-	-	-	-	-	-
09AT17	8/30 15:20		-	-	-	-	-	-	-	-	-	-
09ATS1	9/01 15:45		-	-	-	-	-	-	-	-	-	3.800
09AT12	8/30 16:20		-	-	-	-	-	*	-	-	-	-
"	9/01 14:55		-	-	-	-	-	*	-	-	-	-
"	9/01 15:00		-	-	-	-	-	*	-	-	-	-
09ATA6	8/30 18:30		-	-	-	18.000	*	4.800	-	-	-	-
09ATA3	8/30 17:40		-	-	-	6.400	*	3.900	-	-	-	-
SEDIMENT (ug/kg)												
09AT24	8/31 16:30	020B	-	-	-	-	-	-	-	-	-	-
09CTM4	9/01 7:45	003B	-	-	-	-	-	-	-	-	-	-
09C008	9/01 9:00	001B	-	-	-	3.100	-	1.500	-	-	-	-
09C003	8/31 12:00	002B	-	-	-	-	-	-	-	-	-	-
09CT10	8/31 12:55	006B	-	-	-	-	-	-	-	-	-	-
09BT00	8/31 9:40	006B	-	-	-	-	-	-	-	-	-	-
09AT17	8/30 15:45	020B	-	-	-	-	-	-	-	-	-	-
09AT11	8/30 16:40	015B	-	-	-	-	-	-	-	-	-	-
09AT10	8/30 16:50	020B	-	-	-	-	-	-	-	-	-	-
09ATA6	8/30 18:45	005B	-	-	-	-	-	-	-	-	-	-
09ATA3	8/30 17:50	010B	-	-	-	-	-	-	-	-	-	-
TISSUE (mg/kg)												
09AT24	7/29	Crayfish	-									
09CT90	7/28	Crayfish	-	-	-	-	-	-	-	-	-	-
09CT40	7/28	Crayfish	-	-	-	0.050	-	-	-	-	-	-
09CTM4	7/28	Crayfish	-	-	-	-	-	-	-	-	-	-
09C003	7/29	Crayfish	-	-	-	-	-	-	-	-	-	-
09CT10	7/29	Crayfish	-	-	-	-	-	-	-	-	-	-
09AT17	7/30	Crayfish	-									
09AT11	7/27	Crayfish	-	-	-	-	-	-	-	-	-	-
"	7/28	Crayfish	-									
09AT10	7/27	Crayfish	-	-	-	-	-	-	-	-	-	-
09ATC4	7/27	Crayfish	-	-	-	-	-	-	-	-	-	-
09AT02	7/28	Crayfish	-									
09ATA6	7/27	Crayfish	-									
09ATA3	7/27	Crayfisn	-									

Compounds:

67-72-1	Ethane, Hexachloro-
75-35-4	Ethylene, 1,1-Dichloro-
75-01-4	Ethylene, Chloro-
127-18-4	Ethylene, Tetrachloro-
156-60-5	Ethylene, 1,2-Trans-Dichloro-
79-01-6	Ethylene, 1,1,2-Trichloro-
74-83-9	Methane, Bromo-
74-87-3	Methane, Chloro-
124-48-1	Methane, Chlorodibromo-
75-09-2	Methane, Dichloro-

Codes:

- : analyzed, but not detected
* : detected, but below limit of quantification
blank : insufficient sample, not analyzed

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Table B.7 Halogenated Aliphatics

Station	Date/Time	Depth	CAS # 75-27-4	CAS # 75-71-8	CAS # 56-23-5	CAS # 75-25-2	CAS # 67-66-3	CAS # 75-69-4	CAS # 78-87-5	CAS # 10061-015	CAS # 10061-026
WATER (ug/l)											
09AT24	8/31 17:00		-	-	-	-	*	-	-	-	-
•	9/01 10:40		-	-	-	-	*	-	-	-	-
09CTM4	9/01 7:55		-	-	-	-	-	-	-	-	-
09C008	9/01 8:35		-	-	-	-	*	3.2	-	-	-
09C003	8/31 12:10		-	-	-	-	-	-	-	-	-
09CT10	8/31 13:10		-	-	-	-	*	-	-	-	-
•	9/01 9:55		-	-	-	-	*	-	-	-	-
09BT00	8/31 8:40		-	-	-	-	-	-	-	-	-
•	9/01 11:50		-	-	-	-	-	-	-		
09AT17	8/30 15:20		-	-	-	-	-	-	-	-	-
09ATS1	9/01 15:45		-	-	-	-	-	-	-		
09AT12	8/30 16:20		-	-	-	-	*	-	-	-	-
•	9/01 14:55		-	-	-	-	*	-	-		
•	9/01 15:00		-	-	-	-	*	-	-		
09ATA6	8/30 18:30		-	-	-	-	*	-	-	-	-
09ATA3	8/30 17:40		-	-	-	-	*	-	-	-	-
SEDIMENT (ug/kg)											
09AT24	8/31 16:30	020B	-	-	-	-	-	-	-	-	-
09CTM4	9/01 7:45	003B	-	-	-	-	-	-	-	-	-
09C008	9/01 9:00	001B	-	-	-	-	-	-	-	-	-
09C003	8/31 12:00	002B	-	-	-	-	-	-	-	-	-
09CT10	8/31 12:55	006B	-	-	-	-	-	-	-	-	-
09BT00	8/31 9:40	006B	-	-	-	-	-	-	-	-	-
09AT17	8/30 15:45	020B	-	-	-	-	-	-	-	-	-
09AT11	8/30 16:40	015B	-	-	-	-	-	-	-	-	-
09AT10	8/30 16:50	020B	-	-	-	-	-	-	-	-	-
09ATA6	8/30 18:45	005B	-	-	-	-	-	-	-	-	-
09ATA3	8/30 17:50	010B	-	-	-	-	-	-	-	-	-
TISSUE (mg/kg)											
09CT90	7/28	Crayfish	-	-	-	-	-	-	-	-	-
09CT40	7/28	Crayfish	-	-	-	-	-	-	-		
09CTM4	7/28	Crayfish	-	-	-	-	-	-	-		
09C003	7/29	Crayfish	-	-	-	-	-	-	-	-	-
09CT10	7/29	Crayfish	-	-	-	-	-	-	-	-	-
09AT11	7/27	Crayfish	-	-	-	-	-	-	-		
09AT10	7/27	Crayfish	-	-	-	-	-	-	-		
09ATC4	7/27	Crayfish	-	-	-	-	-	-	-		

Compounds:

75-27-4 Methane, Dichlorobromo-
75-71-8 Methane, Dichlorodifluoro-
56-23-5 Methane, Tetrachloro- (Carbon Tetrachl.)
75-25-2 Methane, Tribromo- (Bromoform)
67-66-3 Methane, Trichloro- (Chloroform)
75-69-4 Methane, Trichlorofluoro-
78-87-5 Propane, 1,2-Dichloro-
10061-01-5 Propene, Cis-1,3-Dichloro-
10061-02-6 Propene, Trans-1,3-Dichloro-

Codes:

- : analyzed, but not detected
* : detected, but below limit of quantification
blank : insufficient sample, not analyzed

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Table B.8 Ethers and Monocyclic Aromatics

Station	Date/Time	Depth	CAS # 110-75-8	CAS # 101-55-3	CAS # 7005-72-3	CAS # 111-44-4	CAS # 39638-329	CAS # 542-88-1	CAS # 111-91-1	CAS # 71-43-2	CAS # 120-82-1	CAS # 95-50-1
WATER (ug/l)												
09AT24	8/31 17:00		-	-	-	-	-		-	-	-	-
"	9/01 10:40		-	-	-	-	-		-	-	-	-
09CTM4	9/01 7:55		-	-	-	-	-		-	-	-	-
09C008	9/01 8:35		-	-	-	-	-		-	-	-	*
09C003	8/31 12:10		-	-	-	-	-		-	-	-	-
09CT10	8/31 13:10		-	-	-	-	-		-	-	-	-
"	9/01 9:55		-	-	-	-	-		-	-	-	-
09BT00	8/31 8:40		-	-	-	-	-		-	-	-	-
"	9/01 11:50		-	-	-	-	-		-	-	-	-
09AT17	8/30 15:20		-	-	-	-	-		-	-	-	-
09ATS1	9/01 15:45		-	-	-	-	-		-	-	-	1.2
09AT12	8/30 16:20		-	-	-	-	-		-	-	-	-
"	9/01 14:55		-	-	-	-	-		-	-	-	-
"	9/01 15:00		-	-	-	-	-		-	-	-	-
09ATA6	8/30 18:30		-	-	-	-	-		-	-	-	-
09ATA3	8/30 17:40		-	-	-	-	*		-	-	-	-
SEDIMENT (ug/kg)												
09AT24	8/31 16:30	020B	-	-	-	-	-		-	-	-	-
09CTM4	9/01 7:45	003B	-	-	-	-	-		-	-	-	-
09C008	9/01 9:00	001B	-	-	-	-	-		-	-	-	-
09C003	8/31 12:00	002B	-	-	-	-	-		-	-	-	-
09CT10	8/31 12:55	006B	-	-	-	-	-		-	-	-	-
09BT00	8/31 9:40	006B	-	-	-	-	-		-	-	-	-
09AT17	8/30 15:45	020B	-	-	-	-	-		-	-	-	-
09AT11	8/30 16:40	015B	-	-	-	-	-		-	-	-	13.0
09AT10	8/30 16:50	020B	-	-	-	-	-		-	-	-	13.0
09ATA6	8/30 18:45	005B	-	-	-	-	-		-	-	-	-
09ATA3	8/30 17:50	010B	-	-	-	-	-		-	-	-	-
TISSUE (mg/kg)												
09AT24	7/29	Crayfish		-	-	-	-		-		-	-
09CT90	7/28	Crayfish	-	-	-	-	-		-	-	-	-
09CT40	7/28	Crayfish	-	-	-	-	-		-	-	-	-
09CTM4	7/28	Crayfish	-	-	-	-	-		-	-	-	-
09C003	7/29	Crayfish	-	-	-	-	-		-	-	-	-
09CT10	7/29	Crayfish	-	-	-	-	-		-	-	-	-
09AT17	7/30	Crayfish		-	-	-	-		-		-	-
09AT11	7/27	Crayfish	-	-	-	-	-		-	-	-	-
"	7/28	Crayfish		-	-	-	-		-		-	-
09AT10	7/27	Crayfish	-	-	-	-	-		-	-	-	-
09ATC4	7/27	Crayfish	-	-	-	-	-		-	-	-	-
09AT02	7/28	Crayfish		-	-	-	-		-		-	-
09ATA6	7/27	Crayfish		-	-	-	-		-		-	-
09ATA3	7/27	Crayfish		-	-	-	-		-		-	-

Compounds:

110-75-8	Ether, Chloroethyl Vinyl
101-55-3	Ether, 4-Bromophenyl Phenyl
7005-72-3	Ether, 4-Chlorophenyl Phenyl
111-44-4	Ether, Bis[2-Chloroethyl]
39638-32-9	Ether, Bis[2-Chloroisopropyl]-
542-88-1	Ether, Bis[Chloromethyl]-
111-91-1	Methane, Bis[2-Chloroethoxy]
71-43-2	Benzene
120-82-1	Benzene, 1,2,4-Trichloro-
95-50-1	Benzene, 1,2-Dichloro-

Codes:

- : analyzed, but not detected
* : detected, but below limit of quantification
blank : insufficient sample, not analyzed

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Table B.9 Monocyclic Aromatics

Station	Date/Time	Depth	CAS # 541-73-1	CAS # 106-46-7	CAS # 108-90-7	CAS # 100-41-4	CAS # 118-74-1	CAS # 98-95-3	CAS # 108-88-3	CAS # 121-14-2	CAS # 606-20-2	CAS # 38976-288
WATER (ug/l)												
09AT24	8/31 17:00		-	-	-	-	-	-	-	-	-	
"	9/01 10:40		-	-	-	-	-	-	-	-	-	
09CTM4	9/01 7:55		-	-	-	-	-	-	-	-	-	
09C008	9/01 8:35		-	-	-	-	-	-	-	-	-	
09C003	8/31 12:10		-	-	-	-	-	-	-	-	-	
09CT10	8/31 13:10		-	*	-	-	-	-	-	-	-	
"	9/01 9:55		-	-	-	-	-	-	-	-	-	
09BT00	8/31 8:40		-	-	-	-	-	-	-	-	-	
"	9/01 11:50		-	-	-	-	-	-	-	-	-	
09AT17	8/30 15:20		-	-	-	-	-	-	-	-	-	
09ATS1	9/01 15:45		*	1.1	9.4	-	-	-	*	-	-	
09AT12	8/30 16:20		-	-	-	-	-	-	-	-	-	
"	9/01 14:55		-	-	-	-	-	-	-	-	-	
"	9/01 15:00		-	-	-	-	-	-	-	-	-	
09ATA6	8/30 18:30		*	-	-	-	-	-	-	-	-	
09ATA3	8/30 17:40		*	-	-	-	-	-	-	-	-	
SEDIMENT (ug/kg)												
09AT24	8/31 16:30	020B	-	-	-	-	-	-	-	-	-	
09CTM4	9/01 7:45	003B	-	-	-	-	-	-	-	-	-	
09C008	9/01 9:00	001B	-	-	-	-	-	-	-	-	-	
09C003	8/31 12:00	002B	-	-	-	-	-	-	-	-	-	
09CT10	8/31 12:55	006B	-	-	-	-	-	-	-	-	-	
09BT00	8/31 9:40	006B	-	-	-	-	-	-	-	-	-	
09AT17	8/30 15:45	020B	-	-	-	-	-	-	-	-	-	
09AT11	8/30 16:40	015B	-	-	-	-	-	-	-	-	-	
09AT10	8/30 16:50	020B	-	-	-	-	-	-	-	-	-	
09ATA6	8/30 18:45	005B	-	5.0	-	-	-	-	-	-	-	
09ATA3	8/30 17:50	010B	-	*	-	-	-	-	-	-	-	
TISSUE (mg/kg)												
09AT24	7/29	Crayfish	-	-			-	-		-	-	
09CT90	7/28	Crayfish	-	-	-	-	-	-	0.03	-	-	
09CT40	7/28	Crayfish	-	-	-	-	-	-	0.02	-	-	
09CTM4	7/28	Crayfish	-	-	-	-	-	-	0.03	-	-	
09C003	7/29	Crayfish	-	-	-	-	-	-	-	-	-	
09CT10	7/29	Crayfish	-	-	-	-	-	-	-	-	-	
09AT17	7/30	Crayfish	-	-			-	-		-	-	
09AT11	7/27	Crayfish	-	-	-	-	-	-	*	-	-	
"	7/28	Crayfish	-	-			-	-		-	-	
09AT10	7/27	Crayfish	-	-	-	-	-	-	*	-	-	
09ATC4	7/27	Crayfish	-	-	-	-	-	-	*	-	0.01	
09AT02	7/28	Crayfish	-	-			-	-		-	-	
09ATA6	7/27	Crayfish	-	-			-	-		-	-	
09ATA3	7/27	Crayfish	-	-			-	-		-	-	

Compounds:

541-73-1 Benzene, 1,3-Dichloro-
106-46-7 Benzene, 1,4-Dichloro-
108-90-7 Benzene, Chloro-
100-41-4 Benzene, Ethyl-
118-74-1 Benzene, Hexachloro-
98-95-3 Benzene, Nitro-
108-88-3 Toluene
121-14-2 Toluene, 2,4-Dinitro-
606-20-2 Toluene, 2,6-Dinitro-
38976-28-8

Codes:

- : analyzed, but not detected
* : detected, but below limit of quantification
blank : insufficient sample, not analyzed

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Table B.10 Phenols and Cresols

Station	Date/Time	Depth	CAS # 59-50-7	CAS # 534-52-1	CAS # 108-95-2	CAS # 88-06-2	CAS # 120-83-2	CAS # 105-67-[illegible]	CA[illegible] [illegible]-5	CAS # 95-57-8	CAS # 88-75-5	CAS # 100-02-7
WATER (ug/l)												
09AT24	8/31 17:00		-	-	-	-	-	-	-	-	-	-
"	9/01 10:40		-	-	-	-	-	-	-	-	-	-
09CTM4	9/01 7:55		-	-	-	-	-	-	-	-	-	-
09C008	9/01 8:35		-	-	-	-	-	-	-	-	-	-
09C003	8/31 12:10		-	-	-	-	-	-	-	-	-	-
09CT10	8/31 13:10		-	-	-	-	-	-	-	-	-	-
"	9/01 9:55		-	-	-	-	-	-	-	-	-	-
09BT00	8/31 8:40		-	-	-	-	-	-	-	-	-	-
09AT17	8/30 15:20		-	-	-	-	-	-	-	-	-	-
09ATS1	9/01 15:45		-	-	-	0.7	22.0	3.3	-	0.4	-	-
09AT12	8/30 16:20		-	-	-	-	-	-	-	-	-	-
"	9/01 14:55		-	-	-	-	-	-	*	-	-	-
"	9/01 15:00		-	-	-	-	-	-	-	-	-	-
09ATA6	8/30 18:30		-	-	-	-	-	-	-	-	-	-
09ATA3	8/30 17:40		-	-	-	-	-	*	-	-	-	-
SEDIMENT (ug/kg)												
09AT24	8/31 16:30	020B	-	-	-	-	-	-	-	-	-	-
09CTM4	9/01 7:45	003B	-	-	-	-	-	-	-	-	-	-
09C008	9/01 9:00	001B	-	-	-	-	-	-	-	-	-	-
09C003	8/31 12:00	002B	-	-	-	-	-	-	-	-	-	-
09CT10	8/31 12:55	006B	-	-	-	-	-	-	-	-	-	-
09BT00	8/31 9:40	006B	-	-	-	-	-	-	-	-	-	-
09AT17	8/30 15:45	020B	-	-	20.0	-	-	-	-	-	-	-
09AT11	8/30 16:40	015B	-	-	-	130	2100	-	-	-	-	-
09AT10	8/30 16:50	020B	-	-	13.0	-	-	-	-	-	-	-
09ATA6	8/30 18:45	005B	-	-	-	-	-	-	-	-	-	-
09ATA3	8/30 17:50	010B	-	-	-	-	-	-	-	-	-	-
TISSUE (mg/kg)												
09AT24	7/29	Crayfish	-	-	-	-	-	-	-	-	-	-
09CT90	7/28	Crayfish	-	-	-	-	-	-	-	-	-	-
09CT40	7/28	Crayfish	-	-	-	-	-	-	-	-	-	-
09CTM4	7/28	Crayfish	-	-	-	-	-	-	-	-	-	-
09C003	7/29	Crayfish	-	-	-	-	-	-	-	-	-	-
09CT10	7/29	Crayfish	-	-	-					-	-	-
09AT17	7/30	Crayfish	-	-	-	-	-	-	-	-	-	-
09AT11	7/27	Crayfish	-	-	-	-	-	-	-	-	-	-
"	7/28	Crayfish	-	-	-	-	-	-	-	-	-	-
09AT10	7/27	Crayfish	-	-	-	-	-	-	-	-	-	-
09ATC4	7/27	Crayfish	-	-	-	-	-	-	-	-	-	-
09AT02	7/28	Crayfish	-	-	-	-	-	-	-	-	-	-
09ATA6	7/27	Crayfish	-	-	-	-	-	-	-	-	-	-
09ATA3	7/27	Crayfish	-	-	-	-	-	-	-	-	-	-

Compounds:

59-50-7 M-Cresol, P-Chloro-
534-52-1 O-Cresol, 4,6-Dinitro-
108-95-2 Phenol
88-06-2 Phenol, 2,4,6-Trichloro-
120-83-2 Phenol, 2,4-Dichloro-
105-67-9 Phenol, 2,4-Dimethyl-
51-28-5 Phenol, 2,4-Dinitro-
95-57-8 Phenol, 2-Chloro-
88-75-5 Phenol, 2-Nitro-
100-02-7 Phenol, 4-Nitro-

Codes:

- : analyzed, but not detected
* : detected, but below limit of quantification
blank : insufficient sample, not analyzed

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Table B.11 Phenols, Phthalate Esters and Polycyclic Aromatics

Station	Date/Time	Depth	CAS # 87-86-5	CAS # 117-81-7	CAS # 84-74-2	CAS # 117-84-0	CAS # 84-66-2	CAS # 131-11-3	CAS # 85-68-7	CAS # 83-32-9	CAS # 208-96-8	CAS # 120-12-7
WATER (ug/l)												
09AT24	8/31 17:00		-	4.7	*	2.3	-	-	-	-	-	-
"	9/01 10:40		-	2.0	*	-	-	-	-	-	-	-
09CTM4	9/01 7:55		-	1.7	0.12	-	-	-	-	-	-	-
09C008	9/01 8:35		-	0.4	*	-	-	-	-	-	-	-
09C003	8/31 12:10		-	0.4	-	-	-	-	-	-	-	-
09CT10	8/31 13:10		-	1.3	*	-	-	-	-	-	-	-
"	9/01 9:55		-	-	*	-	-	-	-	-	-	-
09BT00	8/31 8:40		-	1.5	*	0.2	-	-	-	*	-	-
"	9/01 11:50			0.14	*	-	-	-	-	-	-	-
09AT17	8/30 15:20		-	2.4	*	-	-	-	-	-	-	-
09ATS1	9/01 15:45		*	6.5	0.15	-	-	-	-	*	-	-
09AT12	8/30 16:20		-	5.6	0.2	-	-	-	-	-	-	-
"	9/01 14:55		-	1.0	*	0.13	-	-	-	-	-	-
"	9/01 15:00		-	0.3	*	-	-	-	-	-	-	-
09ATA6	8/30 18:30		-	2.0	0.2	-	*	-	0.24	-	-	-
09ATA3	8/30 17:40		-	54.0	0.2	0.9	*	-	-	-	-	-
SEDIMENT (ug/kg)												
09AT24	8/31 16:30	020B	-	-	-	18.0	-	-	46.0	-	-	13.0
09CTM4	9/01 7:45	003B	-	240	-	-	-	-	-	12.0	-	630.0
09C008	9/01 9:00	001B	-	1900	190	-	-	12.0	330.0	-	-	81.0
09C003	8/31 12:00	002B	-	160	17	-	-	-	-	-	-	-
09CT10	8/31 12:55	006B	-	950	-	-	-	-	-	-	-	25.0
09BT00	8/31 9:40	006B	-	260	68	22.0	3.0	-	-	-	-	-
09AT17	8/30 15:45	020B	-	130	70	-	3.0	-	-	-	-	22.0
09AT11	8/30 16:40	015B	-	180	40	-	-	-	-	-	17.0	290.0
09AT10	8/30 16:50	020B	-	98	70	-	4.0	-	6.0	5.0	-	100.0
09ATA6	8/30 18:45	005B	-	620	-	-	-	-	44.0	-	-	55.0
09ATA3	8/30 17:50	010B	-	160	98	-	-	-	8.0	6.0	3.0	55.0
TISSUE (mg/kg)												
09AT24	7/29	Crayfish	-	0.34	0.22	-	-	-	-	-	-	-
09CT90	7/28	Crayfish	-	0.11	-	-	-	-	-	-	-	-
09CT40	7/28	Crayfish	-	0.61	-	-	-	-	-	-	-	-
09CTM4	7/28	Crayfish	-	0.80	-	-	-	-	3.2	-	-	-
09C003	7/29	Crayfish	-	0.15	-	-	-	-	-	-	-	-
09CT10	7/29	Crayfish	-	0.10	-	-	-	-	-	-	-	-
09AT17	7/30	Crayfish	-	1.00	-	-	-	-	-	-	-	-
09AT11	7/27	Crayfish	-	0.13	-	-	-	-	-	-	-	-
"	7/28	Crayfish	-	0.13	-	-	-	-	-	-	-	-
09AT10	7/27	Crayfish	-	0.03	-	-	-	-	-	-	-	-
09ATC4	7/27	Crayfish	-	0.06	-	-	-	-	-	-	-	-
09AT02	7/28	Crayfish	-	1.50	-	-	-	-	-	-	-	-
09ATA6	7/27	Crayfish	-	0.36	-	-	-	-	4.2	-	-	-
09ATA3	7/27	Crayfish	-	0.05	-	-	-	-	-	-	-	-

Compounds:

87-86-5	Phenol, Pentachloro-
117-81-7	Phthalate, Bis[2-Ethylhexyl]
84-74-2	Phthalate, Di-N-Butyl-
117-84-0	Phthalate, Di-N-Octyl
84-66-2	Phthalate, Diethyl-
131-11-3	Phthalate, Dimethyl
85-68-7	Phthalate, N-Butyl Benzyl
83-32-9	Acenaphthene
208-96-8	Acenaphthylene
120-12-7	Anthracene

Codes:

- : analyzed, but not detected
* : detected, but below limit of quantification
blank : insufficient sample, not analyzed

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Table B.12 Polycyclic Aromatics

Station	Date/Time	Depth	CAS # 56-55-3	CAS # 53-70-3	CAS # 218-01-9	CAS # 206-44-0	CAS # 205-99-2	CAS # 207-08-9	CAS # 86-73-7	CAS # 91-20-3	CAS # 191-24-2	CAS # 85-01-8
WATER (ug/l)												
09AT24	8/31 17:00		-	-	-	-	-	-	-	-	-	-
"	9/01 10:40		-	-	-	-	-	-	-	-	-	-
09CTM4	9/01 7:55		-	-	-	-	-	-	-	-	-	-
09C008	9/01 8:35		-	-	-	-	-	-	-	-	-	-
09C003	8/31 12:10		-	-	-	-	-	-	-	-	-	-
09CT10	8/31 13:10		-	-	-	-	-	-	-	-	-	-
"	9/01 9:55		-	-	-	-	-	-	-	-	-	-
09BT00	8/31 8:40		-	-	-	-	-	-	-	-	-	-
"	9/01 11:50		-	-	-	-	-	-	-	-	-	-
09AT17	8/30 15:20		-	-	-	-	-	-	-	-	-	-
09ATS1	9/01 15:45		-	-	-	-	-	-	*	-	-	-
09AT12	8/30 16:20		-	-	-	-	-	-	-	-	-	-
"	9/01 14:55		-	-	-	*	-	-	-	-	-	-
"	9/01 15:00		-	-	-	-	-	-	-	-	-	-
09ATA6	8/30 18:30		-	-	-	0.11	-	-	-	-	-	-
09ATA3	8/30 17:40		-	-	-	-	-	-	-	-	-	-
SEDIMENT (ug/kg)												
09AT24	8/31 16:30	020B	-	-	-	9.0	-	-	-	4.0	-	13.0
09CTM4	9/01 7:45	003B	-	-	-	240.0	-	-	50.0	85.0	-	630.0
09C008	9/01 9:00	001B	-	-	-	90.0	-	-	-	6.0	-	81.0
09C003	8/31 12:00	002B	-	-	-	5.0	-	-	-	-	-	-
09CT10	8/31 12:55	006B	22.0	-	22.0	19.0	-	-	-	4.0	-	25.0
09BT00	8/31 9:40	006B	-	-	-	-	-	-	-	-	-	-
09AT17	8/30 15:45	020B	4.0	-	4.0	7.7	-	-	-	6.0	-	22.0
09AT11	8/30 16:40	015B	45.0	-	100.0	330.0	-	-	49.0	140.0	19.0	290.0
09AT10	8/30 16:50	020B	5.0	-	12.0	58.0	-	-	7.0	14.0	-	100.0
09ATA6	8/30 18:45	005B	53.0	-	53.0	66.0	-	-	-	11.0	-	55.0
09ATA3	8/30 17:50	010B	19.0	-	49.0	74.0	-	-	10.0	54.0	22.0	90.0
TISSUE (mg/kg)												
09AT24	7/29	Crayfish	-	-	-	-	-	-	-	-	-	-
09CT90	7/28	Crayfish	-	-	-	-	-	-	-	-	-	-
09CT40	7/28	Crayfish	-	-	-	-	-	-	-	-	-	-
09CTM4	7/28	Crayfish	-	-	-	-	-	-	-	-	-	-
09C003	7/29	Crayfish	-	-	-	-	-	-	-	-	-	-
09CT10	7/29	Crayfish	-	-	-	-	-	-	-	-	-	-
09AT17	7/30	Crayfish	-	-	-	-	-	-	-	-	-	-
09AT11	7/27	Crayfish	-	-	-	-		-	-	-	-	-
"	7/28	Crayfish	-	-	-	-	-	-	-	-	-	-
09AT10	7/27	Crayfish	-	-	-	-		-	-	-	-	-
09ATC4	7/27	Crayfish	-	-	-	-	-	-	-	-	-	-
09AT02	7/28	Crayfish	-	-	-	-	-	-	-	-	-	-
09ATA6	7/27	Crayfish	-	-	-	-	-	-	-	-	-	-
09ATA3	7/27	Crayfish	-	-	-	-	-	-	-	-	-	-

Compounds:

56-55-3 Anthracene, Benzo[A]-
53-70-3 Anthracene, Dibenzo[A,H]-
218-01-9 Chrysene
206-44-0 Fluoranthene
205-99-2 Fluoranthene, 3,4-Benzo-
207-08-9 Fluoranthene, Benzo[K]-
86-73-7 Fluorene
91-20-3 Napthalene
191-24-2 Perylene, Benzo[G,H,I]-
85-01-8 Phenanthrene

Codes:

- : analyzed, but not detected
* : detected, but below limit of quantification
blank : insufficient sample, not analyzed

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Table .13 Polycyclic Aromatics and Nitrosamines

Station	Date/Time	Depth	CAS # 129-00-0	CAS # 193-39-5	CAS # 50-32-	CAS # 107-13-1	CAS # 92-87-5	CAS # 91-94-1	CAS # 122-66-7	CAS # 621-64-7	CAS # 62-75-9	CAS # 86-30-6
WATER (ug/l)												
09AT24	8/31 17:00		-	-	-	-	-	-	-	-	-	-
"	9/01 10:40		-	-	-	-	-	-	-	-	-	-
09CTM4	9/01 7:55		-	-	-	-	-	-	-	-	-	-
09C008	9/01 8:35		-	-	-	-	-	-	-	-	-	-
09C003	8/31 12:10		-	-	-	-	-	-	-	-	-	-
09CT10	8/31 13:10		-	-	-	-	-	-	-	-	-	-
"	9/01 9:55		-	-	-	-	-	-	-	-	-	-
09BT00	8/31 8:40		-	-	-	-	-	-	-	-	-	-
"	9/01 11:50		-	-	-	-	-	-	-	-	-	-
09AT17	8/30 15:20		-	-	-	-	-	-	-	-	-	-
09ATS1	9/01 15:45		-	-	-	-	-	-	-	-	-	-
09AT12	8/30 16:20		-	-	-	-	-	-	-	-	-	-
"	9/01 14:55		-	-	-	-	-	-	-	-	-	-
"	9/01 15:00		-	-	-	-	-	-	-	-	-	-
09ATA6	8/30 18:30		-	-	-	-	-	-	-	-	-	-
09ATA3	8/30 17:40		-	-	-	-	-	-	-	-	-	-
SEDIMENT (ug/kg)												
09AT24	8/31 16:30	020B	15.0	-	-	-	-	-	-	-	-	-
09CTM4	9/01 7:45	003B	370.0	-	-	-	-	-	-	-	-	-
09C008	9/01 9:00	001B	300.0	-	-	-	-	-	-	-	-	-
09C003	8/31 12:00	002B	18.0	-	-	-	-	-	-	-	-	-
09CT10	8/31 12:55	006B	31.0	-	-	-	-	-	-	-	-	-
09BT00	8/31 9:40	006B	-	-	-	-	-	-	-	-	-	-
09AT17	8/30 15:45	020B	20.0	-	*	-	-	-	-	-	-	-
09AT11	8/30 16:40	015B	520.0	*	*	-	-	-	-	-	-	-
09AT10	8/30 16:50	020B	10.0	-	-	-	-	-	-	-	-	-
09ATA6	8/30 18:45	005B	110.0	-	-	-	-	-	-	-	-	-
09ATA3	8/30 17:50	010B	140.0	*	*	-	-	-	-	-	-	-
TISSUE (mg/kg)												
09AT24	7/29	Crayfish	-	-	-		-	-	-	-		-
09CT90	7/28	Crayfish	-	-	-	-	-	-	-	-		-
09CT40	7/28	Crayfish	-	-	-	-	-	-	-	-		-
09CTM4	7/28	Crayfish	-	-	-	-	-	-	-	-		-
09C003	7/29	Crayfish	-	-	-	-	-	-	-	-		-
09CT10	7/29	Crayfish	-	-	-	-	-	-	-	-		-
09AT17	7/30	Crayfish	-	-	-		-	-	-	-		-
09AT11	7/27	Crayfish	-	-	-	-	-	-		-	-	-
"	7/28	Crayfish	-	-	-		-	-	-	-		-
09AT10	7/27	Crayfish	-	-	-	-	-	-	-	-	-	-
09ATC4	7/27	Crayfish	-	-	-	-	-	-	-	-		-
09AT02	7/28	Crayfish	-	-	-		-	-	-	-		-
09ATA6	7/27	Crayfish	-	-	-		-	-	-	-		-
09ATA3	7/27	Crayfish	-	-	-		-	-	-	-		-

Compounds:

129-00-0 Pyrene
193-39-5 Pyrene, Indeno[1,2,3-C,D]-
50-32-8 Pyrene, Benzo[A]-
107-13-1 Acrylonitrile
92-87-5 Benzidine
91-94-1 Benzidine, 3,3'-Dichloro-
122-66-7 Hydrazine, 1,2-Diphenyl-
621-64-7 Nitrosamine, Di-N-Propyl-
62-75-9 Nitrosamine, Dimethyl-
86-30-6 Nitrosamine, Diphenyl-

Codes:

- : analyzed, but not detected
* : detected, but below limit of quantification
blank : insufficient sample, not analyzed

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E VEGETATION

SMITH AND BYBEE LAKES ENVIRONMENTAL STUDIES

TECHNICAL APPENDIX E: VEGETATION

Project Sponsored By:
Port of Portland
and
City of Portland Bureau of Environmental Services

Project Managed By:
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1.0 BACKGROUND AND OBJECTIVES

1.1 Background

The pressures from an urbanizing area to develop land convenient to the waterways, coupled with the lack of appreciation of Lowland vegetation, or its lower ranking vis a vis other biota, have resulted in an extensive change or loss in wetland habitat and vegetation along the lower Columbia and Willamette Rivers. Recently, the City of Portland assembled and displayed maps of the North Portland-Vancouver Washington area from 1905, 1940 and 1961 that show the profound reduction in Lowland wetlands and associated vegetation, particularly since 1940 (Portland, City of 1986). What remains of these Lowland wetlands are relicts. Remaining relicts, such as Smith and Bybee Lakes, Sturgeon and Vancouver Lakes and associated smaller lakes, have been influenced by human development and activity. Smith and Bybee Lakes, in particular, have been heavily influenced by such developments as the filling of the perimeter wetlands with dredge spoils, bisection with transmission corridors, an adjacent industrial perimeter, the St. John's Sanitary Landfill, and more recently, the water control structure at the outlet of each of the lakes (see aerial photo).

During early discussions of a water control structure at the entrance to Smith and Bybee Lakes there was some concern about the effect of the structure on wetland plants. The primary reason for approving the structure was to reduce the occurrence of avian botulism in ducks and geese using Smith Lake in late summer (U. S. Army Corps of Engineers 1982). Alterations of the environment, even in the best interest of particular wildlife, such as geese and ducks dying from avian botulism, often occur at the expense of another component of the biota, e.g. plants, that is not as highly valued by those contemplating alterations. Sponsors of the the present planning study felt that a more inclusive evaluation of the effects of this structure on plant growth was in order.

Previous studies that have characterized the Lowland vegetation at Smith and Bybee Lakes include U. S. Army Corps of Engineers (1976,1982), Ellifrit (1982), U. S. Geological Survey (1983), Lev and Jennings (1986), Johnson et al. 1985, Fishman Environmental Services (1985), and Scientific Resources, Inc. (1986a). Studies of vegetation in nearby Columbia River Lowlands include Tabor (1976) and Jones and Stokes Associates, Inc. (1977), Detrick (1980), and the U. S. Army Corps of Engineers (1985).

1.2 Objectives

The overall objective of this component of the Smith and Bybee Lakes - St. John's Landfill area planning project was to characterize the vegetation in order to better plan for and manage future wildlife and human use of the area. Specific objectives of the work were to:

1) Update existing vegetation and habitat maps of the area;

2) Characterize the microscopic plant communities, the algae, of the Columbia Slough and Lakes; and

3) Estimate the effects of increased water levels on tree species within the area, on phytoplankton (microscopic algae plant communities), and on submersed and emergent vegetation.

2.0 METHODS

2.1 Lowland Macrophytic Vegetation

2.1.1 Vegetation mapping

Recent color aerial photographs were used to discriminate and map visual differences in assemblages of vegetation in the project area. An aerial color photograph taken June 19, 1985 was enlarged to a scale of 1 in = 500 ft and developed as a transparency. This was used to trace visually different boundaries of vegetation and open water. A color-infra red aerial photograph taken September 1983, at a scale of 1 in = 500 ft, was used to better define differences in recent vegetation types within the project. Additional black and white, color and color-infra red aerial photographs were obtained from the files of the Portland District Corps of Engineers, METRO, and the U. S. Fish and Wildlife Service for years between 1936 and 1981 to provide background documentation on the area.

A 1982 composite of topographic maps that had been prepared by the Port of Portland 1969-1970 (Bach and Marlow 1982), at a scale of 1 in = 500 ft, was used to study relief within the project boundaries, generally determine lake depths, and define approximate boundaries of upland areas. A transparency was made of the topographic map to overlay color photographs and further define and suggest vegetative differences. A copy of this topographic map is provided as Appendix Map E-3.

Vegetation was mapped on the basis of the classification system of the U. S. Fish and Wildlife Service (Cowardin et al. 1979). The wetland boundary within the project area has not been specifically determined. The 16 ft elevation was used as an approximation of the upper extent of wetland on the basis of the wetland classification done by the U. S. Fish and Wildlife Service [FWS] (Ellifrit 1982; see map in the Appendix) and other work in the vicinity (e.g. Jones and Stokes Associates, Inc. 1977). FWS classifications were used for vegetation in presumably upland areas along the Columbia Slough and the the hooked-shaped slough on the northwest side of the lakes because of the lack of an empirically determined wetland boundary (see Appendix Map E-1).

The preparation of a draft wetland classification map of the area provided the basis for planning field surveys to observe what appeared to be unusual habitats, heights of trees versus shrubs (less than 20 ft tall), determine dominant species, and resolve differences between a 1982 wetland classification map of the area (Ellifrit 1982) and the draft map. Walking surveys were made of the entire perimeter of the lakes, and during each of the seasons (e.g. Scientific Resources, Inc. 1986). Various surveys were made of the lake surfaces of Bybee and Smith Lakes, also during each of the seasons, to collect and identify submersed and emergent vegetation. Information on the hydrophyte status of plants identified was obtained from Reed (1986).

Areas of the various classes of wetland and the upland areas were determined by weighing cut discrete polygons by class of a velum 1:1 copy of the final map. Weights were determined with a Mettler H35 balance, to 0.0001 gram. Five polygons of known area were averaged to determine an area:weight ratio.

Finally, a Wildlife-Fisheries Habitat map was prepared which converted information contained in the letter-number class symbols map into a map where these wetland and upland areas were visually discriminated using color, shading and screening patterns. These two maps are provided as Wetland Classification Map (Appendix Map E-1), and the Wildlife/Fisheries Map (Appendix Map E-2).

2.1.2 Water Level Changes and Vegetation

The mapping of vegetation and the determination of the 10.5 ft msl contour level provided the basic information on the extent of flooding of vegetation within project boundaries resulting from the water control structure. The top of the weir of the water control structure installed summer of 1982 is at an elevation of 10.41 ft msl (a resurvey of the structure in 1986 provided this elevation which corrects an earlier report of 11.22 ft. for the weir in Scientific Resources, Inc. 1986). During field surveys, tree species with trunks partially inundated were noted and depths of submergence of trunks of ash and willow trees were recorded.

Visits were made in August to the approximate or exact sites of 7 transects established by Ellifrit and Lightcap in 1982 (Fishman Environmental Services 1986). These transects were established to provide baseline data on plants following construction of the water control structure and before lakes had filled to the 10.41 ft msl elevation. Species-specific literature reviews were made to get information on the effects of prolonged submergence of plants or plant parts (e.g. the U. S. Fish and Wildlife Service wetland species data base and the University of Florida Aquatic Weed Program).

2.2 Lowland Drifting Algae Vegetation (Phytoplankton)

Some plants because of their diminutive size can only form background color in aquatic landscapes. These small plants, usually visible only with microscope, are collectively called algae, and function as "the grass of many waters" (Tiffany 1958). They are important as water conditioners through their production of oxygen and organic compounds, and use of carbon dioxide, and as food for small aquatic animals which in turn are food for fish and wildlife.

Surface water samples were collected for microscopic analysis in May, June and August from the Columbia Slough and Bybee and Smith Lakes. Densities were determined using Zeiss compound phase contrast microscopes at magnifications of x1000, and counts of 100 units per sample were made to characterize species and relative densities (Greeson et al. 1977). Pigment extractions for recovery of the pigment chlorophyll a were performed to characterize relative biomass of the drifting plant material (APHA 1981). Assistance with identifications of algae species was provided by J. Sweet of Aquatic Analysts who had performed previous analyses for Clifton (1983).

3.0 RESULTS

3.1 Upland Vegetative Types

3.1.1 Upland

In the following discussion, it is recommended the reader have Appendix Map E-1 visible for reference. This map was prepared to classify the various components of wetland and upland in the project area. Table 3-1 provides an overview of these components as they were classified in upland and wetland zones in 1982 and in this project 1986. "Upland" is indicated by the omega sign, and was that area above 16 ft elevation.

As noted in Table 3-1, the largest area of upland was the Landfill which was separated from the lakes and sloughs by a perimeter dike. Other upland occurred on the northwest side of the lakes which was comprised of black cottonwood forest and reed canarygrass grassland and is indicated on Map E-1 as within dotted lines. On the southwest side along N. Portland Road was upland created by filling which was being used by a trucking company. Along the southwestern side of the area bordering Columbia Slough was a narrow upland area comprised of black cottonwood forest and a variety of grasses and forbs. Three small 'islands' of upland occurred northwest of North Slough near Bybee Lake. The total upland area was 299.4 ac.

Vegetation on these 'upland' sites around the perimeter of the project area consisted of 47 tree, shrub, forb and grass species (see Appendix Table A). A total of 108 macrophyte plant species were identified from the entire project area. Since dumping at the St. John's Landfill has been an additional source of new plant introductions to this area, the relatively wide variety of species observed was not unusual.

3.2 Wetland Classes and Vegetation

Three wetland systems were defined within the project boundaries: palustrine, lacustrine and riverine. The letter-number classifiers on Appendix Map E-1 each begin with P, L or R to designate one of these three wetlands. Table 3-1 provides information on wetland systems, classes and areas of each class below two elevations (16 ft. and 10.5 ft). Palustrine wetland is what we generally associate with marsh, swamp or bog where trees, shrubs or shorter plants occur on soggy soils or in standing water. Lacustrine indicates lake wetland where there is less than 30% coverage of the surface by emergent species, the body of water is in a topographic depression, and the total area exceeds 20 acres (Cowardin et al. 1979). Riverine refers to channelled, flowing water.

3.2.1 Palustrine Wetland

The palustrine was the most complex of the three systems present, with five classes and mixtures of classes represented (Appendix Map E-1):

Table 3-1. Comparison of areas (ac) of wetland classes in the Smith and Bybee project area 1982 and 1986.

1986 UPLAND/WETLAND TYPE (USFWS classes)	TOTAL AREA (ac) (UPLAND) (>16 ft msl)	TOTAL AREA (ac) (<16 ft msl)	TOTAL INUND. AREA (ac) (<10.5 ft msl)	1982 WETLAND TYPE** (USFWS classes)	TOTAL AREA (ac)	TOTAL AREA (ac) (< 10.5 ft)
UPLAND						
Landfill	232.1					
Trucking Co.	7.1					
Forested	37.3					
Grassland	22.9					
WETLAND				WETLAND		
Palustrine:				Palustrine:		
POW		0.7	0.7	POWV	20.6	20.6
PUB3		18.0	11.4	POWZ	27.3	11.5
PAB3		13.5	——	POWM	11.0	11.0
				POW/EMZ	173.5	
PEM1		196.9	66.6	PEMY	108.1	78.9
				PEMW	83.5	1.5
				PEM/SSY	12.3	12.3
				PEM/SSW	197.3	197.3
PSS1		302.1	268.9	PSSY	205.7	175.1
PSS/FO		73.9	73.9	PSSW	32.8	15.4
PFO1		250.1	153.5	PFO/SSY	134.5	120.0
PFO/SS 1		9.6	——	PFO/SSW	39.8	
				PFOY	34.4	33.8
				PFOW	104.1	46.1
Lacustrine:						
L2EM1		312.4	312.4	PFLZ	61.5	61.5
L2UB3		198.7	198.7	PFLY	74.7	74.7
Riverine:						
R1UB3 (Col./N. Slough)		92.9	——			
TOTALS (ac)	299.4	1468.8	1086.0		1321.1	859.7

** = FROM N. ELLIFRIT, USFWS (SEE FISHMAN ENVIRONMENTAL SERVICES 1985)

PFO1 Forested Broad-leaved Deciduous
PSS1 Scrub Shrub Broad-leaved Deciduous
PEM1 Emergent Persistent
PAB3 Aquatic Bed Rooted Vascular
PUB3 Unconsolidated Bottom Mud
POW Open Water

The soils of the project area, excluding the Landfill and the filled areas at the north and northwest perimeter of the lakes are classified as Rafton and Sauvie silt loams (Green 1977). These soils are very poorly drained, and found on the broad Columbia River flood plains. Each of the soils has been classified as hydric (U. S. Soil Conservation Service 1985), and do generally support wetland vegetation. In the project area they provide the substrate for virtually all of the palustrine classes. The conservative estimate of the average high water mark for this area, 16 ft msl (Jones and Stokes, Inc. 1977), was chosen as the upper elevation of wetland habitat. As noted in the previous Section, out of the approximately 1768 ac of the project area, 17% was above the 16 ft elevation. Of the total amount of upland, the Landfill comprised 78%.

Forested Broad-leaved Deciduous (PFO1). This category includes trees greater than 20 ft in height. Generally the species forming the most extensive cover on the site was the Pacific willow (*Salix laisandra*) (see Appendix Table A for the list of species identified). On the northwest side of the project bordering the hook-shaped cutoff slough, and along Columbia Slough were mature stands of black cottonwood (*Populus trichocarpa*). Northwest of the entrance of Smith Channel (on the Bybee Lake side) were mature stands of Oregon ash (*Fraxinus latifolia*). Mature ash trees were intermingled with black cottonwood along North and Columbia Sloughs.

Extensive new growth of Oregon ash was present on the southern penninsula (designated as PEM1 because of its dominance by reed canarygrass), near the far southwestern edge of the area near the ephemeral pond (see following), on the southwestern end of the penninsula separating Smith and Bybee Lakes, and in the area immediately northwest of the water control structure near Bybee Lake. The understory of areas dominated by Oregon ash was generally reed canarygrass (*Phalaris arundinacea*), and occasionally common orchard grass (*Dactylis glomerata*). The total area classified PFO1 and PFO/SS1 was 259.7 ac (Table 3-1).

Scrub Shrub Broad-leaved Deciduous (PSS1). This category included woody plants less than 20 ft in height. Extensive stands of younger Pacific willow were at the perimeter of each of the lakes. From the lake, where they were standing in water, into the shore these plants increased in height to the category of trees, hence the frequent designation of mixtures of scrub shrub and tree willow (PSS/FO). From cross sections of plants of the scrub shrub willow fringe of each lake, the ages of the plants were 4-5 yrs. Other deciduous shrubs, none of which were dominant, were observed on the site, such as red osier dogwood (*Cornus stolonifera*), snowberry (*Symphoricarpos albus*), Himalayan blackberry (*Rubus procerus*), Scots broom (*Cytisis scoparius*), red elderberry (*Sambucus racemosa* v. *arborescens*), and Douglas' spiraea (*Spiraea douglasii*). The total area classified PSS1 was 376 ac (Table 3-1).

Emergent Persistent (PEM1). This category included plants that emerge from saturated soils or standing water and tend to have plant parts persist above ground or above water until the next growing season. One species, reed canarygrass occurred throughout the project, as understory in ash forest, and most often as grassland. Generally, reed canarygrass was the dominant or only vegetation in most of the areas designated PEM1. However, there were many unique depressions within the project boundaries that deserve special consideration. These are shown on Appendix Map E-2 as Ephemeral Ponds and Sedge Meadows. Comparison of Map E-1 with Map E-2 will show where these ponds and meadows are within the PEM1 areas.

Distinct sedge meadows composed almost entirely of Columbia sedge (Carex aperta) occurred at six locations (see Map E-2). These areas were inundated by the freshet and then eventually isolated as ponds as the water level decreased (frequently trapping numerous carp), and then eventually dried out by the end of summer. The liverwort marchantia, growing appressed to the mud, and occasionally Epilobium watsonii, occurred within these Columbia sedge meadows at the end of summer. Generally reed canarygrass occurred at the perimeter at slightly higher elevations.

The more interesting areas, from the standpoint of plant and animal diversity, were the ephemeral ponds which were observed at nine locations (Map E-2). Not all of these ponds were alike. For example, the four ponds along Marine Drive had been colonized by Eurasian water-milfoil. These ponds are discussed below under PAB3. As these ponds evaporated, mud flats were created at their perimeters which were colonized by a variety of plants in succession. Four of the five remaining ephemeral ponds (see Map E-2) progressed through the same sequence of water level changes as described for the sedge meadows. The difference in the resulting vegetation may have been due to the latter pond bottoms being at lower elevations, resulting in prolonged inundation. As these ponds evaporated the resulting mud flats were colonized by a wide variety of plants including sedges (Carex comosa, Cyperus erythrorhizos), rushes (Juncus effusus, Scirpus validus), grasses (Heleochloa alopecuroides, Echinochloa crusgali, Paspalum distichum, Holcus lanatus), forbs (Gnaphalium uliginosum, Potentilla anserina, Sagittaria latifolia and Polygonum hydropiper and P. hydropiperoides, and Bidens cernua)(see Appendix Table A for common names of these species). Stranded on the mud and floating on the surface of the remaining water were the diminutive plants Lemna minor, Spirodela polyrhiza, and the fern Azolla mexicana).

The ephemeral ponds were not only of interest for the variety and zonation of plants, but for their attractiveness to wildlife. The concentration of fish in the remaining water provided food for birds, snakes and aquatic furbearers. What happened in these remaining ephemeral ponds was presumably what happened on a larger scale on the mud flats (PFLZ and PFLY) in Bybee Lake prior to construction of the Control Structure in 1982. The single remaining ephemeral pond was the shallow borrow pit mentioned below (PUB3), which appeared to retain water longer than the other ponds and have less mud flat development.

The total area classified as PEM1 was 197 ac (Table 3-1).

Aquatic Bed Rooted Vascular (PAB3). There are three locations on the site with this designation and all are on the northwest side along Marine Drive. The most striking example of this kind of wetland is the segment of a former slough, in the shape of a hook, that was cutoff by previous filling. Like the other areas, Eurasian water-milfoil virtually covers the entire bottom of this otherwise very attractive body of water. Maximum depth of this area was approximately 6 ft. The total area of this class was 13.5 ac.

Unconsolidated Bottom Mud (PUB3). This category refers to open water areas less than 20 acres which have mud bottoms. In addition to the channel which connects Bybee and Smith Lakes, there were two other locations where this seemed the appropriate category: the large pond next to Marine Drive, which contained two or three stands of yellow water-lily and no water-milfoil, and a smaller pond south of the water control structure resulting from former use of this site as a borrow pit for constructing the structure. The total area for this class was 18.0 ac. The acreage of Smith Channel was 11.4.

Open Water (POW). Finally, two sites just southeast of the Landfill at the edge of Smith Lake were designated as open water because of their small area and unique background. These two ponds and two additional small "pot hole" ponds adjacent and southeast of them were created as mitigation. Each are less than one-half to one-third of an acre, and each contain a small island. They serve as waterfowl resting areas. According to Herb (1986) they were one of the first mitigation projects in Oregon, created as compensation for the loss of Potato and Twin Lakes that were within the proposed expansion area of the Landfill in 1979. There was no compensation required for the loss of that segment of Blind Slough within the expansion area, due to the poor quality of its water (see the associated report in this series on water quality for a characterization of that water). These ponds appear to have mud bottoms, and are edged with dense stands of reed canarygrass, which also covers the islands.

3.2.2 Lacustrine Wetland

There were two classes of Lacustrine wetland identified in the project area:

L2UB3 = Littoral Unconsolidated Mud
L2EM1 = Littoral Emergent Persistent

Smith and Bybee Lakes have been called 'lakes' for many years, and yet during late summer and early fall of most years the 'lakes' have apparently been mud flats and marsh (see Section 3.3.2). No Lacustrine wetland was identified in the fall 1982 survey by Ellifrit (1982). The lakes were designated Lacustrine systems in this project because of the increased annual average water levels, their situation in natural topographic depressions, the total acreage of open water (greater than 20 ac) in each lake, and, finally, because of their historical status as lakes (e.g. Shulters 1975, Johnson et al. 1985). Because of the relatively shallow average depth during the growing season, the lakes were classified as littoral lacustrine wetland.

Littoral Unconsolidated Bottom Mud (L2UB3). As noted in Table 3-1, the total inundated area (less than 10.5 ft msl) within the project is approximately 1086 ac, including the 11.4 ac connecting link of Smith Channel (PUB3). The 1086 Ac includes willow scrub shrub and trees standing within the inundated area. Bybee Lake has a water surface of approximately 345 ac and Smith Lake 741 ac. The estimated open water area of each of the lakes, which is designated L2UB3 (littoral unconsolidated bottom mud) was 129.5 ac (37.5%) in Bybee Lake and only 70.0 ac (9.4%) in Smith Lake. Appendix Map E-2 shows more clearly than Map E-1 the large area of inundated vegetation in Smith Lake that includes palustrine emergent (PEM1), scrub-shrub willow (PSS1) and willow forest (PFO1).

Occurring commonly within the open water areas of Bybee Lake, and in the Smith Lake end of Smith Channel were the submersed species coontail (Ceratophyllum demersum) and curly-leaved pondweed (Potamogeton crispus). Occurring also within the inundated area were the drifting, microscopic plants, algae, which are discussed in Section 3.2.

Littoral Emergent Persistent (L2EM1). The largest component of Lacustrine wetland was that area occupied by the emergent rooted macrophyte Smartweed (Polygonum coccineum v. pratincola). In Smith Lake this emergent plant occupied approximately 272.0 ac (36.7%) of the total inundated area at 10.5 ft elevation. In Bybee Lake the plant occupied approximately 40.4 ac (11.7%) of the total inundated area. Recent aerial photographs of the Lakes show the extent of Smartweed clearly, however, observations on the lake within Smartweed were that the robust plant may not in fact cover more than 30% of most of the area where it occurs. More detailed studies would be required to define its actual percent cover. For this reason, where this plant occurred was considered Lacustrine wetland. The term 'persistent' was used for Smartweed because of the persistence through winter and spring of underwater live stems and emergent and apparently dead stems. The submersed plants coontail and curly-leaved pondweed were also observed, but rarely, within L2EM1.

3.2.3 Riverine

There was one class of Riverine wetland identified within the project:

R1UB3 = Tidal Unconsolidated Mud

Tidal Unconsolidated Mud (R1UB3). Columbia Slough, including North Slough, serves as a collector of runoff from a watershed of approximately 53 sq mi that is parallel with the Columbia River and extends to Fairview. Water in the Lower Slough, that segment lying northwest of N.E. 33rd St. and extending to the Willamette River, is under tidal influence. A description of the hydrology of the Slough was reported in Technical Appendix C of this Smith and Bybee Lakes Environmental Studies (Scientific Resources, Inc. 1986b). Aside from the microscopic algae of the Slough (see Section 3.3.7), there were virtually no submersed or rooted emergent macrophytes in the 92.9 ac of the Columbia and North Slough within the project boundaries. The Slough bottom was unconsolidated mud from the Landfill east, and sand in the lower section (see Technical Appendix D, Fishman Environmental Services 1986a).

3.3 Effects of Water Control Structure On Vegetation

3.3.1 Control Structure Installations, Failures, and Repairs

A water level control structure was installed in the fall of 1982 at its present site (see Appendix Map E-1) to retain water at an elevation of 10.5 ft MSL. Water was allowed to enter the lakes but not flow back into the slough, except over the weir. The first structure failed during the winter freshet of 1982-83. Water was not retained in the lakes during the summer of 1983. The structure was repaired and retained water during the summer of 1984. Material for the dike appears to have been taken from the area immediately southeast of the dike, ere water now forms a shallow pond through much of the growing season.

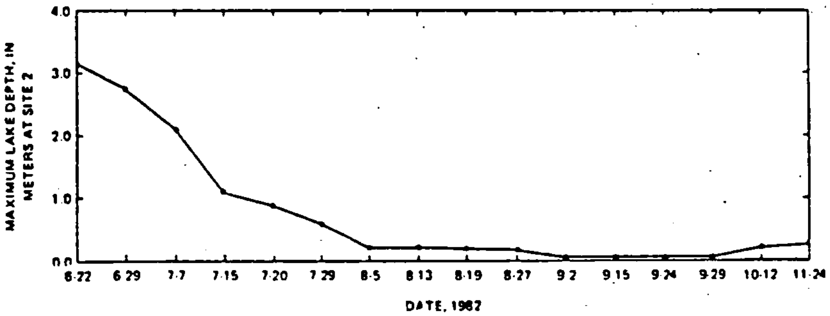
At some time in the spring of 1985, the structure was vandalized. Boards on the structure were removed and water was allowed to drain down to the level of the remaining boards (elevation unknown). The structure was repaired and water was retained during the summer and fall of 1985, though at a level lower than the 10.41 ft elevation of the top of the replacement metal weir. During the late winter freshet of February-March 1986, the top 2-3 ft of the left side of the dike across North Slough washed out. The dike was repaired during April and water was retained in the lakes at the beginning of the recession of river water levels.

The water level control structure has maintained higher seasonal water levels in the lakes through three growing seasons (1984, 1985 and 1986) since the structure was put in place. Only during the growing seasons of 1984 and 1986 was water retained at the elevation of 10.5 ft at the start of the growing season. During the 1985 growing season, water was retained at a lower, but unknown elevation at the start of river water level recession.

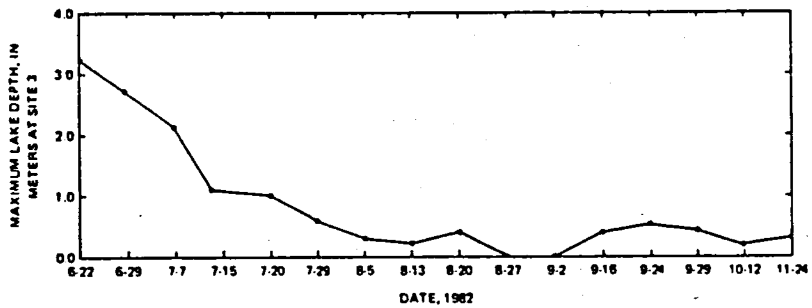
The present structure at this location was the most recent of attempts to control water levels in the lakes. An aerial photograph of the area from 1948 shows a control structure blocking off North Slough approximately 200-300 ft up-slough from its present location (USACE 1948). A photograph from 1940 shows a control structure in place at the mouth of Bybee Lake (USACE 1940). A 1956 photograph shows a control structure at the Bybee Lake end of Smith Channel and across North Slough a hundred feet up from its present location (USACE 1956). According to the U. S. Army Corps of Engineers (1982) this last structure impounding water in Bybee Lake was removed in 1967. For nearly 30 years water had been impounded in Bybee Lake. Another control structure appears in a 1972 photograph in Smith Channel a few hundred feet further in towards Smith Lake (USACE 1972). This last structure appears in a number of subsequent photographs, and a remaining underwater 'sill' is still in place.

3.3.2 Hydrologic Effects

The primary effects of the water control structure on the aquatic environment have been: 1) to retard the water level recession rate from the level of winter-spring freshet to late summer-early fall; and, 2) maintain a higher average water level in each of the basins. U. S. Geological Survey water level records from summer-fall of 1982 show a rapid drop in water levels from June highs to late summer-early fall lows (Figure 3-1). Water levels in



Smith Lake depth profile



Bybee Lake depth profile

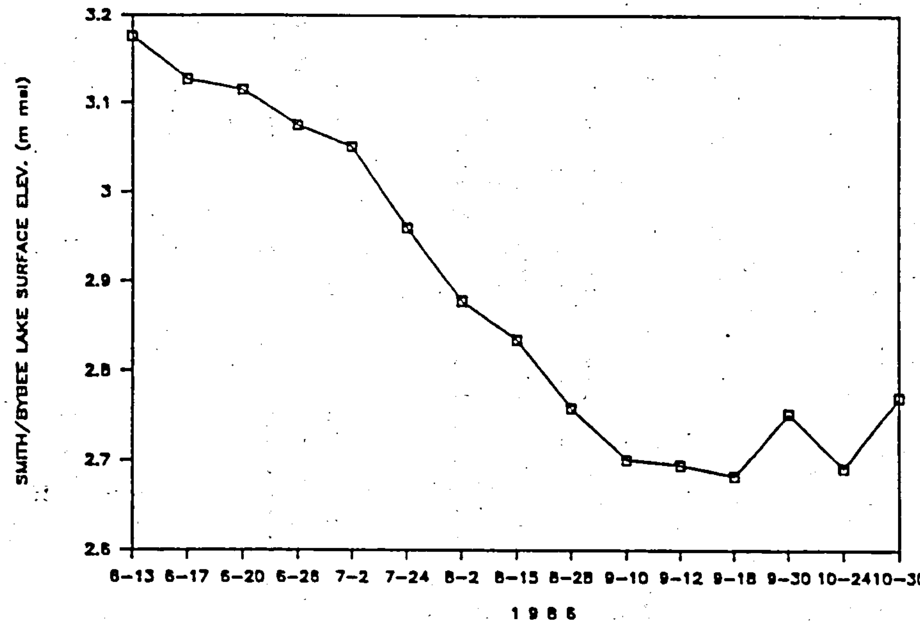


Figure 3 - 1 Comparison of summer-fall lake depth profiles 1982, 1986.
Profiles of 1982 lake depths from Clifton (1983).

1986 for this same period are quite different (Figure 3-1). The average bottom depth of Smith and Bybee Lakes is approximately 5.6 ft (msl). Records from 1982 show that each of the lakes had less than 1.0 ft of water from the first of August through November. This contrasts with data from 1986 which shows that at the lowest lake levels there was still 3.2 ft of water in the Lakes. In 1982 water levels decreased from June through August at a rate of 6.6 ft in approximately 73 days (0.09 ft/day), whereas in 1986 water levels decreased during this early summer period only 1.6 ft in approximately 88 days (0.02 ft/day), or about five times slower (Figure 3-1).

Determining what the effects of the control structure have been in fact is confounded by structure failures and changes since 1982. Recent changes in vegetation have occurred in the lakes, as documented by earlier photographs. The near absence of field data on vegetation in and around the lakes before and after the control structure was constructed, replaced and repaired has made it difficult to relate the structure to vegetation changes.

3.3.3 Reduction of Area of Exposed Lake Bottom

Of the total area of wetland on the site in 1986, approximately 1469 ac (Table 3-1), palustrine wetland comprised 864.8 ac or 58.9%. This is considerably less than the total estimated palustrine wetland in fall, 1982 of 1321.1 ac, or what was then 93.4% of the entire wetland. The loss of 136 ac of mud flats (PFLZ and PFLY) accounts for a large part of the change. These exposed areas of the lake bottom were present from mid to late summer into late fall of each year, affording habitat similar to the unique ephemeral pond areas within PEM1 mentioned above (Section 3.2.1).

The results of revisiting seven 1982 vegetation transects originally described by Ellifrit and Lightcap (Fishman Environmental Services 1985b) are presented in Appendix, Map E-4 and Table C. Missing transect markers at six of the seven sites made exact comparisons impossible, however, it was possible to describe vegetation now present at locations approximate to the original transects. Generally vegetation present above late summer lake levels was similar to what had been described previously. What had changed was the vegetation at the lower elevations of the transects that are now flooded.

<u>Transect 4</u> at the NW corner of Bybee Lake previously had a variety of typical residents of exposed lake bottoms and shallow water at the lower elevations: <u>Bidens</u>, <u>Eleocharis</u>, <u>Equisetum</u>, <u>Polygonum coccineum</u>, <u>Azolla</u>, <u>Callitriche</u>(?) and "scattered clumps of wapato further out". At the time of revisit, there was no wapato, <u>Azolla</u>, or <u>Callitriche</u>. <u>Eleocharis</u>, <u>Equisetum</u>, <u>Potentilla</u>, and <u>Carex aperta</u> were present on the narrow band of exposed shoreline. In the shallow water off the shoreline, the submersed plant <u>Potamogeton crispus</u> was common, growing amidst tree and shrub Pacific willow. Beyond the willows and into the lake the swamp smartweed, <u>Polygonum coccineum</u> was common. At <u>Transect</u> 7 at the NW corner of Smith Lake the revisit found vegetation virtually the same as that described in 1982. Apparently swamp smartweed was dominating the shallow water or exposed Smith Lake bottom preventing the growth of other plants. A revisit to the ephemeral pond at the southwest corner of Smith Lake (<u>Transects 2 and 3</u>) found a similar but slightly more diverse plant assemblage than was described in 1982. However, this ephemeral pond had probably also been affected by the control structure.

It now depended on evaporation from the lake to lower water levels sufficiently to isolate it from Smith Lake, whereas previously the lake would have been isolated earlier in the summer and would have evaporated sooner permitting the growth of more vegetation on the exposed bottom.

The effect of retarding the rate of decrease in water levels has been to expose to air less soil surface in the two basins, and to have that smaller surface area exposed later in the growing season. Germination of seeds present in the mud from the previous growing seasons will now occur later, or, for flooded soils not at all, and plants will tend to be smaller, and perhaps less productive of biomass and seed, due to their shortened growing season. With the reduction in the exposed bottom habitat there has been a reduction in the total biomass of species associated with this habitat, particularly beggarticks (Bidens cernua) and wapato (Sagittaria latifolia). In a study of exposed bottom of a side channel to the Columbia Slough adjacent to Smith Lake (Fishman Environmental Services 1985a) the end of season net primary production (NPP) for a mixed stand of beggarticks and wapato was 255.7 g/sq m/yr live dry weight, only 50% that of reed canarygrass. Unlike reed canarygrass, however, the entire standing crop of beggarticks/wapato would be removed each year during winter and be flushed downstream as detritus. With the control structure there is now less export of this detrital material from the Bybee Lake area.

Finally, the reduction in the exposed lake bottom habitat has resulted in less area for colonization by species best suited for these conditions. The table of plant species in Appendix Table A, lists five species observed in the project area that are commonly present on mud flats resulting from drawn-down lakes or ponds (see the sixth column in the table, and note plants with DRA). Added to these species are the variety of plants that were observed on mud flats of the ephemeral ponds (Section 3.2.1, PEM1).

3.3.4 Inundation of Trees and Grasslands

Perhaps the most extensive impact of controlling water at a higher elevation has been the flooding of the roots and lower trunks of the common trees Pacific willow (Salix lasiandra), and to a lesser extent Oregon ash (Fraxinus latifolia), and reed canarygrass (Phalaris arundinacea) grassland. Due to the lower water levels when the area was mapped in fall of 1982, extensive area was then designated POW/EMZ and PEM/SSW, together totalling 370.8 ac (Table 3-1). From the field notes made in 1982 (see Appendix, Map E-4 and Table C), it would appear that the same vegetation was being observed in 1982 and 1986 but that changes in water level resulted in changes in classification from Palustrine to Lacustrine. The following table summarizes what we now know about plant community coverage at the 10.5 ft inundation level:

CLASS	SMITH LAKE	BYBEE LAKE
Open Water	70.0 ac	129.5 ac
Smartweed	272.0 ac	40.4 ac
Reed Canarygrass	10.0 ac	56.0 ac
Oregon Ash	5.0 ac	5.0 ac
Pacific Willow	384.0 ac	114.1 ac
TOTAL INUNDATED AREA	741.0 ac	345.0 ac

Approximately 500 ac of the inundated area is scrub shrub or tree Pacific willow forest, followed by 66.0 ac of reed canarygrass, and 10 ac of Oregon ash.

Most of the younger Pacific willow trees that form a fringe on the inner side of the tree willows had died when inspected during the 1986 growing season with the remainder severely affected to the extent of sparse leaf production. This inner band (closest to the lake) of younger, "scrub shrub" willows is defined on Appendix Map E-1 as PSS1, and on Appendix Map E-2 as shrub willow swamp. Older willow trees standing in water from 2-3 ft deep into the shoreline had no apparent symptoms of disease or deterioration that may have been due to the inundation of roots and partial trunks. Prospects, however, are not good for these older trees. As of the writing of this report, these trees have been flooded continuously for three growing seasons since the structure was installed in 1982 (see Section 3.3.1). In order to assess impact on species previously subject to periodic flooding that are now subject to permanent flooding, literature was reviewed on each of these three species (<u>Salix laisandra</u>, <u>Fraxinus latifolia</u>, and <u>Phalaris arundinacea</u>) with respect to effects of flooding and wildlife value.

Pacific Willow (<u>Salix laisandra</u> Benth.)

Walter <u>et al</u>. (1980) report that Salix species in general are very tolerant of flooding, i.e. they can withstand flooding up to 2 or more growing seasons. Comes and McCreary (1986) conclude that the species is best planted in water depths up to 3 ft, however, germination of seed appears to be related to exposed mud bank. Whitlow and Harris (1979) state that dormant season flooding has no effect on woody plants and may be beneficial by increasing soil water through the dry season. They show <u>Salix lasiandra</u> as able to survive deep, prolonged flooding for more than one year. Wakefield (1966) produced data showing this species grew where flooding occurred an average of 135 days per year.

Washington Department of Game (WDOG) lists Salix among plants that have high wildlife value and should be planted or retained around ponds and streams. As a component of riparian zones, it is valuable for cover and nesting habitat and for shading the water (Oakley <u>et al</u>. 1985). Comes and McCreary (1986), and Tabor (1976) report that the species is used by birds and small mammals for cover and lightly browsed by deer in winter.

The literature on the Pacific willow suggests that while this species might tolerate prolonged flooding, perhaps even as long as two growing seasons, the tree will eventually die. No report was found on when death would occur, however, the young willow fringe in Smith and Bybee Lakes is virtually dead. Since some of the trees were yet sparsely leaved, the death of these trees has probably been within the past two years. The age of these younger trees, from sectioning, appeared to be around five years. While abundant snags and stumps in the shallow water of a lake may be of benefit to fishermen and birds (Gilmore 1986), it would appear that maintaining the water level at the 10.5 ft elevation through the growing season will eventually produce 500 ac of dead willow timber.

Oregon Ash (Fraxinus latifolia Benth.)

The habitat of the ash is "deep, fertile, rather moist soil" (Hitchcock et al. 1959). Franklin and Dyrness (1973) describe it as occurring on seasonally flooded and swampy habitats in interior valleys and higher elevation forests. It is common in swales and bottomlands which are flooded for much of the rainy season, and is listed in Reed (1986) as a hydrophyte (see Appendix Table A). Walter et al. (1980) report it as tolerant of flooding, and able to withstand inundation for most of one growing season. Dead trees seen in one altered wetland indicate that it is intolerant of permanent standing water (Glad, pers. com. 1986).

WDOG (1985) lists it as a desirable species in freshwater wetlands. Nothing in the literature indicated that it is a food source, but it is possible that birds or small mammals may utilize its fruits but probably not to a great degree. Primary value to wildlife and fish is its presence in riparian communities, where it provides cover, nesting habitat, and shading of adjacent water (Oakley et al. 1985). Dead trees (snags) are also valuable habitat (resting, nesting, food sources) when part of live tree/shrub community (Oakley et al. 1985).

The review of information on the ash would suggest it is less tolerant of flooding than Pacific willow. Mature ash trees which were seen within the flooded area were generally without visible signs of damage. However, an occasional ash tree standing in water was observed to be dead or had yellowing leaves in mid-summer suggesting damage. It is likely that the approximately 10 ac of ash trees standing in water will die as a result of the prolonged flooding. Ash saplings were abundant throughout the project area above the inundated areas, perhaps indicating extensive future changes in the overall appearance of vegetation around the lakes.

Reed Canarygrass (Phalaris arundinacea L.)

Reed canarygrass commonly occurs in ponds, marshes, and wet meadows. As Appendix Table A indicates, it is a facultative wetland plant, also occurring occasionally at drier locations, e.g. roadsides, upper ditch banks, etc. Whitlow and Harris (1979) cite data showing that it is tolerant of inundation. Hoffman et al. (1979) found it to be the most successful species in experimental inundation study -- it tolerated up to 9 weeks of inundation during the growing season, but the longer periods caused some die-back. Stewart and Kantrud (1972) stated that it will tolerate slightly brackish water and thrives in fresh water. Haslam (1978) says it needs to have shoots above water surface for at least part of the growing season if it is to grow well; nutrient uptake occurs most effectively when living roots are present (rhizomes and aerial parts do not function as well). SCS (undated) says it can withstand up to 70 days inundation during growing season in Oregon. Boss (1982) reported reed canarygrass tolerated annual flooding for approximately 5 months, however the net aerial primary productivity (NAPP) was less at lower and longer inundated elevations. Boss (1982) reported mean NAPP (g/sq m/yr) of 1509 (min. 215 - max 3082), apparently live and dead dry weight, for reed canarygrass. This compares with values from the Smith and Bybee Lake area of 827 and 1236 g/sq m/yr (Fishman Environmental Services 1985a) and 1351 g/sq m/yr (Scientific Resources, Inc. (1986).

Landin (1978) noted the seeds are good wildlife food source. Comes et al. (1981) consider it less desirable as wildlife food than Agrostis alba and Festuca rubra. On summer-dry sites, small birds and mammals are commonly seen and small mammal runs are common at ground level (Fishman Environmental Services 1985a). Sampling of reed canarygrass stands along the Lower Columbia River, reported by Tabor (1976) indicated consistent use by 3-5 species of small mammals, particularly in stands not grazed by cattle where there were logs and other debris for small mammal cover. The presence of marsh hawks, red-tailed hawks, and owls in the Smith and Bybee Lake area may be at least partially related to the reed canarygrass habitat as a productive food source.

The literature indicated reed canarygrass has a wide range, including most of the U. S. except extreme southeast; British Isles, Eurasia; probably native to most mid-latitude, low to moderate elevation parts of northern hemisphere, although Hitchcock et al. (1969) indicate it is native to Eurasia. Other references e.g. Hitchcock et al.(1969) indicate that it was introduced to agricultural areas as a constituent of pasture grasses for wet meadows, but there is no evidence that it was not present in the United States before European settlement. Hitchcock says it is a constituent of lowland hay from Montana to Wisconsin. The U. S. Army Corps of Engineers Environmental Laboratory (1978) shows it as a dominant or associated species in typical riparian and lacustrine marshes and freshwater riparian swamps in Pacific Northwest. For lack of information to the contrary it would appear reed canarygrass is a native plant.

At various locations at the perimeter of summer water levels around each of the lakes, reed canarygrass was found in shallow water behind the flooded Pacific willow trees. At many locations the tops of the grass had been cropped by waterfowl (or deer?). Whether the grass will persist at these locations cannot be predicted from the literature review. As small mammal habitat, the approximately 66 ac of flooded grassland is at least no longer available.

3.3.5 Habitat For Submersed and Emergent Macrophytes

There are three submersed plant species (curly leaved pondweed, coontail and Eurasian water-milfoil) and one emergent species (swamp smartweed) that appear to have optimum habitat for growth as a result of the water control structure. Information on each of these species was reviewed as the basis for an assessment of future growth in the lakes vis a vis human use of the area.

The submersed plants curly leaf pondweed (Potamogeton crispus) and coontail (Ceratophyllum demersum) are now common in Bybee Lake and also occur in Smith Lake. These plants would not have grown in Bybee Lake under the previous water regimes where the lake would virtually dry up during late summer and fall. In a similar manner, Eurasian water-milfoil (Myriophyllum spicatum) now grows in the isolated hook-shaped segment of a former slough north of Bybee and Smith Lake because water is trapped in this slough segment which would otherwise have drained down and dried up in late summer. Each of these three submersed species has the potential to become nuisance plants (Warrington 1980). Water in each of the lakes is rich in plant nutrients (see Technical Appendix C: Water Quality, in this series on Smith and Bybee Lakes) as are sediments, and densities of coontail and curly leaf pondweed can be expected to increase in Bybee Lake and Smith Lake where habitat is still available. Water-milfoil has achieved nuisance growth conditions in the isolated hook-shaped slough with respect to use of that slough for small boats. With stable water conditions in Bybee and Smith Lakes, this plant, which has been a nuisance in nearby lakes (e.g. Blue Lake; see Geiger, Foster and Mulvihill 1983), can be expected to spread to Bybee Lake where more habitat is available.

The emergent plant swamp smartweed (Polygonum coccineum) was mapped as established on approximately 312 ac of the inundated area, and most of this in Smith Lake. As noted in an earlier report (Scientific Resources, Inc. 1986), the submerged stems of this plant are nearly leafless, and of similar diameter throughout. The plant proliferates by branching at nodes that occur at frequent intervals along the stem, thus forming an underwater lattice. In spring branches emerge from the water, and leaf out, to a height of 3-4 ft. These tops are killed by winter low temperatures, but the lattice below the surface lives and overwinters. The cover of this plant varies within Smith Lake from around 80% cover in the southwest region of the lake to less than 30% in the region of the lake extending from the Landfill to the southeast. Swamp smartweed has established itself at many locations in Bybee Lake, though its cover where it is established is less than in Smith Lake. Estimates of end of season net primary production for swamp smartweed were 1004.9 $g/m^2/yr$, as compared with 1350.6 $g/m^2/yr$ for reed canarygrass, and 842.9 $g/m^2/yr$ for Columbia sedge (Scientific Resources, Inc. 1986). It would appear from the field notes of Lightcap and Ellifrit in Appendix, Map E-4 and Table C (and in U. S. Army Corps of Engineers 1982) that whereas smartweed was well established in Smith Lake, it was confined to the upper perimeter of the tidally fluctuating Bybee Lake adjacent to the Pacific willow fringe.

The fairly recent (10 yr) colonization and spread of swamp smartweed in the lakes can be tracked through historical aerial photographs of the lakes. In a color infrared photograph from September 1983 (Port of Portland 1983) the most dense growth was in the southeast embayment of Smith Lake, and in the small embayment adjacent to the Landfill northwest of the penninsula extending into the lake from the southwest. Cover and distribution was similar though slightly less than in 1986. In an April 1981 color infrared photograph (U. S. Army Engineers 1981), when water levels were unusually low in the area, swamp smartweed vegetation is present as a fringe in the areas where it later increased its cover. In April, however, the plant would have had dried emergent stems and minimal new leaf growth. In a black and white aerial photograph from April of 1980, however, the emergent stems of smartweed are visible at approximately the same locations as in April of 1981 (METRO 1980). In an October 10, 1979 black and white aerial smartweed appears to be present at locations and in cover similar to the preceding two years (METRO 1979). A 24 September 1974 color infrared photograph, shows very low water in Bybee Lake, and very low water level in Smith Lake. Smartweed is only visible, and then sparsely, in the northwest embayment of Smith Lake, and at scattered locations around the perimeter of the lake.

It appears that the conditions are suitable for the growth of smartweed with water retained in the lakes. The review of available literature suggests (and the name amphibium as well) that swamp smartweed does well in fluctuating, shallow water systems, and does persist under conditions of continuous flooding, as has been observed in Smith and Bybee Lakes since the control structure was installed.

Swamp Smartweed (Polygonum coccineum Muhl.)
(= P. amphibium v. coccineum Farw.)

> As Hitchcock et al. (1959-1969) report, swamp smartweed is "Almost throughout North America... It is closely related, if not synonymous with Polygonum amphibium with which it may merge." The latter occurs in the British Isles (Haslam 1978, Martin 1982.) It is almost certainly native to North America.
>
> Miller (1972) found it in marshes (76 percent frequency) that were flooded all year in Saskatchewan. His study involved measurement of die-back under different flooding depths; he found that none occurred at water depths less than or equal to 30" and the die-back increased with increasing water depth above 30" (36 percent in water deeper than 42"). Die back peaked in first year of continuous flooding, but individual plants survived up to 5 or 6 years of continuous flooding. Haslam (1978) found that Polygonum amphibium was mostly indifferent to depth of water, but usually because it rooted on banks at the edges of streams or out of the water and then grew out into the water. Stewart and Kantrud (1972) found it in shallow marsh communities.
>
> Landin (1978) said that Polygonum in general were good wildlife food. Polygonum coccineum provides excellent waterfowl food, good cover. WDOG (1985) considers the species excellent for planting in wetlands because of good wildlife values.

After three growing seasons of maintained water levels, smartweed is extending its cover, perhaps even at an accelerated rate. Since bottom elevations are similar where smartweed now grows and where it does not yet grow in Smith Lake, this plant could invade and cover the entire lake. It is well established and extending its cover in Bybee Lake.

3.3.6 Increase in Phytoplankton Biomass

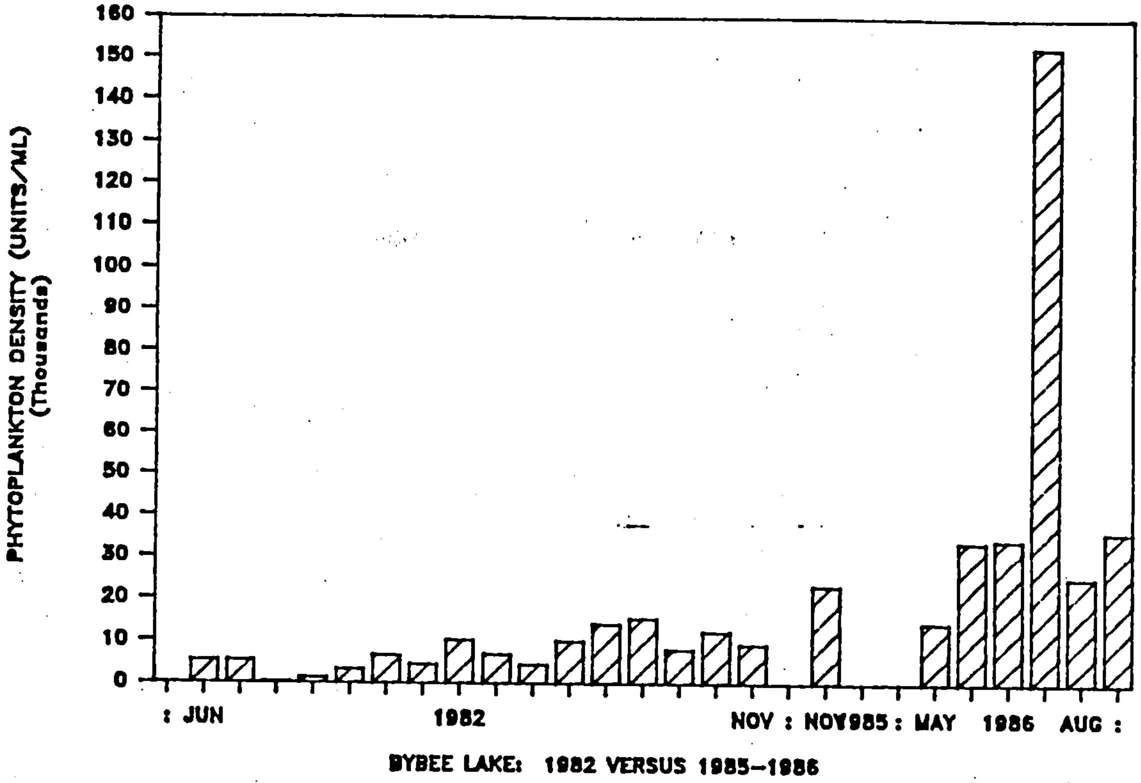
The drifting microscopic algae of the lakes and small ponds in the wetland area are a hidden, but important, component of the system. They are apparent without microscope in the coloration of the water, in the reduction in water transparency and in late fall production of the green films on water surfaces. The complexity of this hidden biota is suggested by the identification of a total of 86 species of algae in 14 separate 1 liter water samples obtained from November 1985 - August 1986 (see Appendix Table B). Five major divisions of algae were represented in this collection:

DIVISIONS	SPECIES
CHLOROPHYTA (green algae)	42
CHRYSOPHYTA (golden brown algae)	28
EUGLENOPHYTA (euglenoid algae)	7
CYANOPHYTA (blue-green algae)	6
CRYPTOPHYTA (cryptophyte algae)	3
TOTAL SPECIES	86

Densities of algae in these samples ranged from 9,620 units/ml in May to 152,718 units/ml in August. Chlorophyll a, the major and common pigment in algae chloroplasts, was extracted from lake water samples during the project. Values ranged from a low of 16.0 mg/m^3 in May to a high of 85.5 $mg/^3$ in September (see Appendix Table B).

Water samples from a June-November 1982 U.S.G.S. study of Smith and Bybee Lakes (Clifton 1983) were analyzed for algae. Densities of algae determined in that study compared with those found during 1985-1986 are shown in Figure 3-2. A marked increase in densities is apparent for both lakes over 1982 values. Figure 3-1 in Section 3.3.2 shows the lake levels in each of the lakes during the 1982 study as well as the lake levels during a similar period in 1986. Less than one foot of water was present in Smith Lake from August through November 1982. Slightly more was in Bybee Lake. This contrasts with the impoundment of a remaining 3-4 ft of water in each of Smith and Bybee Lakes in late fall of 1986 (bottom elevation of the lakes is around 5.0 ft msl; Figure 3-1).

The increase in phytoplankton densities coupled with the increase in the volume of water impounded in the lakes suggests the creation of a very large drifting algae plant biomass within the lakes. Assuming the plant pigment chlorophyll a is approximately 2% of total dry weight plant biomass (Stewart 1974), and using a mean value for chlorophyll a from all 1985-1986 samples (10 samples) of 45.27 mg/m^3, and a total impounded volume for both of the lakes at 10.5 surface elevation of 4.811×10^6 m^3, the average dry weight biomass standing crop in the lakes would have been 10.9×10^6 g, or 2.46 g/m^2 of total lake surface. Assuming, further, that this drifting algae is the food of zooplankton, the algae support very large populations of zooplankton. Two estimates of zooplankton densities in fall of 1985 were 122,219 individuals/m^3 for Bybee Lake, and 22,941 individuals/m^3 for Smith Lake (Scientific



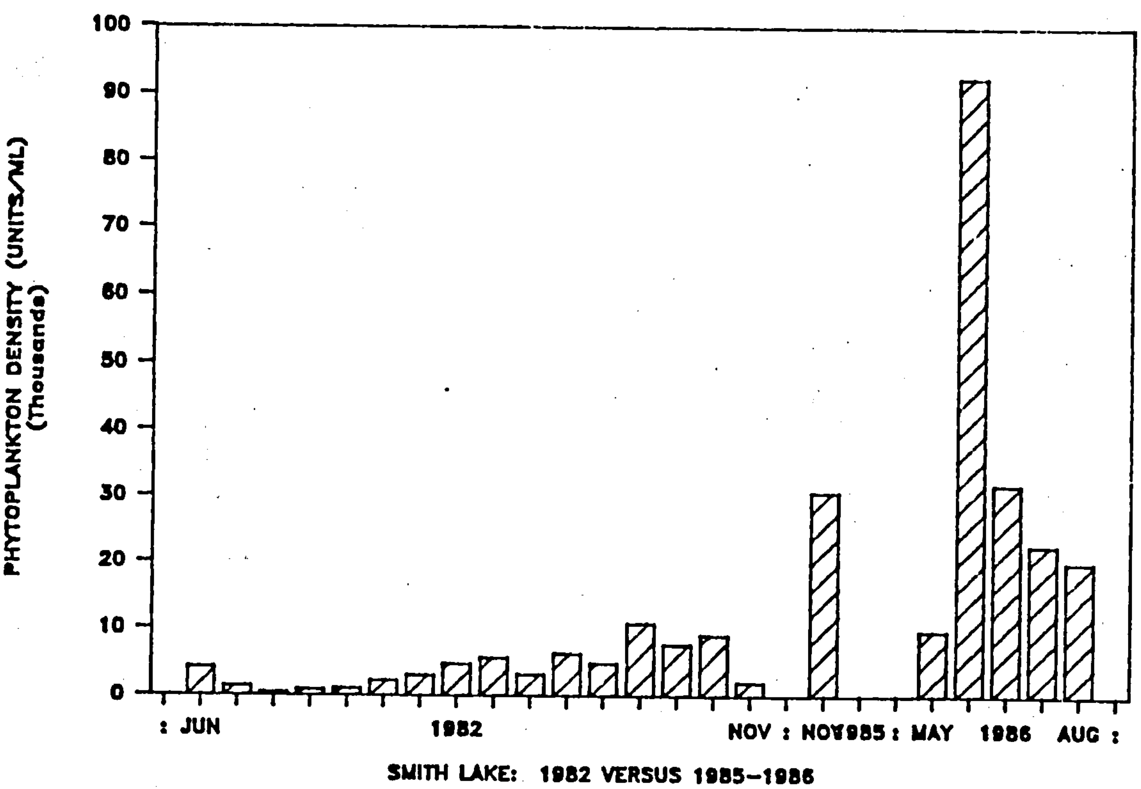


Figure 3 - 2 Comparison of phytoplankton densities in Smith and Bybee Lakes 1982, 1985-1986. Phytoplankton densities from 1982 from Clifton (1983).

Resources, Inc. 1986a).

In spite of the large number of species comprising the phytoplankton populations, only a few (3 - 7) were dominant in any sample in terms of density or individual biovolume (very large differences among species of algae). During the project there were 29 species that were individually at least 5% of the total density or comprised 5% of the total biovolume of the algae assemblages. Twelve of these dominants were common to both of the Lakes. The remainder were dominants in one of the two lakes, but still present in both of the lakes. Composition of the phytoplankton changed from spring through fall with green algae dominating in May through June, with diatoms (golden brown) and blue-green algae dominating in the fall. Whether the lime-green surface films of blue-green algae that appeared in fall will constitute a nuisance will depend on the awareness of those who use the lake, and proposed uses of the lake. While blue-green algae are an annoyance to swimmers, they do not indicate a polluted lake; they do suggest an enriched lake.

Additional information on the water chemistry and quality of the lakes and Columbia Slough has been provided in Technical Appendix C of this series, which reports high concentrations of plant nutrients that support the large drifting algae populations.

4.0 CONCLUSIONS AND RECOMMENDATIONS

4.1 Summary of Vegetation Changes and Previously Predicted Changes

There have been various changes in the vegetation of Smith and Bybee Lakes resulting from the installation of the water control structure:

1) Reduction in the amount of exposed lake bottom and its associated diverse vegetation, particularly in Bybee Lake.
2) The virtual death of the inner band of Pacific willow shrub and the likely death of the remainder of what will be 300 ac of trees; regeneration of willow was sparse;
3) The likely death of 10 ac of Oregon ash; but an associated increase in the number of ash trees regenerating at higher elevations;
4) The loss of 60 ac of reed canarygrass as small mammal habitat but the possible persistence of this grass at a lower density as a shallow water fringe in both Bybee and Smith Lakes;
5) Colonization of Bybee Lake by potentially nuisance submersed plant species curly leaf pondweed and coontail; and the likelihood of colonization by Eurasian water-milfoil which has invaded a cutoff slough and small ponds east of Bybee Lake;
6) Extension of swamp smartweed in Smith Lake, with a spread by 1986 to at least 37% of the lake surface, and an apparent extension in Bybee Lake to 12% of the lake surface'
7) Increase in phytoplankton biomass, on the basis of chlorophyll a, in each of the lakes, apparently both as mass or plant volume per volume of water, and as a total increase at the end of summer due to the larger residual volumes of water in the lakes.

Many of these changes that have occurred in vegetation in Smith and Bybee Lakes as a result of the water control structure were predicted by Lightcap in 1982 (U. S. Army Corps of Engineers 1982; B=Bybee, S=Smith):

1) loss of about 200 ac of exposed lake bottom vegetation; [B]
2) increase in the perimeter of the lakes but decrease in the width of the wetland and higher elevation riparian plant zones; [B,S]
3) willows may be killed at the 6-8 ft (msl) elevations, but willows will invade at higher elevations; [S,B]
4) extensive stands of swamp smartweed will be eliminated by the more permanent body of water, but recolonization by smartweed will occur in newly created shallow zones [S]
5) there will be significant losses of reed canarygrass and slough sedge "grassy" meadows; [B,S]
6) there will be a loss of mature Oregon ash, however, it will regenerate; [S,B]
7) invasion by the submersed plant Eurasian water-milfoil; [B,S]
8) increase in blue-green algae populations; [S,B]

What was not predicted well was the extension of the 'amphibious' smartweed into more of Smith and Bybee Lakes than it previously occupied. The total acreage of willows that would die was not predicted, but younger willows growing at lower elevations have died. The loss of reed canarygrass is apparently much less significant than predicted, and indications are that it has been providing palatable food for ducks in its flooded condition. Lightcap predicted a dominance in late summer by blue-green algae. Blue-green algae were indeed present at the end of summer and prominent because of their buoyancy, rising to the surface and forming lime-green films. The drifting algae populations in each of the lakes are similar and complex. There was a great diversity of primarily green algae, in contrast to a pre-impoundment diatom flora, which apparently supports abundant zooplankton (see the Technical Appendix F: Aquatic Invertebrates in this series) and provides in turn food for fish. The high levels of plant nutrients in the lakes will provide adequate food for a wide variety of phytoplankton typically found in eutrophic lakes, and for submersed and emergent plants.

The significance of these changes in vegetation are of course related to changes in wildlife and fishery habitat, which are discussed in two other Technical Appendices in this series (Technical Appendices G and H). It would appear that the significance of these changes in part depends on what human uses are proposed for the area, especially from the standpoint of ease of navigation. The significance also depends on what your favorite plants are. There may be slight sympathy for the loss of 300 ac of <u>Salix laisandra</u>, anger at the reduction of <u>Sagittaria latifolia</u>, and indifference to whether there are 30 or 100 more or less microscopic algae species from the change in water level.

4.2 Plant Management Guidelines

Common sense, and observations of the way revegetation has occurred in the Smith and Bybee Lakes area, suggests guidelines that may be followed to prevent future radical changes to this relict wetland area.

1) Don't remove plants unless you are reasonably sure of what will replace them (nature abhors bare ground, or empty water).
2) Don't kill a plant until you know how it is being used.
3) Choose the alternative that will result in the least maintenance.

With these in mind, the following modifications are suggested as possible improvements and preventive measures.

4.3 Achieving Greater Diversity through Instability

Various ephemeral ponds within the project area have supported a wide variety of plants and animal use deriving from water level reduction and evaporation. The instability of changing water levels resulting in variously exposed lake bottom produces a variety of occasions and opportunities for plant colonization. The knowledge that Bybee Lake was a larger example of this relatively scarce phenomenon in the Columbia River Lowlands, suggests that an improvement in overall habitat diversity in the area would be achieved by returning Bybee Lake to a tidally influenced condition. This would prevent the growth of nuisance submersed plant species which appear to have minimal wildlife value, and which would need to be controlled with herbicides to prevent their interfering with small boat use of the Lake. Plants growing on the exposed lake bottom will provide detritus during tidal flushing in late fall and winter for use by invertebrates in the lower Slough system and rivers.

This change would entail the construction of a water control structure perhaps at the location of a previous control structure in the lower Smith Channel where a sill remains. Siting the structure at that location would also provide for walking access from the northeast lakes peninsula to the southwest area of the lakes.

4.4 Mitigation Opportunity: Wetland Nursery

Development within the urban area has resulted, and will result, in the loss of wetland habitat, in spite of increasing constraints by government. Approved projects that entail wetland removals or substitutions, and which require mitigation are frequently handicapped by the lack of native wetland plant material. Wetlands marked for change are occasionally removed long before the new development and its associated new "mitigation" wetland can be constructed. The result is a waste of valuable, diverse and mature plant material. Acquiring native plant material to accomplish adequate mitigation is frequently limited by what can be obtained from a local nursery. Surveys of available wetland plant material from local nurseries suggests that little is available.

A jointly funded interagency-intergovernmental wetland nursery associated with Bybee Lake would provide a protected site for relocating plant material from urban wetlands marked for removal or change, and, in turn provide materials for creating viable and adequate new wetlands. The Division of State Lands would appear to be a suitable agency for coordinating nursery transactions given its position as arbiter with the Corps of Engineers on wetland loss and mitigation. Funding to maintain the nursery could be provided as a portion of development costs. The City of Portland, through the services of its City Forester, could lend support and guidance for the design of the nursery area. And the City with the Port of Portland could determine the best and most controlled access to the nursery under all weather conditions.

4.5 Managing Smith Lake for Human Use

A 1948 aerial photograph of the southwest one-half of Smith Lake, including the Blind Slough area, showed recent extensive and complete clearing of vegetation from the perimeter of the Lake (U. S. Army Corps of Engineers 1948). Piles of trees and brush lines were clearly visible. There is no record of what was intended by such modifications. To provide for future active, non-motorized, or small motor, boating use on Smith Lake it may be desirable to make similarly large changes in living and dead vegetation. The following three management efforts would provide for more intense human use of the lake:

1) Selectively remove dead willow scrub-shrub and trees to provide better access to the lake;
2) Selectively control the spread of swamp smartweed to provide for ease of navigation and perhaps for an improved fishery;
3) Provide for increased flushing of the lake with water lower in plant nutrients to reduce phytoplankton biomass and undesirable species of algae.

Willow Removal. Access to the lake from traditional locations, e.g. the boat ramp in the southwest corner of the lake, is severely impeded by willow vegetation. The closely spaced nearly dead willow fringe around the lake also restricts boaters from access to the bank through more widely spaced willows, which will eventually die. Selective removal of willow would enhance the usability of the lake without sacrificing the value of willow snags as habitat for birds.

Selective Control of Smartweed. The emergent nature of this plant lends it to control by an aerial application of a systemic herbicide such as glyphosate. Proper timing of application would provide for the elimination of both emergent and submersed plant stems and open pathways for boating and possibly for improved fishery (more structure). Since the plant has been identified as valuable for waterfowl, total elimination of the plant would be undesirable. It would appear that long-term control of smartweed will be necessary to prevent the further encroachment of the remaining open water by this plant.

Flushing to Reduce Algae Density. The quantity of rooted plants in Smith Lake compete with the drifting algae for plant nutrients. Smartweed, however, like other plants, may be pumping nutrients from the sediments into the water as well as using nutrients from the water for growth. Having the capability of being able to replace 1-2% of the total water volume per day in the lake with water of lower amounts of plant nutrients would reduce algae biomass. This approach has improved the water quality of Vancouver Lake, Washington (Ogden Beeman Associates 1985; Cooper Consultants, Inc. 1985). The estimated volume of Smith Lake maintained at an elevation of 10.5 ft. is 2660 ac ft. (116 million cubic feet). Introduction of 2.3 million cubic feet per day would be required to replace 2% of the lake volume.

4.6 Preventive milfoil control in the cutoff Slough

To prevent the spread of Eurasian water-milfoil from the small ponds and the cutoff Slough to available habitat in Smith Lake, it is recommended that herbicide control of the milfoil be considered. Presently the cutoff or hook-shaped slough is unsuitable for small boat use due to the density of the milfoil. The slough, however, could be a very attractive setting for small boat use, and an easily accessible fishery. Control of milfoil growth, if not elimination, would provide for both uses.

4.7 Selective Black Cottonwood Plantings

The tall black cottonwoods on the higher ground near the southeast edge of the area (near Marine Drive) and those along the Columbia Slough are attractive landmarks for the area and valuable avian habitat. Consideration should be given to assuring the continued growth of replacement cottonwoods at suitable sites in the project area.

4.8 Monitoring for Improved Protection and Management

Due to the foresight of individuals in the Corps of Engineers and the U. S. Fish and Wildlife Service summertime monitoring of water quality in each of the lakes was conducted in 1982. That fall, some observations were made of vegetation at selected and defined sites. That information made comparisons between pre- and post-impoundment conditions possible.

A vegetation monitoring program is recommended to provide timely information for people who will be managing this area, and information for people who will track the progress of this area 5, 10 or more years from now. Human use and disturbance of the area will continue. Clearing of transmission right of ways, for example, effects a lot of vegetation. It may be that other ways of managing this vegetation are preferable to those being used. The stabilizing of water levels provides an opportunity for the growth of cat-tail (Typha latifolia). Small clumps of this plant and numerous new starts around the perimeter of Smith Lake suggests that a very large niche exists at the lakes for the growth of this invasive plant. Growth of potentially nuisance submersed plant species could be rapid, producing growth that will interfere with proposed human uses. Early detection would enable simpler control. The system is dynamic because a new habitat was created by controlling water level. Changes presently taking place will result in a wetland somewhat different from what was there in 1986. Documentation of these changes and their progression to an eventual new stability in this relict wetland will be of value in managing this area intelligently.

5.0 REFERENCES

Bach, W. N. and D. V. Marlow. 1982. Rivergate Industrial Area: Topography of the Smith and Bybee Lakes. [Map]. Map Number RG 70-502 June 1982 11/10. Port of Portland.

APHA. 1981. Standard methods for the examination of water and wastewater. 15th Edition. 1980. APHA-AWWA-WPCF. American Public Health Association, Washington, D. C. 1134 pp.

Boss, Theodore. 1983. Vegetation ecology and net primary productivity of selected freshwater wetlands in Oregon. Ph.D. Thesis. Oregon and microbiological samples. Chapter A4 TWRI, U.S. Geological Survey.

Clifton, Daphne G. 1983. Water-quality data for Smith and Bybee Lakes, Portland, Oregon, June to November 1982. U. S. Department of the Interior, Geological Survey. Open-File Report 83-204. 56 pp.

Comes, R. D. and Timothy McCreary. 1986. Approaches to revegetate shorelines at Lake Wallula on the Columbia River, Washington-Oregon. Prepared for Department of the Army, Corps of Engineers, Waterways Experiment Station, Vicksburg, Mississippi. Technical Report E-86-2. 89 pp.

Comes, R. D., L. Y. Marquis, and A. D. Kelley. 1981. Response of seedlings of three perennial grasses to dalapon. amitrole, and glyphosate. Weed Sci. 29:619-621.

Cooper Consultants, Inc. 1985. Water quality effects of dredging and flushing at Vancouver Lake. Prepared for the Port of Vancouver, Vancouver, Washington by Richard B. Raymond and Stephen A. Wille of Cooper Consultants, Inc, Portland, Oregon. Paged by Section.

Cowardin, L. M., V. Carter, F. C. Golet and E. T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. Office of Biological Services, Fish and Wildlife Service, U. S. Department of the Interior. FWS/OBS-79/31. 103 pp.

Dennis, L. J. 1980. Gilkey's weeds of the Pacific Northwest. Oregon State University Press, Corvallis.

Detrick, Christopher. 1980. Winter wildlife inventory of and management alternatives for the Steigerwald Lake wetland, Clark County, Washington. Prepared for U. S. Fish and Wildlife Service, Olympia Washington. Contract No. 14-16-0001-79166(JS). 68 pp.

Ellifrit, N. 1982. Smith and Bybee Lakes habitat types. Blue line of June 1982 photograph, Scale 1 inch = 500 ft. Port of Portland, Drawing No. RG 82-504 1/1

Fishman Environmental Services. 1985a. Wetland assessment. Prepared for Columbia Steel Casting Company, Inc., Portland, Oregon. 72 pp.

Fishman Environmental Services. 1985b Smith and Bybee Lakes baseline data report. Prepared by FES, Portland, Oregon for the Port of Portland, Portland, Oregon. December 30, 1985.

Franklin, J. F., and C. T. Dyrness. 1973. Natural vegetation of Oregon and Washington. USDA For. Serv. Gen. Tech. Rep. PNW-8.

Geiger, N. S., L. Folster, and E. Mulvihill. 1983. Blue Lake Clean Lakes Program Phase I diagnostic/feasibility study. Final Report. Prepared for Multnomah County by Beak Consultants, Inc. Portland, Oregon. Paged by Section.

Gilmore, Len. 1986. Pillars of a lake community. Missouri Conservationist 47(11):12-15.

Glad, J. B. 1986. Plant ecologist. Portland, Oregon. Personal communication with Stan Geiger, Scientific Resources, Inc. November 15, 1986.

Green, George L. 1977. Soil survey of Multnomah County, Oregon. Soil Conservation Service, U. S. Department of Agriculture. 225 pp. + Maps.

Greeson, P. E., T. A. Ehlke, G. A. Irwin, B. W. Lium and K. V. Slack. 1977. Methods for collection and analysis of aquatic biological and microbiological samples. Chapter A4 TWRI, U. S. Geological Survey. See Part 2, p. 91ff.

Haslam, S. M. 1978. River plants. Cambridge University Press, Cambridge.

Hitchcock, A. S. 1950. Manual of grasses of the United States. Dover Publications, Inc., New York.

Hitchcock, C. L., A. Cronquist, M. Ownbey, and J. W. Thompson. 1959 [1964, 1969]. Vascular plants of the Pacific Northwest, Parts 4, 2, and 1 University of Washington Press, Seattle.

Hoffman, George R., S. G. Shetron, C. V. Klimas, and H. H. Allen. 1986. Lakeshore revegetation studies at Lake Oahe, South Dakota. Prepared for the Department of the Army Corps of Engineers, Waterways Experiment Station, Vicksburg, Mississippi. Technical Report E-86-3. 16 pp.

Johnson, D. M., R. Petersen, D. R. Lycan, J. W. Sweet, M. Neuhaus and A. L.Schaedel. 1985. Atlas of Oregon lakes. Oregon State University Press, Corvallis, Oregon 317 pp.

Jones and Stokes Associates, Inc. 1977. Wetland habitat evaluation: Vancouver Lake Washington. Prep. for USEPA Reg. X, Seattle, WA. November 1977. 36 pp + Append.

Kibby, H. V., J. L. Gallagher, and W. D. Sanville. 1980. Field guide to evaluate net primary production of wetlands. EPA-600/8-80-037. Environmental Research Laboratory, USEPA, Corvallis, OR.

Lev, Esther. 1986. Columbia South Shore: Wildlife management plan outline. Prepared for the Portland Development Commission, October 1986. 17 pp.

Lev, Esther and Michael Jennings. 1986. Smith and Bybee Lakes Natural Area: An overview. Bureau of Planning, City of Portland, Oregon. June 1986. Appendix I of Goal 5 Natural Resources Inventory (Draft) pp. 117-128.

Landin, M. C. 1978. Annotated tables of vegetation growing on dredged materials throughout the United States. U. S., Army Engineers Waterways Experiment Station Tech. Paper D-78-7.

Martin, W. K. 1982. The new concise British flora. Edbury Press, London.

Meeks, R. L. 1969. The effect of drawdown date on wetland plant succession. J. Wildl. Manage. 33(4):817-821.

METRO. 1979. Black and white aerial photograph, METRO-79 25-48. 10 October 1979. Spencer Gross Photogrammetric Engineering, Portland, Oregon.

METRO. 1980. Black and white aerial photograph METRO-80 26-50, 14 April 1980. Spencer Gross, Photogrammetric Engineering, Portland, Oregon.

Miller, J. B. 1972. Vegetation changes in shallow marsh wetlands under improving moisture regimes. Can. J. Bot. 51:1442-1457.

Oakley, A. L., J. A. Collins, L. B. Everson, D. A. Heller, J. C. Howerton, and R. E. Vincent. 1985. Riparian zones and freshwater wetlands. pp. 80 in E. R. Brown, ed. Management of wildlife and fish habitats in managed forests of western Oregon and Washington. USDA For. Serv. Pac. NW Region, Portland.

Ogden Beeman and Associates, Inc. 1985. Flushing system characteristics. Prepared for the Port of Vancouver, Vancouver, Washington. Portland, Oregon. 22 pp.

Portland, City of. 1986. Columbia South Shore: Analysis of economic, social, environmental and energy consequences for wetlands and wildlife habitat areas (Draft Report). Bureau of Planning, City of Portland, Oregon. October 1986. 52 pp.

Portland, Port of. 1983. Color infrared aerial photograph of Smith and Bybee Lakes, September 1986. Scale 1:6000

Reed, Porter B., Jr. 1986. 1986 Wetland Plant List. Northwest Region. WELUT-86/W13.09 May 1986. Prepared for the National Wetlands Inventory. U. S. Fish and Wildlife Service, St. Petersburg, FL. Paged by Section.

Scientific Resources, Inc. 1986a. Smith and Bybee Lake Area fall-winter data collection. Prepared by SRI, Portland, Oregon, for Fishman Environmental Services, [for Port of Portland], Portland, Oregon. 17 pp. + Appendices. 31 January 1986.

Scientific Resources, Inc. 1986b. Water Quality in Columbia Slough and Smith and Bybee Lakes 1986. Technical Appendix C of Smith and Bybee Lakes environmental studies. Prepared for the Port of Portland by Fishman Environmental Services. 63 pp + Appendices.

Shulters, M. V. 1975. Lakes of Oregon. Vol. 3. Hood River, Multnomah, Washington, and Yamhill Counties. U. S. Geological Survey Open-File Report. 93 pp.

Stanton, F. W. Undated. Planting food for wildlife. Oregon State Game Comm., Portland.

Stewart, R. E., and H. A. Kantrud. 1972. Vegetation of prairie potholes, North Dakota, in relation to quality of water and other environmental factors. Geol. Surv. Paper 585-D.

Stewart, W. D. P. 1974. Algal physiology and biochemistry. University of California Press, Berkley. 989 pp.

Tabor, J. 1976. Inventory of Riparian habitats and associated wildlife along the Columbia River. Oregon Cooperative Wildlife Research Unit, Oregon State University. Vol. 2A. 861 pp.

Tiffany, L. H. 1958. Algae, the grass of many waters. Charles C. Thomas, Springfield, Illinois. 199 pp.

U. S. Army Corps of Engineers. 1940. Aerial Photograph 40-2308, 28 Aug. 1940. Scale 1:10,900. Cartography and Remote Sensing Section. Portland District, Portland, Oregon.

U. S. Army Corps of Engineers. 1948. Aerial Photograph 48-4065, 5 Sept. 1948. Scale 1:12,000. Cartography and Remote Sensing Section. Portland District, Portland, Oregon.

U. S. Army Corps of Engineers. 1956. Aerial Photograph 56-3018, 19 Nov. 1956. Scale 1:27,000. Cartography and Remote Sensing Section. Portland District, Portland, Oregon.

U. S. Army Corps of Engineers. 1972. Aerial Photograph 72-2491, 11 Nov. 1972. Scale 1:48,000. Cartography and Remote Sensing Section. Portland District, Portland, Oregon.

U. S. Army Corps of Engineers. 1981. Aerial Photograph 81-533, 18 April 1981. Scale 1:48,000. Cartography and Remote Sensing Section Section. Portland District, Portland, Oregon.

U. S. Army Corps of Engineers. 1976. Revised Draft Environmental Impact Statement. Rivergate-North Portland Flood Control Project. Office of the Chief of Engineers, Washington, D. C. Paged by Section.

U. S. Army Corps of Engineers. 1978. Preliminary guide to wetlands of the West Coast states. U. S. Army Engineers Waterways Experiment Station. Tech. Rep. Y-78-4.

U. S. Army Corps of Engineers. 1982. Final Environmental Assessment, 404(b)(1) Evaluation and Finding of No Significant Impact. Reference No. 071-OYA-2-004236 (Columbia Slough - Water Control Structures). 29 April 1982. J. F. Bechly, Chief, Nav. Div. 12 pp.

U. S. Army Corps of Engineers. 1983. Memorandum for Record: Smith and Bybee lakes: Completion of water quality tasks assigned to NPPEN-HH-R. Douglas Larson. 3 June 1983. 10 pp. + Attachments. Portland, October 1986. 52 pp.

U. S. Army Corps of Engineers. 1985. Draft Environmental Impact Statement, West Hayden Island Marine Industrial Park. Prepared by Portland General Electric Company. Paged by Section.

U. S. Soil Conservation Service. Undated. Oregon interagency guide for conservation and forage plantings. USDA SCS, Portland.

U. S. Soil Conservation Service. 1985. Hydric soils of the United States 1985. In cooperation with the National Technical Committee for Hydric Soils. U. S. Department of the Interior. First Edition, October 1985. Paged by Section.

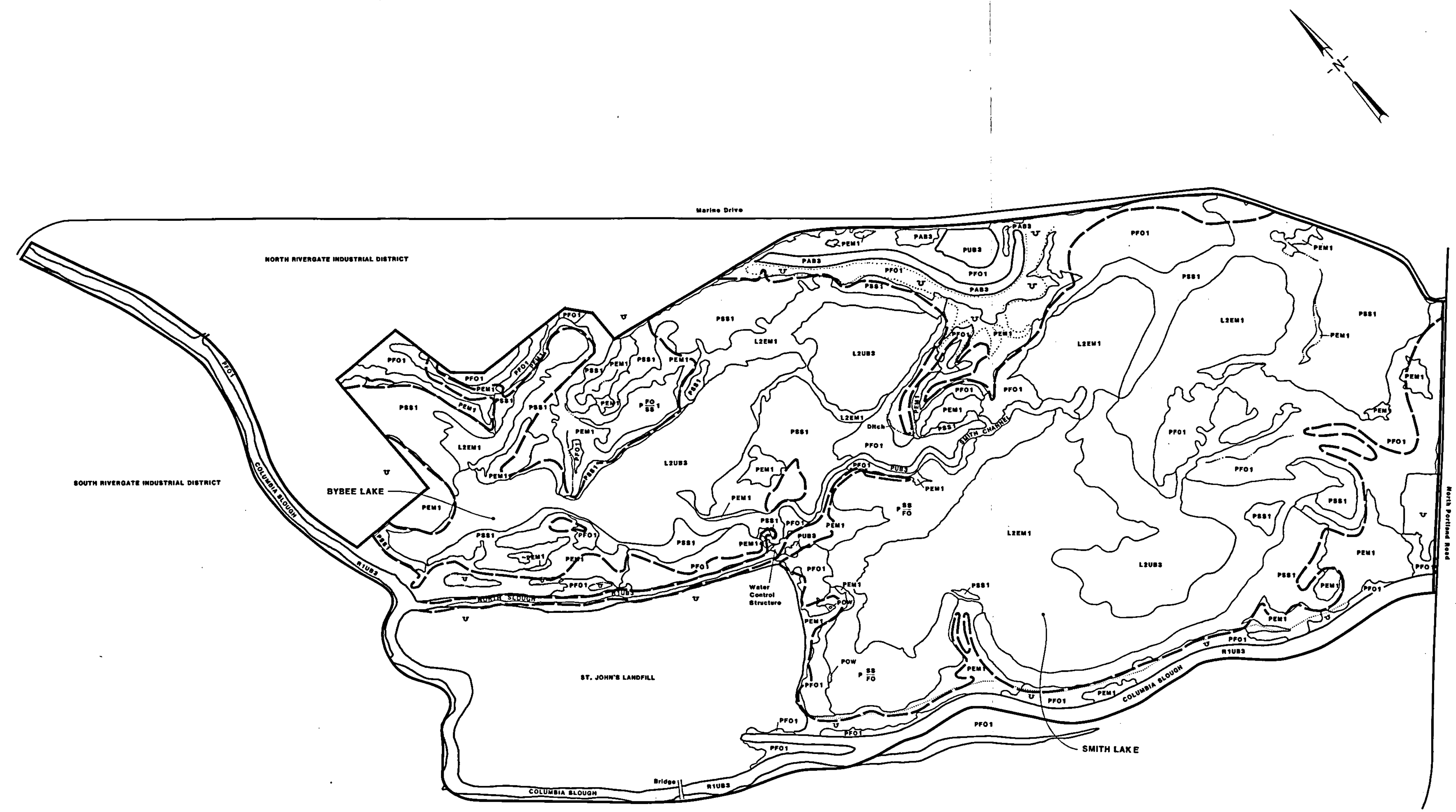
Walters, M. Alice, R. O. Teskey and T. M. Hinckley. 1980. Impact of water levels changes on woody riparian and wetland communities. Volume VIII. Pacific Northwest and Rocky Mountain Regions. Prepared for Office of Biological Services, U. S. Department of Fish and Wildlife. FWS/OBS-78/94. 46pp.

Warrington, Pat. 1980. Aquatic plants of British Columbia. Studies on aquatic macrophytes. Part XXXIII. Inventory and Engineering Branch, Ministry of Environment, Province of British Columbia. Paged by Section.

Washington Department of Game. 1985. Recommended plantings. Mimeo.

Whitlow, Thomas H. and Richard. W. Harris. 1979. Flood tolerance in plants: A state-of-the-art review. Prepared for the U. S. Army Engineers, Waterways Experiment Station, Vicksburg, Mississippi. Technical Report E-79-2. 161 pp + Appendices.

APPENDIX
MAPS



VEGETATION CLASSIFICATION (USFWS)

WETLAND

Palustrine (P)

- PFO1 Forested Broad-leaved Deciduous
- PSS1 Scrub Shrub Broad-leaved Deciduous
- PEM1 Emergent Persistent
- PAB3 Aquatic Bed Rooted Vascular
- PUB3 Unconsolidated Bottom Mud
- POW Palustrine Open Water

Lacustrine (L)

- L2UB3 Littoral Unconsolidated Bottom Mud
- L2EM1 Littoral Emergent Persistent

Riverine (R)

- R1UB3 Tidal Unconsolidated Mud

SCIENTIFIC RESOURCES, INC.

LEGEND

- STUDY AREA BOUNDARY / TOP OF BANK (APPROX. 30 FT.)
- APPROX. LAKE SHORE LINE (10.5 FT. CONTOUR)
- APPROXIMATE UPLAND BOUNDARY

NOTE: THE UPLAND BOUNDARY IS THE 16 FT. CONTOUR, AS USED HISTORICALLY FOR THIS AREA. THE ACTUAL WETLAND/UPLAND BOUNDARY HAS NOT BEEN DETERMINED.

Port of Portland

GRAPHIC SCALE IN FEET

500 0 500 1000 1500 2000 2500

DECEMBER, 1986

SMITH AND BYBEE LAKES
MANAGEMENT PLAN
ENVIRONMENTAL STUDIES
WETLAND CLASSIFICATION MAP

SUBMITTED BY:

SENIOR PLANNER, LAND DEVELOPMENT

DRAWING NO.: RG 86-511 18/23 (C-18)

MAP E-1

LEGEND

DATUM ALL ELEVATIONS = USGS.
LANDFILL DIKE
CONTROL STRUCTURE
TREE / SHRUB LINE - SMITH & BYBEE LAKES, SHORELINE - COLUMBIA SLOUGH
STUDY AREA BOUNDARY / TOP OF BANK (APPROX. 30 FT.)
APPROX. LAKE SHORE LINE (10.5 FT. CONTOUR)

Port of Portland

GRAPHIC SCALE IN FEET
500 0 500 1000 1500 2000 2500

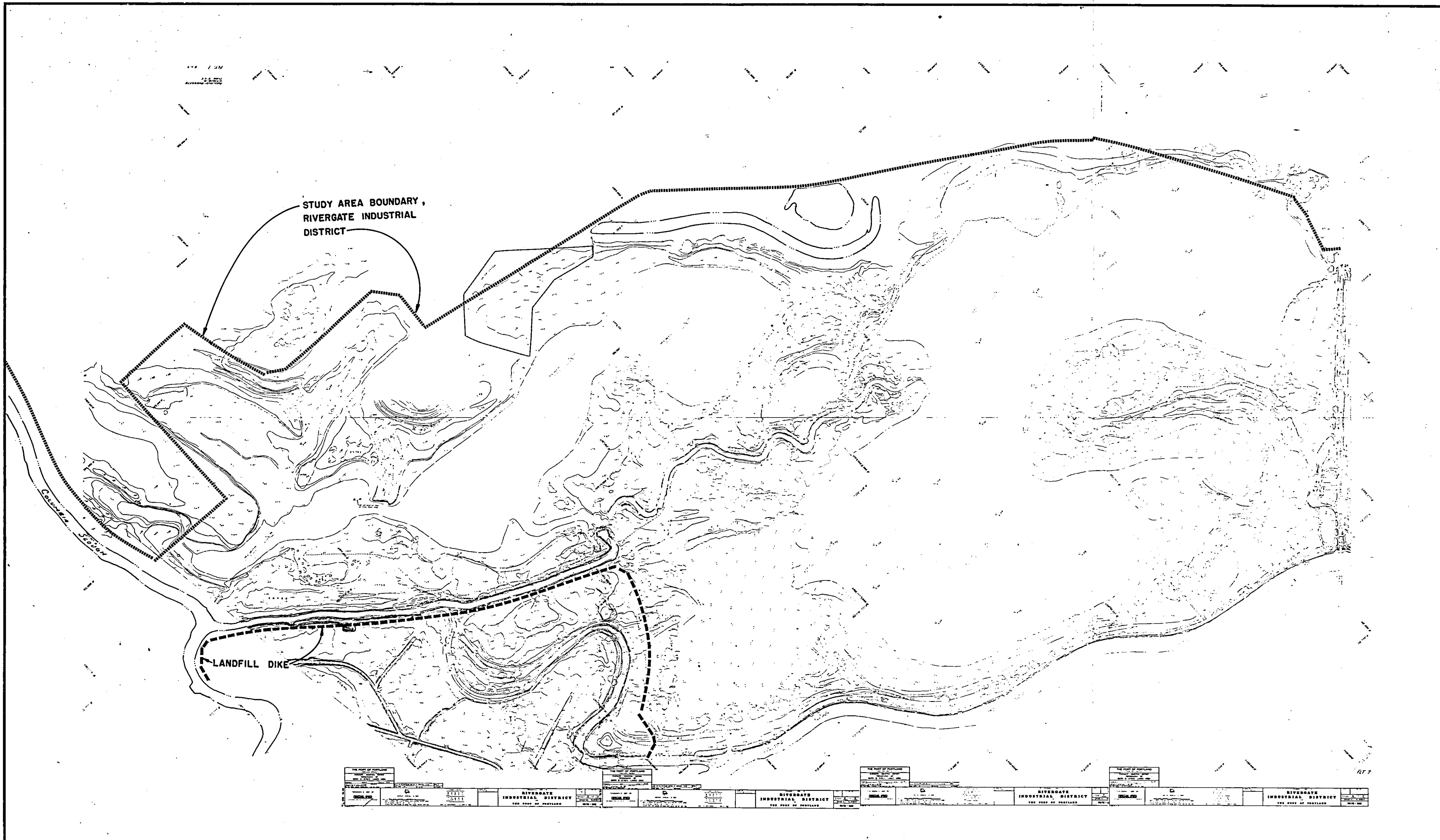
DECEMBER, 1986

SMITH AND BYBEE LAKES
MANAGEMENT PLAN
ENVIRONMENTAL STUDIES
STUDY AREA HABITAT MAP

SUBMITTED BY:
SENIOR PLANNER, LAND DEVELOPMENT

DRAWING NO.:
RG 86-511 19/23 (C-19)

MAP E-2



NO	DATE	BY	REVISIONS	CK'D	APP'V'D	NO	DATE	BY	REVISIONS	CK'D	APP'V'D

THE PORT OF PORTLAND
PORTLAND, OREGON

GRAPHIC SCALE IN FEET
500 0 500 1000 1500 2000 2500
DECEMBER, 1986

DESIGNED BY	W. N. BACH
DRAWN BY	D. V. MARLOW
CHECKED BY	
DATE	JUNE, 1982
SCALE	1" = 500'

RIVERGATE INDUSTRIAL DISTRICT
TOPOGRAPHY OF SMITH & BYBEE LAKES AREA

SUBMITTED BY R J Helman
MANAGER, TECHNICAL SERVICES

DRAWING NO.
RG 86-511 20/23 (C-20)

50% REDUCTION

MAP E-3

NO	DATE	BY	REVISIONS	CK'D	APP'V'D	NO	DATE	BY	REVISIONS	CK'D	APP'V'D

THE PORT OF PORTLAND
PORTLAND, OREGON

GRAPHIC SCALE IN FEET

500 0 500 1000 1500 2000 2500

DECEMBER, 1986

DESIGNED BY N. ELLIFRIT, USF&WS
DRAWN BY SH. ROHANI
CHECKED BY W. N. BACH
DATE OCT. 1982
SCALE 1" = 500'

RIVERGATE INDUSTRIAL DISTRICT

SMITH & BYBEE LAKES

HABITAT TYPES, 1982

SUBMITTED BY
MANAGER, TECHNICAL SERVICES

DRAWING NO.
RG 86-511 21/23 (C-21)

50% REDUCTION

MAP E-4

APPENDIX TABLES

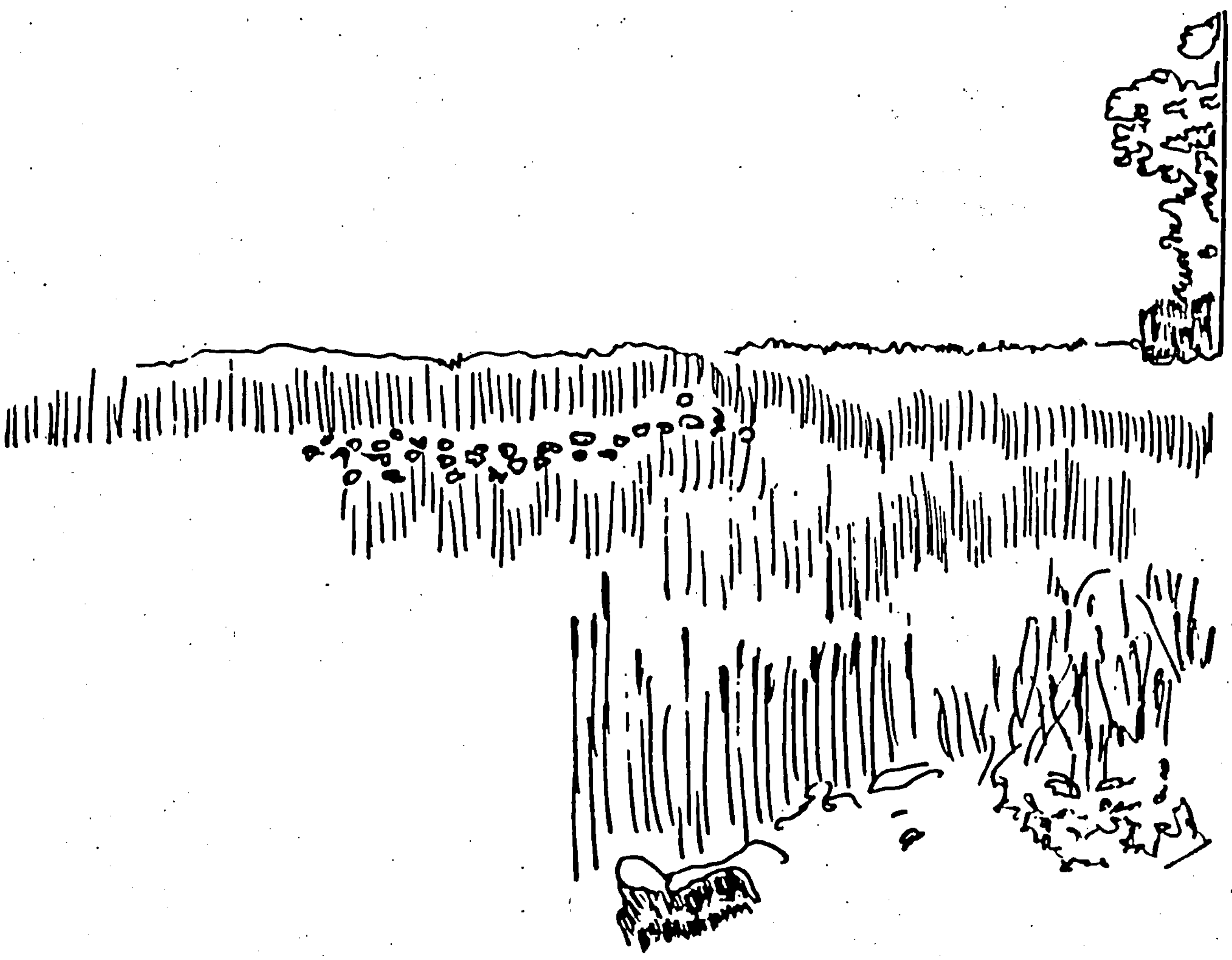


TABLE A. SPECIES OF MACROPHYTIC PLANTS IDENTIFIED FROM THE SMITH AND BYBEE LAKES AREA 1986

GENUS	GENUS	SPECIES	AUTHOR	COMMON NAME	HABIT**	REG9-IND**	UPLAND
Alisma	Alisma	plantago-aquatica	L.	Common Waterplantain	PNEF	OBL	
Amsinckia	Amsinckia	retrorsa	Suksd.	Rigid Fiddleneck		NOL	#
Anaphalis	Anaphalis	margaritacea	(L.) B. & H.	Pearly-everlasting		NOL	#
Anthemis	Anthemis	cotula	L.	Mayweed Dogfennel	AIF	FACU	#
Arctium	Arctium	minus	(Hill) Bernh.	Common Burdock		NOL	#
Artemisia	Artemisia	biennis	Willd.	Biennial Wormwood	AIF	FACW	#
Aster	Aster	chilensis	Nees	Pacific Aster	PNF	FAC	#
Azolla	Azolla	mexicana	Schlecht. & Cham. Ex K. Presl	Mexican Water-fern	PNF2W	OBL	
Barbarea	Barbarea	vulgaris	R. Br.	Bitter Wintercress	BIF	FAC-	
Bassia	Bassia	hyssopifolia	(Pallas) Kuntze	Fivehook Bassia	AIF	FACW	
Bidens	Bidens	cernua	L.	Nodding Beggarticks	AIF	FACW+,DRA	
Bidens	Bidens	frondosa	L.	Leafy Beggarticks	ANF	FACW+,DRA	
Carex	Carex	aperta	Boott	Columbia Sedge	PNGL	FACW	
Carex	Carex	comosa	Boott	Longhair Sedge	PNEGL	OBL	
Carex	Carex	obnupta	L.H. Bailey	Slough Sedge	PNGL	OBL	
Ceratophyllum	Ceratophyllum	demersum	L.	Coontail	PNF2F	OBL	
Chenopodium	Chenopodium	album	L.	Lambsquarters	AIF	FAC	#
Chenopodium	Chenopodium	ambrosioides	L.	Mexican Tea	AIF	NC	#
Chenopodium	Chenopodium	murale	L.	Sowbane		NOL	#
Chryptantha	Chryptantha	sp.		White Forget-me-not		NOL	#
Chrysanthemum	Chrysanthemum	leucanthemum	L.	Ox-eye Daisy		NOL	#
Cichorium	Cichorium	intybus	L.	Blue Sailors		NOL	#
Cirsium	Cirsium	arvense	(L.) Scop.	Canada Thistle	PIF	FACU+	#
Cirsium	Cirsium	vulgare	(Savi) Tenore	Bull Thistle		NOL	#
Conyza	Conyza	canadensis	(L.) Cronq.	Canada Horseweed	ANF	FACU	
Cornus	Cornus	stolonifera	Michx.	Red Osier Dogwood	NS	FACW	
Crataegus	Crataegus	sp.		Hawthorne		NOL	#
Cuscuta	Cuscuta	suksdorfii	Yuncker	Suksdorff's Dodder		NOL	
Cyperus	Cyperus	erythrorhizos	Muhl.	Red-rooted Flatsedge	APNEGL	OBL,DRA	
Cytisus	Cytisus	scoparius	(L.) Link	Scot's Broom		NOL	#
Dactylis	Dactylis	glomerata	L.	Common Orchard Grass	PIG	FACU	
Daucus	Daucus	carota	L.	Queen Ann's Lace		NOL	#
Dipsacus	Dipsacus	sylvestris	Huds.	Teasel		NOL	#
Echinochloa	Echinochloa	crusgali	(L.) Beauv.	Barnyard Grass	AIG	FACW,DRA	
Eleocharis	Eleocharis	obtusa	(Willd.) J. A. Schultes	Blunt Spikerush	APNEGL	OBL	
Eleocharis	Eleocharis	ovata	(Roth) Roem. & J.A. Schultes	Ovate Spikerush	ANEGL	OBL	
Epilobium	Epilobium	watsonii	Barbey	Watson's Willow-herb		NOL	
Equisetum	Equisetum	sp.		Horsetail		NOL	
Fraxinus	Fraxinus	latifolia	Benth.	Oregon Ash	NT	FACW	
Gnaphalium	Gnaphalium	uliginosum	L.	Marsh Cudweed		NOL	
Helenium	Helenium	autumnale v. grandif.	L.	Sneezeweed	PNF	FACW	
Heleochloa	Heleochloa	alopecuroides	(Pill. and Mitterp.) Host	Marsh Grass		NOL	

** = FOR EXPLANATION OF SYMBOLS SEE PAGES IMMEDIATELY FOLLOWING TABLE

TABLE A. SPECIES OF MACROPHYTIC PLANTS IDENTIFIED FROM THE SMITH AND BYBEE LAKES AREA 1986

GENUS	GENUS	SPECIES	AUTHOR	COMMON NAME	HABIT**	REGO-IND**	UPLAND
Hieracium	Hieracium	vulgatum	Fries	Common Hawkweed		NOL	#
Holcus	Holcus	lanatus	L.	Velvet Grass		NOL	
Hypericum	Hypericum	perforatum	L.	Common St. John's-wort		NOL	#
Impatiens	Impatiens	capensis	Meerb.	Spotted Touch-me-not	ANF	FACW	
Juncus	Juncus	effusus var. pacificus	L.	Soft Rush	PNEGL	FACW+	
Lactuca	Lactuca	ludoviciana	(Nutt.) Riddell	Biannual Lettuce	BPNF	NC	#
Lactuca	Lactuca	serriola	L.	Prickly Lettuce	ABIF	FAC-	#
Lactuca	Lactuca	sp.		Lettuce		NOL	#
Lemna	Lemna	minor	L.	Lesser Duckweed	PN/F	OBL	
Leontodon	Leontodon	nudicaulis	(L.) Merat	Hairy Hawkbit		NOL	#
Lotus	Lotus	purshiana	(Benth.) Clements & Clements	Spanish-clover		NOL	#
Lycopersicon	Lycopersicon	esculentum	Mill.	Tomato		NOL	#
Lycopus	Lycopus	americanus	Muhl. Ex W. Barton	American Bugleweed	PNF	OBL	
Lythrum	Lythrum	salicaria	L.	Purple Loosestrife	PIF	NC	
Marchantia	Marchantia	sp.		Liverwort		NOL	
Mentha	Mentha	arvensis	L.	Field Mint	PNF	FAC	
Mimulus	Mimulus	guttatus	DC.	Common Monkey-flower	ANF	OBL	
Myriophyllum	Myriophyllum	spicatum	L.	Eurasian Water-milfoil	PNZF	OBL	
Navarretia	Navarretia	squarrosa	(Esch.) Hook. & Arn.	Skunkweed		NOL	#
Nuphar	Nuphar	polysepalum	Engelm.	Yellow Water-lily		NOL	
Oenothera	Oenothera	strigosa	Mkze. & Bush	Common Evening-primrose		NOL	#
Panicum	Panicum	capillare	L.	Witch-grass	ANG	FAC	
Paspalum	Paspalum	distichum	L.	Knotgrass	PNEG	FACW, DRA	
Phalaris	Phalaris	arundinacea	L.	Reed Canarygrass	PNG	FACW	
Plantago	Plantago	lanceolata	L.	English Plantain	ABPIF	FACU+	#
Plantago	Plantago	major	L.	Common Plantain	PIF	FAC+	#
Polygonum	Polygonum	aviculare	L.	Prostrate Knotweed	APIF	FACW-	
Polygonum	Polygonum	coccineum v. pratin.	(Greene) Stanford	Swamp Persicaria		NOL	
Polygonum	Polygonum	hydropiper	L.	Water Pepper	AIEF	OBL	
Polygonum	Polygonum	hydropiperoides	Michx.	Mild Water Pepper	PNEF	OBL	
Polygonum	Polygonum	punctatum	Elliott	Water Smartweed	PNEF	OBL	
Populus	Populus	trichocarpa	T. & G.	Black Cottonwood		NOL	#
Potamogeton	Potamogeton	crispus	L.	Curly-leaved Pondweed	PIZF	OBL	
Potentilla	Potentilla	anserina	L.	Silverweed	PNF	OBL	
Prunella	Prunella	vulgaris	L.	Common Self-heal	PIF	FACU+	#
Ranunculus	Ranunculus	sceleratus	L.	Celeryleaf Buttercup	APNEF	OBL	
Raphanus	Raphanus	satiuus	L.	Wild Radish		NOL	#
Ribes	Ribes	divaricatum	Dougl.	Spreading Gooseberry	NS	NR	#
Rorippa	Rorippa	curvisiliqua	(Hook.) Bessey Ex Britton	Western Yellowcress	ANEF	NR, DRA	#
Rosa	Rosa	sp.		Rose		NOL	#
Rubus	Rubus	procerus (= discolor)	Weihe & Nees	Himalayan Blackberry	I	FACU-	
Rubus	Rubus	sp.		Trailing blackberry		NOL	#

** = FOR EXPLANATION OF SYMBOLS SEE PAGES IMMEDIATELY FOLLOWING TABLE

TABLE A. SPECIES OF MACROPHYTIC PLANTS IDENTIFIED FROM THE SMITH AND BYBEE LAKES AREA 1986

GENUS	GENUS	SPECIES	AUTHOR	COMMON NAME	HABIT**	REG9-IND**	UPLAND
Rumex	Rumex	crispus	L.	Curly Dock	PIF	FACW	
Sagittaria	Sagittaria	latifolia	Willd.	Broadleaf Arrowhead	PNEF	OBL	
Salix	Salix	fluviatilis	Nutt.	Columbia River Willow		NOL	
Salix	Salix	lasiandra	Benth.	Pacific Willow	NST	FACW+	
Sambucus	Sambucus	racemosa v. arborescens	L.	Red Elderberry	NS	FACU	#
Scirpus	Scirpus	validus	Vahl	Softstem Bulrush	PNEGL	OBL	
Sonchus	Sonchus	oleraceus	L.	Common Sow-thistle		NOL	#
Senecio	Senecio	jacobaea	L.	Tansy Ragwort		NOL	
Solanum	Solanum	dulcamara	L.	Bittersweet Nightshade	PIF	FAC	
Solidago	Solidago	canadensis	L.	Canada Goldenrod	PNF	FACU	#
Solidago	Solidago	occidentalis	(Nutt.) Torr. & Gray	Western Goldenrod		NOL	#
Solidago	Solidago	sp.		Goldenrod		NOL	#
Spiraea	Spiraea	douglasii	Hook.	Douglas' Spiraea	NS	FACW	
Spirodela	Spirodela	polyrhiza	(L.) Schleid.	Big Duckweed	PN/F	OBL	
Symphoricarpos	Symphoricarpos	albus	(L.) Blake	Common Snowberry	NS	FACU	#
Tanacetum	Tanacetum	vulgare	L.	Common Tansy		NOL	#
Trifolium	Trifolium	arvense	L.	Hare's-foot		NOL	#
Trifolium	Trifolium	pratense	L.	Red Clover	BPIF	FACU	#
Trifolium	Trifolium	sp.		Clover		NOL	#
Typha	Typha	latifolia	L.	Common Cat-tail	PNEF	OBL	
Urtica	Urtica	dioica	L.	Slimsting Nettle	PIF	NC	
Veronica	Veronica	anagallis-aquatica	L.	Water Speedwell	BPNEF	OBL	
Veronica	Veronica	sp.		Speedwell		NOL	
Xanthium	Xanthium	strumarium	L.	Cocklebur	ANF	FAC,DRA	
		TOTAL IDENTIFIED		108		TOTAL UPLAND	47

** = FOR EXPLANATION OF SYMBOLS SEE PAGES IMMEDIATELY FOLLOWING TABLE; + = PRESUMED UPLAND

EXPLANATION OF SYMBOLS USED IN PLANT SPECIES TABLE

THESE PAGES HAVE BEEN COPIED FROM REED (1986), 1986 WETLAND PLANT LIST FOR THE NORTHWEST REGION. U. S. FISH AND WILDLIFE SERVICE.

FNUM

The family number assigned to the species in the NLSPN.

NAT-IND

Frequency of occurrence in wetland versus nonwetland across the entire distribution of the species. A frequency, for example, of 67%-99% (Facultative Wetland) means that 67%-99% of all individuals of a species that occur in an area occur in wetlands. A question mark following the indicator denotes a tentative assignment based upon the botanical literature and not confirmed by regional review. When two indicators are given, they reflect the range from the lowest to the highest frequency of occurrence in wetlands across the regions in which the species is found.

Obligate (OBL). Always found in wetlands under natural (not planted) conditions (frequency greater than 99%), but may persist in nonwetlands if planted there by man or in wetlands that have been drained, filled, or otherwise transformed into nonwetlands.

Facultative Wetland (FACW). Usually found in wetlands (67%-99% frequency), but occasionally found in nonwetlands.

Facultative (FAC). Sometimes found in wetlands (34%-66% frequency), but also occurs in nonwetlands.

Facultative Upland (FACU). Seldom found in wetlands (1%-33% frequency) and usually occurs in nonwetlands.

Nonwetland (UPL). Occurs in wetlands in another region, but not found (<1% frequency) in wetlands in the region specified. If a species does not occur in wetlands in any region, it is not on the list.

Drawdown (DRA). Typically associated with the drier stages of wetlands, such as mud flats, vernal pools, and playa lakes.

R_IND.

Frequency of occurrence in wetlands versus nonwetlands in the region. Regional indicators reflect the unanimous agreement of the regional interagency review panel. If a regional panel was not able to reach a unanimous decision on a species (approximately 350 species Nationwide), NA (no agreement) was recorded in the regional indicator (R_IND) field. An NR (no review) was recorded for those species that have not received any regional review (approximately 800 species Nationwide). An NC (not considered) identifies those species that have not been reviewed because of their recent addition to the list. These species have been added either because of a revision in the distribution of the species or the documentation of a wetland citation in the botanical literature. An NO designates that no indicator has been assigned because the species does not occur in a particular region according to the region distributional field. A positive (+) or negative (-) symbol was used with the Facultative Indicator categories to more specifically define the regional frequency of occurrence in wetlands. The positive sign indicates a frequency toward the higher end of the category (more frequently found in wetlands), and a negative sign indicates a frequency toward the lower end of the category (less frequently found in wetlands).

SCI-NAME.

The genus and species applied to the taxon in the NLSPN.

AUTHOR.

The author of the scientific name as cited by the NLSPN.

SYNONYMY

Alternate scientific names applied to the species by major regional or state floras.

SYMBOL.

Symbol assigned in the National List of Scientific Plant Names (NLSPN), consisting of the first two letters of the genus name and the first two letters of the species epithet with additional numbers added in numeric sequence to the four-letter symbol to break ties. Tentative plant symbols for species not in the NLSPN have been created by taking the first two letters of the genus and the species names, adding a numeric tie breaker if necessary, and ending with a question mark. All records have a unique symbol.

COMMON-NAME.

A popular name applied to the species.

HABIT.

The plant characteristics and life form assigned to each species in the NLSPN.

"HABIT" symbols used by the NLSPN:

A	=	Annual	P	=	Perennial
B	=	Biennial	+,P2	=	Parasitic
C	=	Clubmoss	P3	=	Pepperwort
E	=	Emergent	Q	=	Quillwort
E2	=	Epiphytic	S	=	Shrub
F	=	Forb	-,S2	=	Saprophytic
/,F2	=	Floating	S,S3	=	Submerged
F3	=	Fern	$,S4	=	Succulent
G	=	Grass	T	=	Tree
GL	=	Grasslike	V	=	Vine
H	=	Partly woody	W	=	Woody
HS	=	Half shrub	WV	=	Woody vine
I	=	Introduced	X	=	Hybrid
N	=	Native	Q	=	On trees

These HABIT symbols are combined to describe the species (e.g., ANG means annual native grass, PIT means perennial introduced tree).

TABLE B – 1. CHLOROPHYLL A AND PHEOPHYTIL A (MG/CU M) IN 1986 LAKE AND SLOUGH SAMPLES.

STATIONS/DATE	CHLa (mg/cum)	PHEOa (mg/cum)
MAY 27, 1986		
Sta E/0550	57.7	38.1
Sta E/0755	16.0	16.1
Sta E/1047	33.1	-1.0
Sta E/1450	49.2	9.2
Sta E/1709	69.5	23.3
N. Slough/1113	102.6	-30.0
Bybee Lk. 30 May	41.5	1.7
Smith Lk. 30 May	16.0	15.6
JUNE 20, 1986		
Bybee Lk.	18.7	9.0
Smith Lk.	21.4	5.3
SEPTEMBER 17-18, 1986		
Sta E/0338 (9/17)	45.8	37.6
Sta E/0443 (9/17)	10.7	12.0
Sta E/1144 (9/17)	19.1	16.7
Sta E/1242 (9/17)	45.1	32.7
Bybee Lk.(willows)	60.6	46.0
Bybee Lk.(gage)	74.8	24.0
Smith Lk. (willows)	85.5	17.5
Smith Lk. (gage)	83.8	19.4

TABLES B-2

RESULTS OF 1986 SMITH AND BYBEE LAKES PHYTOPLANKTON ANALYSES

PHYTOPLANKTON SAMPLE ANALYSIS

SAMPLE: Bybee Lake

SAMPLE DATE: 86-05-30

TOTAL DENSITY (#/ml): 14362

TOTAL BIOVOLUME (cu.uM/ml): 4302233

DIVERSITY INDEX: 4.12

	SPECIES	DENSITY	PCT	BIOVOL	PCT
1	Melosira distans	3116	21.7	1048959	24.4
2	Crucigenia quadrata	1761	12.3	149720	3.5
3	Pediastrum tetras	1084	7.5	325183	7.6
4	Scenedesmus quadricauda	948	6.6	88158	2.0
5	Stephanodiscus hantzschii	813	5.7	97555	2.3
6	Crucigenia tetrapedia	677	4.7	92135	2.1
7	Ankistrodesmus falcatus	677	4.7	23711	0.6
8	Aphanizomenon flos-aquae	542	3.8	325183	7.6
9	Melosira ambigua	542	3.8	1037470	24.1
10	Sphaerocystis schroeteri	406	2.8	211369	4.9
11	Selenastrum minutum	406	2.8	8130	0.2
12	Nitzschia acicularis	406	2.8	113814	2.6
13	Scenedesmus acuminatus	271	1.9	65037	1.5
14	Cryptomonas sp.	271	1.9	108394	2.5
15	Tetraedron caudatum	271	1.9	10839	0.3
16	Micractinium pusillum	271	1.9	59617	1.4
17	Pediastrum duplex	271	1.9	108394	2.5
18	Scenedesmus sp.	271	1.9	54197	1.3
19	Stephanodiscus astraea minutula	135	0.9	47423	1.1
20	Scenedesmus abundans	135	0.9	13549	0.3
21	Crucigenia fenestrata	135	0.9	11517	0.3
22	Tetraedron regulare	135	0.9	15582	0.4
23	Crucigenia crucifera	135	0.9	11517	0.3
24	Pandorina sp.	135	0.9	142268	3.3
25	Cymbella minuta	135	0.9	50132	1.2
26	Tetrastrum staurogeniaforme	135	0.9	29266	0.7
27	Fragilaria construens	135	0.9	15175	0.4
28	Scenedesmus bijuga	135	0.9	37938	0.9

PHYTOPLANKTON SAMPLE ANALYSIS

SAMPLE: Smith Lake

SAMPLE DATE: 86-05-30

TOTAL DENSITY (#/ml): 9620

TOTAL BIOVOLUME (cu.uM/ml): 1647730

DIVERSITY INDEX: 2.95

--	SPECIES	DENSITY	PCT	BIOVOL	PCT
1	Crucigenia quadrata	4561	47.4	500136	30.4
2	Crucigenia tetrapedia	912	9.5	91498	5.6
3	Crucigenia crucifera	829	8.6	119835	7.3
4	Melosira distans	581	6.0	164368	10.0
5	Scenedesmus quadricauda	581	6.0	91693	5.6
6	Pediastrum tetras	498	5.2	149276	9.1
7	Micractinium pusillum	249	2.6	54734	3.3
8	Selenastrum minutum	166	1.7	3317	0.2
9	Ankistrodesmus falcatus	166	1.7	4147	0.3
10	Anabaena sp.	83	0.9	82931	5.0
11	Stephanodiscus hantzschii	83	0.9	9952	0.6
12	Trachelomonas volvocina	83	0.9	156325	9.5
13	Tetraedron regulare	83	0.9	9537	0.6
14	Pediastrum duplex	83	0.9	33172	2.0
15	Scenedesmus sp.	83	0.9	16586	1.0
16	Tetraedron sp.	83	0.9	2239	0.1
17	Achnanthes minutissima	83	0.9	4147	0.3
18	Chrysococcus rufescens	83	0.9	7049	0.4
19	Pandorina sp.	83	0.9	87078	5.3
20	Oocystis parva	83	0.9	9952	0.6
21	Scenedesmus abundans	83	0.9	16586	1.0
22	Cryptomonas sp.	83	0.9	33172	2.0

PHYTOPLANKTON SAMPLE ANALYSIS

SAMPLE: Smith Lake, NE corner - 1300

SAMPLE DATE: 86-06-20

TOTAL DENSITY (#/ml): 92500

TOTAL BIOVOLUME (cu.uM/ml): 3.544826E+07

DIVERSITY INDEX: 2.11

--	SPECIES	DENSITY	PCT	BIOVOL	PCT
1	Crucigenia quadrata	60680	65.6	6498828	18.3
2	Crucigenia tetrapedia	9620	10.4	17989400	50.7
3	Sphaerocystis schroeteri	4440	4.8	2308800	6.5
4	Crucigenia crucifera	2220	2.4	503829	1.4
5	Trachelomonas volvocina	2220	2.4	4184700	11.8
6	Oocystis parva	2220	2.4	266400	0.8
7	Cryptomonas erosa	1480	1.6	769600	2.2
8	Rhodomonas minuta	1480	1.6	29600	0.1
9	Selenastrum minutum	1480	1.6	29600	0.1
10	Scenedesmus quadricauda	1480	1.6	384800	1.1
11	Cryptomonas sp.	740	0.8	296000	0.8
12	Trachelomonas sp.	740	0.8	1480000	4.2
13	Scenedesmus abundans	740	0.8	148000	0.4
14	Pediastrum tetras	740	0.8	222000	0.6
15	Scenedesmus bijuga	740	0.8	207200	0.6
16	Ankistrodesmus falcatus	740	0.8	18500	0.1
17	Navicula sp.	740	0.8	111000	0.3

PHYTOPLANKTON SAMPLE ANALYSIS

SAMPLE: Smith Lake

SAMPLE DATE: 86-06-20

TOTAL DENSITY (#/ml): 33749

TOTAL BIOVOLUME (cu.uM/ml): 5059698

DIVERSITY INDEX: 2.86

--	SPECIES	DENSITY	PCT	BIOVOL	PCT
1	Crucigenia quadrata	15770	46.7	1581780	31.3
2	Crucigenia tetrapedia	4416	13.1	589280	11.6
3	Ankistrodesmus falcatus	2523	7.5	63082	1.2
4	Melosira distans	2208	6.5	747540	14.8
5	Scenedesmus quadricauda	1892	5.6	328436	6.5
6	Sphaerocystis schroeteri	1262	3.7	656053	13.0
7	Oocystis pusilla	946	2.8	56774	1.1
8	Scenedesmus abundans	631	1.9	126164	2.5
9	Selenastrum minutum	631	1.9	12616	0.2
10	Micractinium pusillum	631	1.9	138780	2.7
11	Melosira granulata	631	1.9	346951	6.9
12	Oocystis parva	315	0.9	9462	0.2
13	Tetraedron caudatum	315	0.9	12616	0.2
14	Crucigenia crucifera	315	0.9	26810	0.5
15	Achnanthes linearis	315	0.9	41634	0.8
16	Cryptomonas erosa	315	0.9	164013	3.2
17	Pediastrum tetras	315	0.9	94623	1.9
18	Scenedesmus sp.	315	0.9	63082	1.2

BB88

PHYTOPLANKTON SAMPLE ANALYSIS

SAMPLE: Bybee Lake, 1431

SAMPLE DATE: 86-06-20

TOTAL DENSITY (#/ml): 31672

TOTAL BIOVOLUME (cu.uM/ml): 9391932

DIVERSITY INDEX: 3.26

--	SPECIES	DENSITY	PCT	BIOVOL	PCT
1	Melosira distans	15096	47.7	5230764	55.7
2	Crucigenia quadrata	2664	8.4	452880	4.8
3	Scenedesmus quadricauda	1776	5.6	173160	1.8
4	Ankistrodesmus falcatus	1184	3.7	29600	0.3
5	Crucigenia tetrapedia	1184	3.7	176120	1.9
6	Stephanodiscus hantzschii	1184	3.7	142080	1.5
7	Crucigenia crucifera	1184	3.7	176120	1.9
8	Selenastrum minutum	888	2.8	17760	0.2
9	Stephanodiscus astraea minutula	592	1.9	207200	2.2
10	Fragilaria pinnata	296	0.9	35520	0.4
11	Aphanizomenon flos-aquae	296	0.9	177600	1.9
12	Melosira granulata	296	0.9	325600	3.5
13	Rhodomonas minuta	296	0.9	5920	0.1
14	Trachelomonas volvocina	296	0.9	557960	5.9
15	Tetraedron regulare	296	0.9	34040	0.4
16	Trachelomonas robusta	296	0.9	621600	6.6
17	Micractinium pusillum	296	0.9	65120	0.7
18	Scenedesmus arcuatus	296	0.9	41440	0.4
19	Tetraedron caudatum	296	0.9	11840	0.1
20	Oocystis lacustris	296	0.9	71040	0.8
21	Anacystis sp.	296	0.9	88800	0.9
22	Pediastrum duplex	296	0.9	118400	1.3
23	Anabaena sp.	296	0.9	296000	3.2
24	Scenedesmus sp.	296	0.9	59200	0.6
25	Oocystis sp.	296	0.9	44400	0.5
26	Navicula cryptocephala	296	0.9	54760	0.6
27	Navicula biconica	296	0.9	17760	0.2
28	Kirchneriella sp.	296	0.9	5328	0.1
29	Cryptomonas erosa	296	0.9	153920	1.6

PHYTOPLANKTON SAMPLE ANALYSIS

SAMPLE: Smith Lake, SL A

SAMPLE DATE: 86-08-28

TOTAL DENSITY (#/ml): 22504

TOTAL BIOVOLUME (cu.uM/ml): 1.228916E+07

DIVERSITY INDEX: 4.72

--	SPECIES	DENSITY	PCT	BIOVOL	PCT
1	Cyclotella kutzingiana	3779	16.8	434618	3.5
2	Melosira granulata angustissima	1890	8.4	2191986	17.8
3	Ankistrodesmus falcatus	1374	6.1	34357	0.3
4	Oscillatoria sp.	1203	5.3	1551225	12.6
5	Aphanizomenon flos-aquae	1203	5.3	822510	6.7
6	Anabaena flos-aquae	1031	4.6	1030714	8.4
7	Selenastrum minutum	1031	4.6	68646	0.6
8	Trachelomonas volvocina	687	3.1	1295264	10.5
9	Synedra radians	687	3.1	247371	2.0
10	Dictyosphaerium ehrenbergianum	687	3.1	123686	1.0
11	Melosira distans	687	3.1	238095	1.9
12	Crucigenia tetrapedia	515	2.3	43805	0.4
13	Sphaerocystis schroeteri	515	2.3	267986	2.2
14	Micractinium pusillum	515	2.3	113379	0.9
15	Melosira ambigua	515	2.3	1010806	8.2
16	Scenedesmus quadricauda	344	1.5	66996	0.5
17	Crucigenia quadrata	344	1.5	29204	0.2
18	Crucigenia crucifera	344	1.5	87611	0.7
19	Cryptomonas sp.	344	1.5	137429	1.1
20	Chlamydomonas sp.	344	1.5	111661	0.9
21	Nephrocytium sp.	344	1.5	32639	0.3
22	Scenedesmus abundans	344	1.5	34357	0.3
23	Stephanodiscus astraea minutula	344	1.5	120250	1.0
24	Cryptomonas erosa	344	1.5	178657	1.5
25	Scenedesmus sp.	344	1.5	17179	0.1
26	Anabaena sp.	344	1.5	343571	2.8
27	Scenedesmus bijuga	172	0.8	48100	0.4
28	Chrysococcus rufescens	172	0.8	14602	0.1
29	Nitzschia acicularis	172	0.8	48100	0.4
30	Trachelomonas pulchella	172	0.8	343571	2.8
31	Nitzschia frustulum	172	0.8	20614	0.2
32	Euglena elongata	172	0.8	396653	3.2
33	Closteriopsis longissima	172	0.8	61156	0.5
34	Rhodomonas minuta	172	0.8	3436	0.0
35	Pandorina sp.	172	0.8	180375	1.5
36	Crucigenia fenestrata	172	0.8	14602	0.1
37	Euglena sp.	172	0.8	99636	0.8
38	Cyclotella meneghiniana	172	0.8	65279	0.5
39	Scenedesmus denticulatus	172	0.8	15461	0.1
40	Trachelomonas sp.	172	0.8	343571	2.8

PHYTOPLANKTON SAMPLE ANALYSIS

SAMPLE: Smith Lake, SL B

SAMPLE DATE: 86-08-28

TOTAL DENSITY (#/ml): 19946

TOTAL BIOVOLUME (cu.uM/ml): 1.140018E+07

DIVERSITY INDEX: 4.47

--	SPECIES	DENSITY	PCT	BIOVOL	PCT
1	Oscillatoria sp.	2648	13.3	3177248	27.9
2	Ankistrodesmus falcatus	1942	9.7	97083	0.9
3	Anabaena flos-aquae	1765	8.8	1941651	17.0
4	Aphanizomenon flos-aquae	1412	7.1	847266	7.4
5	Sphaerocystis schroeteri	1059	5.3	550723	4.8
6	Melosira distans	1059	5.3	419397	3.7
7	Trachelomonas volvocina	706	3.5	1330914	11.7
8	Dictyosphaerium ehrenbergianum	706	3.5	127090	1.1
9	Cryptomonas erosa	706	3.5	367149	3.2
10	Synedra radians	706	3.5	254180	2.2
11	Cyclotella sp.	706	3.5	120029	1.1
12	Nitzschia acicularis	706	3.5	197695	1.7
13	Cyclotella meneghiniana	706	3.5	402451	3.5
14	Melosira granulata angustissima	706	3.5	264771	2.3
15	Selenastrum minutum	530	2.7	17687	0.2
16	Rhodomonas minuta	353	1.8	7061	0.1
17	Stephanodiscus astraea minutula	353	1.8	123560	1.1
18	Tetraedron sp.	353	1.8	9532	0.1
19	Chrysococcus rufescens	353	1.8	30007	0.3
20	Scenedesmus quadricauda	353	1.8	45894	0.4
21	Crucigenia quadrata	353	1.8	30007	0.3
22	Phacus sp.	177	0.9	61780	0.5
23	Scenedesmus abundans	177	0.9	35303	0.3
24	Chodatella wratislawiensis	177	0.9	10591	0.1
25	Crucigenia tetrapedia	177	0.9	15004	0.1
26	Coelastrum sp.	177	0.9	141211	1.2
27	Pandorina sp.	177	0.9	185339	1.6
28	Scenedesmus acuminatus	177	0.9	21182	0.2
29	Anabaena sp.	177	0.9	176514	1.5
30	Trachelomonas sp.	177	0.9	353028	3.1
31	Micractinium pusillum	177	0.9	38833	0.3

PHYTOPLANKTON SAMPLE ANALYSIS

SAMPLE: Smith Channel

SAMPLE DATE: 86-08-28

TOTAL DENSITY (#/ml): 28996

TOTAL BIOVOLUME (cu.uM/ml): 1.872042E+07

DIVERSITY INDEX: 4.65

--	SPECIES	DENSITY	PCT	BIOVOL	PCT
1	Anabaena flos-aquae	5691	19.6	5690704	30.4
2	Melosira granulata angustissima	2439	8.4	2304735	12.3
3	Crucigenia tetrapedia	2168	7.5	436721	2.3
4	Trachelomonas volvocina	1355	4.7	2554042	13.6
5	Scenedesmus hystrix	1084	3.7	216789	1.2
6	Ankistrodesmus falcatus	1084	3.7	67746	0.4
7	Cryptomonas erosa	1084	3.7	563651	3.0
8	Crucigenia quadrata	1084	3.7	253372	1.4
9	Stephanodiscus astraea minutula	813	2.8	284535	1.5
10	Scenedesmus quadricauda	813	2.8	105685	0.6
11	Cryptomonas sp.	542	1.9	216789	1.2
12	Pediastrum tetras	542	1.9	162592	0.9
13	Melosira distans	542	1.9	321931	1.7
14	Trachelomonas sp.	542	1.9	1083944	5.8
15	Chrysococcus rufescens	542	1.9	46068	0.2
16	Cyclotella glomerata	542	1.9	32518	0.2
17	Oscillatoria sp.	542	1.9	541972	2.9
18	Anabaena sp.	542	1.9	541972	2.9
19	Synedra radians	542	1.9	195110	1.0
20	Achnanthes minutissima	542	1.9	27099	0.1
21	Dictyosphaerium ehrenbergianum	542	1.9	97555	0.5
22	Cyclotella kutzingiana	542	1.9	62327	0.3
23	Selenastrum minutum	542	1.9	37938	0.2
24	Melosira ambigua	271	0.9	1436496	7.7
25	Schroderia sp.	271	0.9	12194	0.1
26	Cyclotella sp.	271	0.9	23034	0.1
27	Tetraedron sp.	271	0.9	7317	0.0
28	Phacus sp.	271	0.9	94845	0.5
29	Unident. green alga	271	0.9	40648	0.2
30	Nitzschia acicularis	271	0.9	75876	0.4
31	Cyclotella pseudostelligera	271	0.9	17614	0.1
32	Trachelomonas sp.	271	0.9	541972	2.9
33	Rhodomonas sp.	271	0.9	5420	0.0
34	Tetraedron caudatum	271	0.9	10839	0.1
35	Nitzschia sp.	271	0.9	32518	0.2
36	Synedra rumpens	271	0.9	101620	0.5
37	Stephanodiscus hantzschii	271	0.9	32518	0.2
38	Euglena sp.	271	0.9	157172	0.8
39	Pandorina sp.	271	0.9	284535	1.5

PHYTOPLANKTON SAMPLE ANALYSIS

SAMPLE: Bybee Lake, NE

SAMPLE DATE: 86-08-28

TOTAL DENSITY (#/ml): 34336

TOTAL BIOVOLUME (cu.uM/ml): 2.997207E+07

DIVERSITY INDEX: 2.99

--	SPECIES	DENSITY	PCT	BIOVOL	PCT
1	Anabaena flos-aquae	17760	51.7	19891200	66.4
2	Oscillatoria sp.	3256	9.5	3256000	10.9
3	Melosira granulata angustissima	2072	6.0	2144520	7.2
4	Ankistrodesmus falcatus	1184	3.4	29600	0.1
5	Melosira distans	1184	3.4	293040	1.0
6	Stephanodiscus astraea minutula	1184	3.4	414400	1.4
7	Dictyosphaerium ehrenbergianum	888	2.6	159840	0.5
8	Scenedesmus hystrix	592	1.7	94720	0.3
9	Rhodomonas sp.	592	1.7	11840	0.0
10	Pandorina sp.	592	1.7	621600	2.1
11	Cyclotella kutzingiana	592	1.7	68080	0.2
12	Caloneis hyalina	296	0.9	65120	0.2
13	Melosira ambigua	296	0.9	1046064	3.5
14	Achnanthes minutissima	296	0.9	14800	0.0
15	Scenedesmus abundans	296	0.9	29600	0.1
16	Scenedesmus sp.	296	0.9	59200	0.2
17	Selenastrum minutum	296	0.9	5920	0.0
18	Cryptomonas erosa	296	0.9	153920	0.5
19	Navicula sp.	296	0.9	44400	0.1
20	Trachelomonas volvocina	296	0.9	557960	1.9
21	Cyclotella glomerata	296	0.9	17760	0.1
22	Trachelomonas hispida	296	0.9	621600	2.1
23	Stephanodiscus hantzschii	296	0.9	35520	0.1
24	Anabaena sp.	296	0.9	296000	1.0
25	Cyclotella sp.	296	0.9	25160	0.1
26	Fragilaria construens venter	296	0.9	14208	0.0

PHYTOPLANKTON SAMPLE ANALYSIS

SAMPLE: Bybee Lake, NW Channel

SAMPLE DATE: 86-08-28

TOTAL DENSITY (#/ml): 152718

TOTAL BIOVOLUME (cu.uM/ml): 1.037404E+08

DIVERSITY INDEX: 4.09

	SPECIES	DENSITY	PCT	BIOVOL	PCT
1	Trachelomonas volvocina	31265	20.5	58934530	56.8
2	Nitzschia acicularis	21645	14.2	6060600	5.8
3	Scenedesmus quadricauda	14430	9.4	2654399	2.6
4	Ankistrodesmus falcatus	12025	7.9	330688	0.3
5	Cyclotella glomerata	9620	6.3	577200	0.6
6	Scenedesmus acuminatus	8418	5.5	1732322	1.7
7	Cryptomonas erosa	6013	3.9	3126500	3.0
8	Melosira granulata angustissima	3608	2.4	2408006	2.3
9	Melosira ambigua	3608	2.4	9200460	8.9
10	Nitzschia palea	3608	2.4	649350	0.6
11	Chlamydomonas sp.	3608	2.4	1172438	1.1
12	Unident. green alga	3608	2.4	541125	0.5
13	Anabaena flos-aquae	2405	1.6	2405000	2.3
14	Dictyosphaerium ehrenbergianum	2405	1.6	432900	0.4
15	Cyclotella sp.	2405	1.6	204425	0.2
16	Melosira distans	2405	1.6	952380	0.9
17	Trachelomonas acanthostoma	2405	1.6	6183255	6.0
18	Sphaerocystis schroeteri	2405	1.6	1250600	1.2
19	Chodatella wratislawiensis	2405	1.6	144300	0.1
20	Nitzschia sp.	2405	1.6	288600	0.3
21	Euglena sp.	1203	0.8	697450	0.7
22	Scenedesmus hystrix	1203	0.8	192400	0.2
23	Actinastrum hantzschii	1203	0.8	865800	0.8
24	Pandorina sp.	1203	0.8	1262625	1.2
25	Stephanodiscus astraea minutula	1203	0.8	841750	0.8
26	Selenastrum minutum	1203	0.8	24050	0.0
27	Pediastrum tetras	1203	0.8	360750	0.3
28	Scenedesmus bijuga	1203	0.8	168350	0.2
29	Schroderia sp.	1203	0.8	54113	0.1
30	Rhodomonas sp.	1203	0.8	24050	0.0

PHYTOPLANKTON SAMPLE ANALYSIS

SAMPLE: Bybee Lake, West end

SAMPLE DATE: 86-08-28

TOTAL DENSITY (#/ml): 25178

TOTAL BIOVOLUME (cu.uM/ml): 1.172429E+07

DIVERSITY INDEX: 4.90

--	SPECIES	DENSITY	PCT	BIOVOL	PCT
1	Stephanodiscus astraea minutula	1900	7.5	665086	5.7
2	Melosira granulata angustissima	1900	7.5	475062	4.1
3	Nitzschia acicularis	1663	6.6	465561	4.0
4	Anabaena flos-aquae	1425	5.7	1425185	12.2
5	Chlamydomonas sp.	1188	4.7	385988	3.3
6	Oscillatoria sp.	1188	4.7	2137778	18.2
7	Chrysococcus rufescens	1188	4.7	100951	0.9
8	Melosira distans	1188	4.7	329218	2.8
9	Sphaerocystis schroeteri	1188	4.7	617580	5.3
10	Scenedesmus quadricauda	1188	4.7	216153	1.8
11	Cyclotella glomerata	950	3.8	57007	0.5
12	Trachelomonas volvocina	950	3.8	1790983	15.3
13	Dictyosphaerium ehrenbergianum	713	2.8	128267	1.1
14	Cryptomonas erosa	713	2.8	370548	3.2
15	Crucigenia tetrapedia	713	2.8	121141	1.0
16	Selenastrum minutum	713	2.8	14252	0.1
17	Ankistrodesmus falcatus	475	1.9	11877	0.1
18	Pediastrum tetras	475	1.9	142519	1.2
19	Scenedesmus abundans	475	1.9	47506	0.4
20	Tetrastrum staurogeniaforme	238	0.9	51307	0.4
21	Tetraedron regulare	238	0.9	27316	0.2
22	Nitzschia sp.	238	0.9	28504	0.2
23	Crucigenia crucifera	238	0.9	20190	0.2
24	Schroderia sp.	238	0.9	10689	0.1
25	Melosira ambigua	238	0.9	699528	6.0
26	Nitzschia sp.	238	0.9	28504	0.2
27	Kirchneriella sp.	238	0.9	17102	0.1
28	Crucigenia quadrata	238	0.9	444183	3.8
29	Scenedesmus hystrix	238	0.9	38005	0.3
30	Cyclotella sp.	238	0.9	20190	0.2
31	Pediastrum duplex	238	0.9	95012	0.8
32	Rhodomonas minuta	238	0.9	4751	0.0
33	Nitzschia sp.	238	0.9	28504	0.2
34	Stephanodiscus hantzschii	238	0.9	28504	0.2
35	Tetraedron caudatum	238	0.9	9501	0.1
36	Coscinodiscus sp.	238	0.9	356296	3.0
37	Scenedesmus acuminatus	238	0.9	57007	0.5
38	Chodatella wratislawiensis	238	0.9	14252	0.1
39	Coelastrum sp.	238	0.9	190025	1.6
40	Micractinium pusillum	238	0.9	52257	0.4

PHYTOPLANKTON SAMPLE ANALYSIS

SAMPLE: Bybee Lake, Staff gage

SAMPLE DATE: 86-08-28

TOTAL DENSITY (#/ml): 36148

TOTAL BIOVOLUME (cu.uM/ml): 2.154078E+07

DIVERSITY INDEX: 4.63

--	SPECIES	DENSITY	PCT	BIOVOL	PCT
1	Anabaena flos-aquae	5247	14.5	6139309	28.5
2	Oscillatoria sp.	3207	8.9	4072467	18.9
3	Nitzschia acicularis	3207	8.9	897867	4.2
4	Melosira granulata angustissima	2915	8.1	2550758	11.8
5	Ankistrodesmus falcatus	2041	5.6	58157	0.3
6	Melosira distans	1749	4.8	751514	3.5
7	Stephanodiscus astraea minutula	1458	4.0	510152	2.4
8	Rhodomonas sp.	1166	3.2	23321	0.1
9	Crucigenia tetrapedia	1166	3.2	173452	0.8
10	Cyclotella glomerata	875	2.4	52473	0.2
11	Micractinium pusillum	875	2.4	192400	0.9
12	Sphaerocystis schroeteri	875	2.4	454764	2.1
13	Trachelomonas volvocina	875	2.4	1648518	7.7
14	Pandorina sp.	583	1.6	612182	2.8
15	Chodatella wratislawiensis	583	1.6	34982	0.2
16	Melosira ambigua	583	1.6	686810	3.2
17	Aphanizomenon flos-aquae	583	1.6	349818	1.6
18	Cyclotella sp.	583	1.6	49558	0.2
19	Dictyosphaerium ehrenbergianum	583	1.6	104945	0.5
20	Cyclotella pseudostelligera	583	1.6	37897	0.2
21	Anabaena sp.	583	1.6	583030	2.7
22	Scenedesmus quadricauda	583	1.6	75794	0.4
23	Chrysococcus rufescens	583	1.6	49558	0.2
24	Pediastrum tetras	583	1.6	174909	0.8
25	Pediastrum duplex	292	0.8	116606	0.5
26	Scenedesmus hystrix	292	0.8	46642	0.2
27	Gomphosphaeria lacustris	292	0.8	244873	1.1
28	Cryptomonas erosa	292	0.8	151588	0.7
29	Closteriopsis longissima	292	0.8	103779	0.5
30	Euglena sp.	292	0.8	169079	0.8
31	Rhodomonas minuta	292	0.8	5830	0.0
32	Nitzschia paleacea	292	0.8	28568	0.1
33	Scenedesmus acuminatus	292	0.8	69964	0.3
34	Oocystis lacustris	292	0.8	34982	0.2
35	Cryptomonas sp.	292	0.8	116606	0.5
36	Crucigenia crucifera	292	0.8	99115	0.5
37	Cyclotella kutzingiana	292	0.8	33524	0.2
38	Nitzschia sp.	292	0.8	34982	0.2

RESULTS OF 1986 COLUMBIA AND NORTH SLOUGH PHYTOPLANKTON ANALYSES

PHYTOPLANKTON SAMPLE ANALYSIS

SAMPLE: Willamette River, 0619

SAMPLE DATE: 86-05-27

TOTAL DENSITY (#/ml): 2190

TOTAL BIOVOLUME (cu.uM/ml): 2050369

DIVERSITY INDEX: 3.80

--	SPECIES	DENSITY	PCT	BIOVOL	PCT
1	Stephanodiscus hantzschii	474	21.6	56832	2.8
2	Stephanodiscus astraea minutula	414	18.9	145040	7.1
3	Asterionella formosa	296	13.5	143838	7.0
4	Melosira italica	257	11.7	1133359	55.3
5	Cyclotella sp.	79	3.6	6709	0.3
6	Chrysococcus rufescens	59	2.7	5032	0.2
7	Diatoma tenue elongatum	59	2.7	42624	2.1
8	Scenedesmus quadricauda	39	1.8	7696	0.4
9	Nitzschia acicularis	39	1.8	11051	0.5
10	Melosira distans	39	1.8	23443	1.1
11	Fragilaria construens	20	0.9	2210	0.1
12	Aphanizomenon flos-aquae	20	0.9	23680	1.2
13	Melosira varians	20	0.9	12827	0.6
14	Gomphonema sp.	20	0.9	3947	0.2
15	Achnanthes minutissima	20	0.9	987	0.0
16	Stephanodiscus subsalsus	20	0.9	1125	0.1
17	Trachelomonas sp.	20	0.9	39467	1.9
18	Cyclotella meneghiniana	20	0.9	7499	0.4
19	Synedra ulna	20	0.9	39269	1.9
20	Cyclotella pseudostelligera	20	0.9	1283	0.1
21	Cymbella minuta	20	0.9	7301	0.4
22	Rhoicosphenia curvata	20	0.9	2309	0.1
23	Navicula cryptocephala veneta	20	0.9	1875	0.1
24	Cymbella sinuata	20	0.9	2763	0.1
25	Gomphoneis herculeana	20	0.9	106560	5.2
26	Nitzschia fonticola	20	0.9	829	0.0
27	Cryptomonas erosa	20	0.9	10261	0.5
28	Gomphonema angustatum	20	0.9	3552	0.2
29	Stephanodiscus astraea	20	0.9	158695	7.7
30	Nitzschia palea	20	0.9	39072	1.9
31	Achnanthes lanceolata	20	0.9	3552	0.2
32	Fragilaria vaucheria	20	0.9	5683	0.3

PHYTOPLANKTON SAMPLE ANALYSIS

SAMPLE: Sta E, 0550

SAMPLE DATE: 86-05-27

TOTAL DENSITY (#/ml): 14271

TOTAL BIOVOLUME (cu.uM/ml): 4189771

DIVERSITY INDEX: 4.08

	SPECIES	DENSITY	PCT	BIOVOL	PCT
1	Stephanodiscus hantzschii	4587	32.1	721080	17.2
2	Scenedesmus quadricauda	1019	7.1	256414	6.1
3	Nitzschia acicularis	892	6.3	249738	6.0
4	Stephanodiscus astraea minutula	765	5.4	267576	6.4
5	Nitzschia holsatica	637	4.5	280318	6.7
6	Cryptomonas sp.	510	3.6	203868	4.9
7	Rhodomonas sp.	510	3.6	10193	0.2
8	Asterionella formosa	382	2.7	226576	5.4
9	Melosira distans	382	2.7	126395	3.0
10	Synedra rumpens	382	2.7	143344	3.4
11	Scenedesmus abundans	382	2.7	63645	1.5
12	Cyclotella kutzingiana	255	1.8	29306	0.7
13	Cyclotella meneghiniana	255	1.8	96837	2.3
14	Nitzschia palea	255	1.8	45870	1.1
15	Fragilaria construens venter	255	1.8	12232	0.3
16	Nitzschia amphibia	255	1.8	24464	0.6
17	Nitzschia clausii	255	1.8	81547	1.9
18	Ankistrodesmus falcatus	255	1.8	6371	0.2
19	Trachelomonas volvocina	127	0.9	240181	5.7
20	Cryptomonas erosa	127	0.9	66257	1.6
21	Nitzschia dissipata	127	0.9	34275	0.8
22	Cyclotella pseudostelligera	127	0.9	8282	0.2
23	Fragilaria vaucheria	127	0.9	36696	0.9
24	Achnanthes minutissima	127	0.9	6371	0.2
25	Anabaena sp.	127	0.9	127417	3.0
26	Nitzschia microcephala	127	0.9	12742	0.3
27	Melosira granulata	127	0.9	70079	1.7
28	Nitzschia paleacea	127	0.9	12487	0.3
29	Cyclotella sp.	127	0.9	10830	0.3
30	Selenastrum minutum	127	0.9	2548	0.1
31	Ochromonas sp.	127	0.9	10830	0.3
32	Nitzschia sp.	127	0.9	15290	0.4
33	Melosira ambigua	127	0.9	675439	16.1
34	Fragilaria construens	127	0.9	14271	0.3

PHYTOPLANKTON SAMPLE ANALYSIS

SAMPLE: Sta E - center, 0755

SAMPLE DATE: 86-05-24

TOTAL DENSITY (#/ml): 2782

TOTAL BIOVOLUME (cu.uM/ml): 1749490

DIVERSITY INDEX: 4.17

	SPECIES	DENSITY	PCT	BIOVOL	PCT
1	Melosira italica	438	15.7	800177	45.7
2	Stephanodiscus hantzschii	412	14.8	49452	2.8
3	Stephanodiscus astraea minutula	361	13.0	126206	7.2
4	Asterionella formosa	335	12.0	87016	5.0
5	Unident. pennate diatom	129	4.6	202831	11.6
6	Scenedesmus quadricauda	129	4.6	33483	1.9
7	Fragilaria construens venter	77	2.8	40798	2.3
8	Diatoma tenue elongatum	77	2.8	55634	3.2
9	Gomphonema angustatum	52	1.9	9272	0.5
10	Cryptomonas erosa	52	1.9	26787	1.5
11	Scenedesmus abundans	52	1.9	6439	0.4
12	Ankistrodesmus falcatus	52	1.9	1288	0.1
13	Chrysococcus rufescens	52	1.9	4379	0.3
14	Fragilaria pinnata	52	1.9	3091	0.2
15	Nitzschia amphibia	26	0.9	2473	0.1
16	Fragilaria vaucheria	26	0.9	37089	2.1
17	Fragilaria crotonensis	26	0.9	43271	2.5
18	Unident. centric diatom	26	0.9	2576	0.1
19	Navicula cryptocephala veneta	26	0.9	2447	0.1
20	Fragilaria construens	26	0.9	2885	0.2
21	Synedra ulna	26	0.9	51255	2.9
22	Achnanthes linearis	26	0.9	3400	0.2
23	Cyclotella sp.	26	0.9	2189	0.1
24	Cryptomonas ovata	26	0.9	44481	2.5
25	Tabellaria fenestrata	26	0.9	61815	3.5
26	Nitzschia palea	26	0.9	4636	0.3
27	Cryptomonas sp.	26	0.9	10303	0.6
28	Cyclotella meneghiniana	26	0.9	9787	0.6
29	Chlamydomonas sp.	26	0.9	8371	0.5
30	Cyclotella pseudostelligera	26	0.9	1674	0.1
31	Navicula contenta biceps	26	0.9	2061	0.1
32	Melosira distans	26	0.9	5100	0.3
33	Navicula sp.	26	0.9	3863	0.2
34	Cyclotella kutzingiana	26	0.9	2962	0.2

PHYTOPLANKTON SAMPLE ANALYSIS

SAMPLE: Sta E, 1047

SAMPLE DATE: 86-05-27

TOTAL DENSITY (#/ml): 3064

TOTAL BIOVOLUME (cu.uM/ml): 3140161

DIVERSITY INDEX: 3.37

--	SPECIES	DENSITY	PCT	BIOVOL	PCT
1	Melosira italica	1059	34.6	2185408	69.6
2	Stephanodiscus astraea minutula	458	15.0	160333	5.1
3	Asterionella formosa	344	11.2	111915	3.6
4	Stephanodiscus hantzschii	258	8.4	30921	1.0
5	Scenedesmus quadricauda	115	3.7	20471	0.7
6	Diatoma tenue elongatum	115	3.7	82457	2.6
7	Fragilaria construens	86	2.8	9620	0.3
8	Fragilaria construens venter	57	1.9	2749	0.1
9	Ankistrodesmus falcatus	57	1.9	1432	0.0
10	Fragilaria crotonensis	57	1.9	192400	6.1
11	Cryptomonas erosa	57	1.9	29776	0.9
12	Chrysococcus rufescens	57	1.9	4867	0.2
13	Selenastrum minutum	57	1.9	1145	0.0
14	Stephanodiscus astraea	29	0.9	230250	7.3
15	Frustulia rhomboides	29	0.9	30921	1.0
16	Cocconeis placentula	29	0.9	13170	0.4
17	Nitzschia amphibia	29	0.9	2749	0.1
18	Cyclotella meneghiniana	29	0.9	10880	0.3
19	Dinobryon sertularia	29	0.9	3436	0.1
20	Cryptomonas sp.	29	0.9	11452	0.4
21	Crucigenia quadrata	29	0.9	2434	0.1
22	Quadrigula closterioides	29	0.9	802	0.0
23	Rhodomonas minuta	29	0.9	573	0.0

PHYTOPLANKTON SAMPLE ANALYSIS

SAMPLE: Sta E, 1450

SAMPLE DATE: 86-05-27

TOTAL DENSITY (#/ml): 6992

TOTAL BIOVOLUME (cu.uM/ml): 1739622

DIVERSITY INDEX: 4.37

--	SPECIES	DENSITY	PCT	BIOVOL	PCT
1	Unident. pennate diatom	942	13.5	242372	13.9
2	Stephanodiscus hantzschii	893	12.8	107109	6.2
3	Ankistrodesmus falcatus	545	7.8	13637	0.8
4	Chrysococcus rufescens	545	7.8	46364	2.7
5	Scenedesmus quadricauda	496	7.1	119258	6.9
6	Stephanodiscus astraea minutula	446	6.4	156201	9.0
7	Melosira distans	347	5.0	98282	5.6
8	Asterionella formosa	298	4.3	70436	4.0
9	Cryptomonas erosa	298	4.3	154713	8.9
10	Selenastrum minutum	298	4.3	7914	0.5
11	Scenedesmus abundans	198	2.8	32232	1.9
12	Cryptomonas sp.	149	2.1	59505	3.4
13	Pediastrum duplex	99	1.4	39670	2.3
14	Melosira italica	99	1.4	140135	8.1
15	Scenedesmus acuminatus	99	1.4	23802	1.4
16	Nitzschia amphibia	99	1.4	9521	0.5
17	Melosira granulata	99	1.4	54546	3.1
18	Fragilaria pinnata	99	1.4	8926	0.5
19	Chlamydomonas sp.	99	1.4	32232	1.9
20	Dinobryon sertularia	99	1.4	11901	0.7
21	Fragilaria construens	99	1.4	11108	0.6
22	Melosira ambigua	50	0.7	29207	1.7
23	Tetraedron caudatum	50	0.7	1984	0.1
24	Stephanodiscus subsalsus	50	0.7	5653	0.3
25	Sphaerocystis schroeteri	50	0.7	25786	1.5
26	Navicula sp.	50	0.7	7438	0.4
27	Crucigenia quadrata	50	0.7	4215	0.2
28	Navicula minima	50	0.7	2182	0.1
29	Trachelomonas granulosa	50	0.7	178020	10.2
30	Rhodomonas minuta	50	0.7	992	0.1
31	Synedra rumpens	50	0.7	18595	1.1
32	Fragilaria vaucheria	50	0.7	14281	0.8
33	Scenedesmus denticulatus	50	0.7	8926	0.5
34	Achnanthes minutissima	50	0.7	2479	0.1

PHYTOPLANKTON SAMPLE ANALYSIS

SAMPLE: Sta E, 1709

SAMPLE DATE: 86-05-27

TOTAL DENSITY (#/ml): 13280

TOTAL BIOVOLUME (cu.uM/ml): 3108546

DIVERSITY INDEX: 4.19

--	SPECIES	DENSITY	PCT	BIOVOL	PCT
1	Unident. pennate diatom	2614	19.7	512370	16.5
2	Stephanodiscus hantzschii	1673	12.6	200765	6.5
3	Scenedesmus quadricauda	1150	8.7	210835	6.8
4	Rhodomonas minuta	1150	8.7	23004	0.7
5	Cryptomonas erosa	732	5.5	380617	12.2
6	Rhodomonas sp.	627	4.7	12548	0.4
7	Ankistrodesmus falcatus	627	4.7	15685	0.5
8	Cryptomonas sp.	523	3.9	209130	6.7
9	Stephanodiscus astraea minutula	418	3.1	146391	4.7
10	Melosira sp.	418	3.1	261413	8.4
11	Scenedesmus abundans	314	2.4	62739	2.0
12	Selenastrum minutum	209	1.6	4183	0.1
13	Crucigenia tetrapedia	209	1.6	17776	0.6
14	Navicula pupula	209	1.6	56465	1.8
15	Melosira ambigua	209	1.6	369533	11.9
16	Dinobryon sertularia	209	1.6	25096	0.8
17	Cyclotella pseudostelligera	209	1.6	13593	0.4
18	Stephanodiscus subsalsus	209	1.6	47682	1.5
19	Asterionella formosa	209	1.6	37225	1.2
20	Achnanthes lewisiana	105	0.8	13071	0.4
21	Anabaena sp.	105	0.8	104565	3.4
22	Cyclotella kutzingiana	105	0.8	12025	0.4
23	Unident. pennate diatom	105	0.8	36598	1.2
24	Amphora perpusilla	105	0.8	17358	0.6
25	Achnanthes minutissima	105	0.8	5228	0.2
26	Melosira distans	105	0.8	20704	0.7
27	Crucigenia quadrata	105	0.8	8888	0.3
28	Trachelomonas hispida	105	0.8	219587	7.1
29	Fragilaria construens	105	0.8	11711	0.4
30	Cyclotella sp.	105	0.8	8888	0.3
31	Chrysococcus rufescens	105	0.8	8888	0.3
32	Chlamydomonas sp.	105	0.8	33984	1.1

PHYTOPLANKTON SAMPLE ANALYSIS

SAMPLE: North Slough, 1113

SAMPLE DATE: 86-05-27

TOTAL DENSITY (#/ml): 13837

TOTAL BIOVOLUME (cu.uM/ml): 4346370

DIVERSITY INDEX: 4.09

	SPECIES	DENSITY	PCT	BIOVOL	PCT
1	Stephanodiscus hantzschii	3953	28.6	488643	11.2
2	Scenedesmus quadricauda	1186	8.6	248236	5.7
3	Melosira distans	1186	8.6	469667	10.8
4	Cryptomonas erosa	791	5.7	411156	9.5
5	Crucigenia tetrapedia	527	3.8	44805	1.0
6	Nitzschia holsatica	527	3.8	304414	7.0
7	Ankistrodesmus falcatus	395	2.9	9884	0.2
8	Sphaerocystis schroeteri	395	2.9	205578	4.7
9	Cyclotella sp.	395	2.9	33604	0.8
10	Asterionella formosa	395	2.9	234335	5.4
11	Cryptomonas sp.	395	2.9	158137	3.6
12	Melosira ambigua	395	2.9	388871	8.9
13	Anabaena sp.	395	2.9	395342	9.1
14	Fragilaria construens venter	264	1.9	12651	0.3
15	Fragilaria pinnata	264	1.9	15814	0.4
16	Crucigenia quadrata	264	1.9	22403	0.5
17	Nitzschia frustulum	132	1.0	15814	0.4
18	Stephanodiscus astraea minutula	132	1.0	46123	1.1
19	Nitzschia clausii	132	1.0	42170	1.0
20	Melosira italica	132	1.0	248275	5.7
21	Rhodomonas minuta	132	1.0	2636	0.1
22	Chlorella sp.	132	1.0	7907	0.2
23	Unident. green alga	132	1.0	19767	0.5
24	Cryptomonas ovata	132	1.0	227585	5.2
25	Amphora ovalis	132	1.0	76169	1.8
26	Cyclotella meneghiniana	132	1.0	50077	1.2
27	Eunotia sp.	132	1.0	59301	1.4
28	Nitzschia sp.	132	1.0	15814	0.4
29	Pediastrum duplex	132	1.0	52712	1.2
30	Scenedesmus denticulatus	132	1.0	5930	0.1
31	Achnanthes linearis	132	1.0	17395	0.4
32	Cyclotella kutzingiana	132	1.0	15155	0.3

PHYTOPLANKTON SAMPLE ANALYSIS

SAMPLE: North Slough

SAMPLE DATE: 86-08-28

TOTAL DENSITY (#/ml): 22738

TOTAL BIOVOLUME (cu.uM/ml): 1.244701E+07

DIVERSITY INDEX: 4.76

--	SPECIES	DENSITY	PCT	BIOVOL	PCT
1	Anabaena flos-aquae	3061	13.5	3703700	29.8
2	Nitzschia acicularis	2186	9.6	612182	4.9
3	Melosira granulata angustissima	1968	8.7	1421683	11.4
4	Scenedesmus quadricauda	1312	5.8	198675	1.6
5	Stephanodiscus astraea minutula	1093	4.8	382614	3.1
6	Melosira distans	1093	4.8	432900	3.5
7	Ankistrodesmus falcatus	875	3.8	21864	0.2
8	Anacystis sp.	656	2.9	196773	1.6
9	Crucigenia tetrapedia	656	2.9	111505	0.9
10	Trachelomonas volvocina	656	2.9	1236389	9.9
11	Oscillatoria sp.	656	2.9	655909	5.3
12	Cyclotella glomerata	656	2.9	39355	0.3
13	Dictyosphaerium ehrenbergianum	437	1.9	78709	0.6
14	Cyclotella pseudostelligera	437	1.9	28423	0.2
15	Tetraedron sp.	437	1.9	11806	0.1
16	Pediastrum tetras	437	1.9	131182	1.1
17	Anabaena sp.	437	1.9	437273	3.5
18	Fragilaria pinnata	437	1.9	26236	0.2
19	Melosira ambigua	437	1.9	1545322	12.4
20	Cyclotella meneghiniana	437	1.9	166164	1.3
21	Stephanodiscus subsalsus	219	1.0	24925	0.2
22	Achnanthes minutissima	219	1.0	10932	0.1
23	Tetraedron regulare	219	1.0	25143	0.2
24	Cyclotella kutzingiana	219	1.0	25143	0.2
25	Navicula cryptocephala	219	1.0	40448	0.3
26	Scenedesmus abundans	219	1.0	21864	0.2
27	Tetrastrum staurogeniaforme	219	1.0	47225	0.4
28	Pandorina sp.	219	1.0	229568	1.8
29	Achnanthes linearis	219	1.0	28860	0.2
30	Phacus sp.	219	1.0	76523	0.6
31	Fragilaria construens venter	219	1.0	10495	0.1
32	Fragilaria construens	219	1.0	24487	0.2
33	Stephanodiscus hantzschii	219	1.0	26236	0.2
34	Selenastrum minutum	219	1.0	17491	0.1
35	Chrysococcus rufescens	219	1.0	18584	0.1
36	Nitzschia palea	219	1.0	39355	0.3
37	Scenedesmus denticulatus	219	1.0	19677	0.2
38	Coelastrum sp.	219	1.0	174909	1.4
39	Unident. green alga	219	1.0	32795	0.3
40	Cryptomonas erosa	219	1.0	113691	0.9

PHYTOPLANKTON SAMPLE ANALYSIS

SAMPLE: Columbia Slough

SAMPLE DATE: 86-08-28

TOTAL DENSITY (#/ml): 38197

TOTAL BIOVOLUME (cu.uM/ml): 9825270

DIVERSITY INDEX: 3.81

--	SPECIES	DENSITY	PCT	BIOVOL	PCT
1	Cyclotella pseudostelligera	7639	20.0	496562	5.1
2	Scenedesmus quadricauda	5376	14.1	1212530	12.3
3	Stephanodiscus astraea minutula	5093	13.3	1782530	18.1
4	Melosira distans	3678	9.6	1456581	14.8
5	Cyclotella glomerata	3395	8.9	220015	2.2
6	Rhodomonas minuta	1698	4.4	33953	0.3
7	Nitzschia palea	1415	3.7	356506	3.6
8	Cryptomonas erosa	1415	3.7	735647	7.5
9	Stephanodiscus hantzschii	1132	3.0	135812	1.4
10	Scenedesmus abundans	1132	3.0	169765	1.7
11	Stephanodiscus subsalsus	849	2.2	64349	0.7
12	Pandorina sp.	566	1.5	594176	6.0
13	Selenastrum minutum	566	1.5	33953	0.3
14	Cryptomonas ovata	566	1.5	977279	9.9
15	Melosira ambigua	283	0.7	833262	8.5
16	Achnanthes hungarica	283	0.7	43856	0.4
17	Chlamydomonas sp.	283	0.7	91956	0.9
18	Tetraedron regulare	283	0.7	32538	0.3
19	Synedra rumpens	283	0.7	106103	1.1
20	Scenedesmus acuminatus	283	0.7	67906	0.7
21	Navicula pupula	283	0.7	76394	0.8
22	Pediastrum duplex	283	0.7	113176	1.2
23	Chrysococcus rufescens	283	0.7	24050	0.2
24	Crucigenia quadrata	283	0.7	24050	0.2
25	Asterionella formosa	283	0.7	50364	0.5
26	Cyclotella sp.	283	0.7	24050	0.2
27	Nitzschia frustulum	283	0.7	67906	0.7

TABLES C

VEGETATION TRANSECTS AT SMITH AND BYBEE LAKES: 1982 AND 1986

SMITH-BYBEE LAKES

VEGETATION TRANSECTS

10/29/82

#1. Bybee Lhke outlet channel, south side

Channel

STAKE

lake level

43'	Emergent	Polygonum spp., Equisetum, Eleocharis, Potentilla, cudweed, Bidens, liverwort, rice cut grass, Mazus (?).
10'	Shrub	Pacific willow. some forb understory - swamp smartweed.
46'	Shrub	Taller Pacific willow. no understory.
STAKE		
10'	Canopy break	A few young ash trees.
21'	Forested	Pacific willow. Carex understory.
42'	Forest	Mature ash. Reed canarygrass understory. Scattered Carex, mature Pacific willow, young red-osier dogwood

STAKE

TRANSECT 1 REVISITED:

SCIENTIFIC RESOURCES, INC. SEPTEMBER 7, 1986

No transect markers found. Starting at channel into Bybee Lake, scattered Polygonum coccineum, then shrub Pacific willows, most dead. Walking toward North Slough in water where shrub willows were standing there was some Polygonum hydropiperoides, but generally no other vegetation in water at base of older Pacific Willow trees. At slightly higher elevation, soggy but not inundated soils, some scattered young Oregon ash trees with mature Pacific Willow trees and understory of scattered reed canarygrass. Moving toward North Slough, at higher elevation, Pacific Willow trees with understory of reed canarygrass, occasional red osier dogwood, Carex aperta. Occasional mature ash trees in with Pacific willow.

SMITH-BYBEE LAKES

VEGETATION TRANSECTS

10/29/82

#2. SE corner Smith Lake. PEMY wetland, east side, east to west.

STAKE

50'

Carex, reed canarygrass. 100% cover

STAKE

56'

Polygonum spp. Mostly 1 species, but crosses a patch of swamp smartweed. Standing water (rain). Smartweed dead.

STAKE

TRANSECT 2 REVISITED:

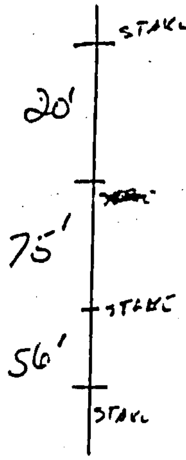
SCIENTIFIC RESOURCES, INC. SEPTEMBER 15, 1986

No transect stakes found. This large ephemeral pond had nearly evaporated, exposing *Polygonum hydropiperoides* in the center of the pond, and at the edge of the center, narrow stem variety of wapato (*Sagittaria latifolia*). Earlier, when there was more water in this pond, ducks were cropping the wapato. Moving across the exposed bottom towards the shoreline, the water fern was abundant. Near the shoreline was scattered reed canarygrass, then a band of *Carex aperta*, then a dense band of *Bidens cernua*, and finally a surrounding grassland of reed canarygrass.

SMITH-BYBEE LAKES

VEGETATION TRANSECTS 10/29/82

#3. SE corner Smith Lake. PEMY wetland, south side. south to north.



Forested	Pacific willow fringe, mature trees. Reed canarygrass understory.
Emergent	Polygonum sp. Same as Transect #2. stake in deeper water.
Emergent	Polygonum spp. Crosses patch of swamp smartweed.

TRANSECT 3 REVISITED:

SCIENTIFIC RESOURCES, INC. SEPTEMBER 15, 1986

No transect stakes found. The vegetation in the then exposed pond bottom was Polygonum hydropiperoides, then Sagittaria latifolia (wapato). The Mexican water fern was abundant on the exposed mud bottom. At the edge of the exposed bottom were younger then mature Pacific willow trees with juvenile Oregon ash common. At slightly higher elevation reed canarygrass became the only understory.

SMITH-BYBEE LAKES

VEGETATION TRANSECTS

11/2/82

#4. Bybee Lake, NW corner

Distance	Zone	Description
10'	Emergent	_Carex_ upland
10'	Emergent	Mixed _Carex_, _Equisetum_, _Potentilla_.
23'	Shrub	Small Pacific willow. Understory of _Carex_, _Potentilla_, _Equisetum_.
225' (8.5' – STAKE – 14')	Emergent	_Eleocharis_ with scattered ~~klux~~ plants of wapato. Very wet and soft.
39' (lake level)	Shrub/forest	Mature Pacific willow. Little understory.
54'	Emergent	Bybee Lake. _Bidens_, _Eleocharis_, _Equisetum_, swamp smartweed, _Azoila_, _Calitriche_ (?), scattered clumps pf wapato further out. Water up so some plants covered that normally grow out of water.

STAKE

TRANSECT 4 REVISITED:

SCIENTIFIC RESOURCES, INC. 28 AUGUST 1986

There was no marker found to identify the exact location of the transect. A most likely site was found using transect locations on photograph provided by Ellifrit (see Photo Appendix E). The increased elevation of the water, the lack of previous markers, and the previous length of the transect led to choice of a transect leading from the now flooded area lying between Bybee and Smith Lakes to Bybee Lake. Along this transect, approximately 220 ft from water's edge to water's edge, was a slight rise in elevation which creates the penninsula between the lakes. At the edge of the interior flooded area and moving towards Bybee Lake, Pacific willow extended from in water onto the shoreline. The understory of the shoreline was *Carex aperta* with occasional young Oregon ash trees. Present also on the shoreline was *Veronica*, *Polygonum* sp., and trailing blackberry. At slightly higher elevation along the transect was reed canarygrass with occasional Douglas spiraea and red osier dogwood. Nearing Bybee Lake shoreline vegetation changed to *Carex aperta*, which appeared to be cropped by geese or ducks. Other plants present on the shoreline exposed during summer were *Solanum dulcamara*, *Potentilla*, *Equisetum*, *Eleocharis*, *Cirsium arvense*, and *Aster chilensis*. Within the lake water were Pacific willow trees, moving out changing to scrub shrub Pacific willow trees that were dead. From the lake shore out fifty feet growing among the willows was the submersed plant *Potamogeton crispus*. No wapato was observed along the transect.

11/2/82

SMITH-BYBEE LAKES

VEGETATION TRANSECTS

#5. Spit of land between Smith and Bybee Lakes, north side. 2 finger wetlands. Wapato transplant. 2 plants each stake. Standing water.

PEMY wetlands like Transects #2 and 3.

(5dm)

STAKE Emergent Reed canarygrass mixed with _Carex_.

16.25'

STAKE Emergent Break between _Carex_ and _Polygonum_ sp. Small ash.

16.25'

STAKE Emergent _Polygonum_ sp. Scattered _Nummularia_.

16.25'

STAKE Emergent _Polygonum_ sp.

16.25'

STAKE Emergent _Polygonum_ sp.

TRANSECT 5 REVISITED:

SCIENTIFIC RESOURCES, INC. AUGUST 28, 1986

One stake of the five original ones was found in 2.5 ft of water. There was generally open water, with scattered _Polygonum coccineum_, near the stake. At the shoreline was a mud flat with three wapato plants (_Sagittaria latifolia_). These appeared to be the plants transplanted by Lightcap. No other wapato was found. On the exposed mud the water fern (_Azolla mexicana_) was abundant. _Carex aperta_ was growing at a slightly higher elevation near the mud flat, and above that reed canarygrass.

SMITH-BYBEE LAKES

VEGETATION TRANSECTS

11/2/82

#6. Spit of land between Smith and Bybee lakes, north side. Depression, will not be flooded.

	Forested	Cottonwood
24'	Emergent	Reed canarygrass
33'	Emergent	Dead *Carex*
75'	Emergent	live *Carex*.
18'	Disturbed	Road.
39'	Emergent	Reed Canarygrass.
75'	Emergent	*Carex* - to low spot.

STAKE

TRANSECT 6 REVISITED:

SCIENTIFIC RESOURCES, INC. AUGUST 28, 1986

No stake found at low spot of this 'ephemeral pond' location. The vegetation along the transect from the low spot of this then dry pond to the tall black cottonwood trees toward Marine Drive was the same as previously reported. Scattered *Epilobium watsonii* occurred among the *Carex aperta* in the lowest area of the then dry pond.

SMITH-BYBEE LAKES

VEGETATION TRANSECTS

11/2/82

#7. NW corner Smith Lake. NW to SE

	Forested	Ash tree
66'	Emergent	High. Mostly reed canarygrass, occasional ash, Columbia River and Pacific willow, red-osier dogwood, cottonwood.
55'	Shrub/Forested	Pacific willow. Understory - Potentilla, Equisetum, swamp smartweed, reed canarygrass.
66' (upper lake level)	Forested	Pacific willow, no understory.
26'	Emergent	Swamp smartweed, occasional Eleocharis.
75'	Shrub	Scrub Pacific willow, very dense. Occasional swamp smartweed.
	Emergent	Smith Lake - almost totally covered with swamp smartweed.

TRANSECT 7 REVISITED:

SCIENTIFIC RESOURCES, INC. AUGUST 2, 1986

No transect markers found. Generally vegetation from Smith Lake into shore was same as observed in 1982. At the shoreline, only sparse Eleocharis, with occasional Potentilla, and Equisetum. The understory of the Pacific willow is reed canarygrass, with occasional Polygonum sp. (not coccineum). At slightly higher elevation Oregon ash and understory of reed canrygrass. At higher elevation toward Marine Drive, mature black cottonwood, with understory of Himalayan blackberry, red osier dogwood.

F AQUATIC INVERTEBRATES

FISHMAN ENVIRONMENTAL SERVICES
P.O. BOX 19023 PORTLAND, OR 97219

SMITH AND BYBEE LAKES ENVIRONMENTAL STUDIES

TECHNICAL APPENDIX F: AQUATIC INVERTEBRATES

Project Sponsored by:

Port of Portland

and

City of Portland
Bureau of Environmental Services

Prepared by:

Paul A. Fishman
Fishman Environmental Services

DECEMBER, 1986

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02199
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Paul A. Fishman

FISHMAN

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1 INTRODUCTION

Collections of zooplankton and benthic invertebrates from the Smith and Bybee Lakes study area were designed at a "survey" level.[1] The objective of these collections was to gather information on species composition, relative abundance, and community composition through the study period, and relate these factors to other wetland parameters.

2 METHODS

Zooplankton samples were collected with a 0.5 m diameter net with 130 μ mesh. All samples consisted of 5 vertical hauls through 3 to 5 feet of water. Sampling was accomplished either from a boat, or from the three bridges across Columbia Slough in the study area. Samples were preserved in 10% buffered formalin.

Benthic invertebrate samples were collected with a 0.024 sq m Ekman sampler. Sediments from the sampler were field screened through a 1.0 mm mesh; material retained on the screen was preserved in 10% buffered formalin.

The objective of the zooplankton analyses was to determine the relative abundance of species in each sample, rather than a total percent abundance by species. A representative portion of each sample was examined; the number of animals counted varied with the size and diversity of samples. The number of animals counted per sample ranged from about 200 to 530; relative species abundances were expressed as percent of total count. Animals were identified to the lowest possible taxonomic level.

Benthic samples were examined, and animals were separated from sediment and/or debris. Benthic animals were identified and counted, and notes were kept concerning the

----

1. Zooplankton refers to generally microscopic animals found in natural waters. The term "benthic" refers to the bottom of a body of water.

type of material in each sample. Identifications were to major taxonomic category rather than Genera or species. The volume of detritus, or organic material, in each sample was measured by water displacement.

3 RESULTS

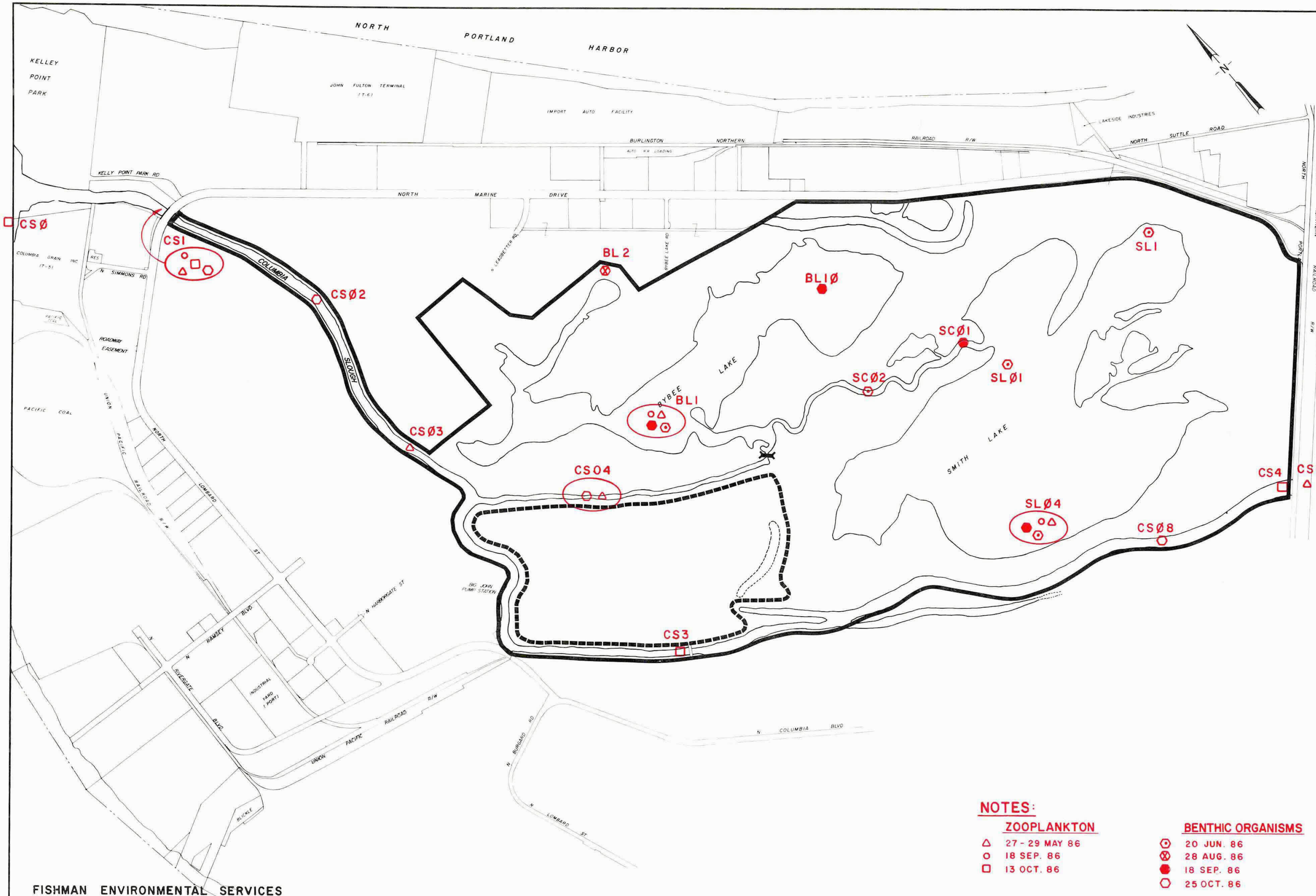
The distributions of plankton and benthic samples through time and space are presented in Figure F-1.

3.1 Zooplankton

The relative zooplankton counts for late May, mid September and mid October are presented in Tables F-1 through F-3. Table F-4 presents a summary of relative abundance by major taxonomic categories; the table also indicates the tidal condition in Columbia Slough during the sampling.

Zooplankton sampled in Smith and Bybee Lakes was similar in the two lakes in terms of abundance of general taxonomic categories (Table F-4). The May samples were dominated by the same species of Cladoceran (water flea). The September samples showed that Cladoceran populations had greatly decreased, and the samples were dominated by rotifers and cyclopoid copepods in Smith Lake, and cyclopoid copepods in Bybee Lake. The major difference during September was the greater abundance of rotifers in the Smith Lake sample.

Zooplankton samples from Columbia Slough in May were dominated either by cladocerans or rotifers. Differences in species composition in these samples might be explained on the basis of the water being sampled. The water sampled at CS1 was river water coming into the slough on the rising tide, while the samples at CSO3 and CS5 were from slough water on the falling tide. The river water had a cladoceran population dominated by the species Bosmina longirostris, with abundance similar to the lakes and North Slough (station CSO4). The abundance of B. longirostris was much lower in the slough water. Samples from the slough water, on the other hand, were dominated by rotifers, particularly the species Brachionus calyciflorus and Polyarthra vulgaris; abundance of these species in lake and river water was much lower.



FISHMAN ENVIRONMENTAL SERVICES

LEGEND

DATUM — ALL ELEVATIONS = USGS.
LANDFILL DIKE
CONTROL STRUCTURE
TREE / SHRUB LINE-SMITH & BYBEE LAKES, SHORELINE-COLUMBIA SLOUGH
STUDY AREA BOUNDARY / TOP OF BANK (APPROX. 30 FT.)

Port of Portland

GRAPHIC SCALE IN FEET

500 0 500 1000 1500 2000 2500

DECEMBER , 1986

SMITH AND BYBEE LAKES
MANAGEMENT PLAN
ENVIRONMENTAL STUDIES
INVERTEBRATE SAMPLING STATIONS

SENIOR PLANNER, LAND DEVELOPMENT

RG 86-511 22/23 (C-22)

FIGURE F - 1

TABLE F-1

RELATIVE ZOOPLANKTON COUNTS
from the AREA of the COLUMBIA-WILLAMETTE CONFLUENCE

COLLECTION PERIOD: 27-29 May 1986
COUNTING DATES: 24-25 October 1986

Species	% of Total Count					
SAMPLE IDENTIFICATION:	CS03 St. A	CS5 St. B (Col.Sl.)	CS1 Rivergate Brdg. (Col.Sl.)	CS04 St. D (N.Sl.)	BL1 Bybee Lake	SL04 Smith Lake
Subphylum CRUSTACEA						
Cladocerans						
Alona costata (?)	0.2	--	0.9	--	--	--
Bosmina longirostris	23.8	14.0	55.5	57.4	79.3*	50.2
Ceriodaphnia pulchella	0.2	1.6	0.9	1.0	0.3	9.3
Chydorus sphaericus	1.8	3.5	1.7	0.3	0.3	3.4
Daphnia spp.	1.8	1.0	8.8	4.6	3.0	--
(galeata mendotae, pulex, rosea & schødleri)						
Eubosmina hagmanni	--	--	0.4	--	-- *	4.9
Macrothrix laticornis	--	0.1	--	--	--	--
Calanoid Copepods	--	--				
Diaptomus franciscanus			0.9	--	0.3	2.9
Diaptomus copepodites			2.5	0.7	1.2	7.8
Cyclopoid Copepods						
Cyclops spp.	3.7	2.7	3.0	5.6	4.8	6.8
(bicuspidatus thomasi, varicans rubellus & vernalis)						
Cyclops copepodites	5.3	3.5	4.7	7.0	5.9	6.8
Harpacticoid Copepods	--	--	--	--	--	--
Copepod nauplii	5.9	2.9	5.1	5.6	3.6	6.4
Phylum ROTIFERA						
Asplanchna priodonta	2.8	11.3	2.1	5.3	0.7	1.5
Brachionus calyciflorus	25.2	40.8	12.0	1.6	0.3	--
B. rubens (?)	0.4	2.1	--	0.3	--	--
Euchlanis dilatata (?)	--	--	0.4	--	--	--
Kellicottia bostoniensis	--	--	5.6	--	--	--
Keratella cochlearis	--	--	0.4	--	--	--
Polyarthra vulgaris	28.2	15.1	--	10.6	0.3	--
Synchaeta oblonga	0.7	1.4	--	--	--	--
Other Zooplankton	--	--	--	--	--	--
Total Numbers Counted:	457	451#	234	303	392	205
Total Species Observed:	12	12	17	11	11*	8

#: Rotifers counted separately from crustaceans due to their very high numbers.
*: A few of the bosminids counted as B. longirostris are probably E. hagmanni in this sample, but they are less than 5% of the total numbers of B. longirostris. The total number of species observed for Bybee Lake assumes that E. hagmanni is present. I counted Bybee Lake before Smith Lake and only positively distinguished the two species in Smith Lake.

TABLE F-2

RELATIVE ZOOPLANKTON COUNTS
from the AREA of the COLUMBIA-WILLAMETTE CONFLUENCE

COLLECTION PERIOD: 18 September 1986
COUNTING DATES: 25 & 31 October 1986

Species	% of Total Count		
SAMPLE IDENTIFICATION:	CS1 Rivergate Brdg. (Col.Sl.)	BL1 Bybee Lake	SL04 Smith Lake
Subphylum CRUSTACEA			
Cladocerans			
Alona costata (?)	--	--	0.2
Bosmina longirostris	20.0	1.1	5.3
Ceriodaphnia pulchella	--	0.4	0.7
Chydorus sphaericus	0.5	0.4	0.7
Daphnia spp. (galeata mendotae & pulex)	7.9	1.1	0.2
Diaphanosoma brachyurum	0.5	1.1	5.1
Leptodora kindti	--	--	0.2
Moina brachiata	--	--	0.2
Pleuroxus aduncus	2.7	--	--
Calanoid Copepods			
Diaptomus spp. (connexus (?), franciscanus & novamexicanus)	1.4	3.0	0.2
Diaptomus copepodites	7.4	1.1	2.2
Cyclopoid Copepods			
Cyclops spp. (bicuspidatus thomasi, varicans rubellus & vernalis)	19.0	36.0	9.8
Cyclops copepodites	21.4	42.4	22.9
Eucyclops agilis	--	2.3	--
Harpacticoid Copepods (either Canthocamptus sp. or Mesochra sp.)	--	0.8	--
Copepod nauplii	14.0	5.7	11.3
Phylum ROTIFERA			
Asplanchna priodonta	--	1.5	0.7
Brachionus calyciflorus	3.7	1.9	15.8
Euchlanis dilatata (?)	0.5	--	--
Kellicottia bostoniensis	--	--	0.4
Polyarthra vulgaris	--	--	24.1
Synchaeta oblonga	--	0.8	--
Other Zooplankton			
Chironomid larvae	0.5	--	--
nematode	--	0.4	--
immature oligochaete	0.5	--	--
Total Numbers Counted:	215	264	532
Total Species Observed:	13	15	15

TABLE F-3

RELATIVE ZOOPLANKTON COUNTS from the AREA of the COLUMBIA-WILLAMETTE CONFLUENCE

COLLECTION PERIOD: 13 October 1986
COUNTING DATES: 25 & 31 October and 1 November 1986

Species	% of Total Count			
SAMPLE IDENTIFICATION:	CS1 Columbia Rivergate	CS3 River Sl. Landfill	CS4 Bridges Portland Rd.	CSO Willamette River
Subphylum CRUSTACEA				
Cladocerans				
Acroperus harpae	--	--	--	0.4
Alona costata (?) & sp.	--	0.6	2.6	--
Bosmina longirostris	8.0	3.1	5.0	34.7
Chydorus sphaericus	1.4	0.6	0.3	1.2
Daphnia spp. (pulex & rosea)	--	--	0.3	4.2
Diaphanosoma brachyurum	--	0.3	--	0.4
Macrothrix laticornis	0.7	--	0.8	--
Pleuroxus aduncus	25.6	69.4	69.2	5.7
Calanoid Copepods				
Diaptomus novamexicanus	0.4	--	--	1.2
Diaptomus copepodites	0.7	--	--	3.4
Cyclopoid Copepods				
Cyclops bicuspidatus thomasi	17.7	7.4	1.3	6.5
Cyclops copepodites	29.2	4.9	2.1	11.8
Harpacticoid Copepods				
Bryocamptus washingtonensis	1.1	0.3	0.8	1.5
either Canthocampus sp. or Mesochra sp.	--	--	--	5.0
Copepod nauplii	3.6	1.9	0.5	11.0
Phylum ROTIFERA				
Asplanchna priodonta	3.2	1.9	--	--
Brachionus calyciflorus	8.0	8.0	10.5	1.1
B. rubens (?)	--	--	--	0.4
Polyarthra vulgaris	--	--	6.3	1.9
Rotaria neptunia (?)	--	0.3	--	--
Other Zooplankton				
Chironomid larvae	--	--	--	0.4
nematode	--	--	--	2.7
immature oligochaete	0.4	1.2	--	5.7
ostracod	--	--	0.3	--
Total Numbers Counted:	277	323	381	262
Total Species Observed:	10	11	12	18

TABLE F-4

ZOOPLANKTON SUMMARY
SMITH AND BYBEE LAKES STUDY AREA, 1986

STATION		DATE	RELATIVE ABUNDANCE WITHIN SAMPLE (%) CLADOCERA	CALANOID COPEPOD	CYCLOPOID COPEPOD	HARPACTICOID COPEPOD	COPEPOD NAUPLII	ROTIFER	OTHERS
Smith Lake									
	SL04	MAY	67.8	10.7	13.6	0	6.4	1.5	0
		SEP	12.6	2.4	32.7	0	11.3	41	0
Bybee Lake									
	BL1	MAY	82.9	1.5	10.7	0	3.6	1.3	0
		SEP	4.1	4.1	80.7	.8	5.7	4.2	.4
Columbia Slough									
	CS1	MAY +	68.2	3.4	7.7	0	5.1	20.5	0
		SEP -	31.6	8.8	40.4	0	14	4.2	1
		OCT -	35.7	1.1	46.9	1.1	3.6	11.2	.4
	CS0	OCT	46.6	4.6	18.3	6.5	11	3.4	8.8
	CS03	MAY -	27.8	9	9	0	5.9	57.3	0
	CS04	MAY	63.3	13.3	12.6	0	5.6	17.8	0
	CS3	OCT -	74	0	12.3	.3	1.9	10.2	1.2
	CS4	OCT -	78.2	0	3.4	.8	.5	16.8	.3
	CS5	MAY -	20.2	6.2	6.2	0	2.9	70.7	0

+ = tide flowing (rising)
- = tide ebbing (falling)

The September and October Columbia Slough samples still showed moderate to high relative abundance for cladocerans, with cyclopoid copepods more abundant than during May.

3.2 Benthic Invertebrates

The numbers of animals per sample, and the calculated numbers per square meter for benthic samples are presented in Table F-5.

Oligochaete worms were the dominant organism in all samples. These worms were, with the exception of a small number of midge fly larvae (Chironomidae) the only benthic organisms found in the Smith Lake samples and, except for 2 clams and some "other" organisms, were the only organisms found in Columbia Slough samples. Bybee Lake and Smith Channel samples contained small to moderate numbers of midge fly larvae, some phantom midge fly larvae (Chaoborus), and a few "others."

The characteristics of sample sediment are shown in Table F-6. Data for percent silt and sand are from Fishman Environmental Services (1986a).

4 DISCUSSION

Some trends are evident in the data for invertebrates collected in the study area. It is important to keep in mind, however, that this was a survey level study rather than an in-depth assessment; any conclusions drawn from non-replicated sampling must be kept in this context.

4.1 Zooplankton

The two previous studies of zooplankton in Smith and Bybee Lakes are summarized by Fishman Environmental Services (1985). The data from 1982 (Clifton 1983) showed a peak in zooplankton abundance in both lakes during June, very low abundance by mid-August, and a second peak during October (see Figure 2.2-1, Fishman Environmental Services 1985).

TABLE F-5

BENTHIC INVERTEBRATES SAMPLED IN
SMITH AND BYBEE LAKES STUDY AREA, 1986

----------NUMBER OF INDIVIDUALS PER SAMPLE / NUMBER PER SQUARE METER----------

STATION		DATE	OLIGOCHAETE WORM	CHIRONOMID LARVA	CHIRONOMID PUPA	CHAOBORUS LARVA	NEMATODE WORM	CLAM	OTHER	TOTAL
Smith Lake										
	SL1	20JUN86	6/250	0	0	0	0	0	0	6/250
	SL01	20JUN86	20/833	2/83	0	0	0	0	0	22/916
	SL04	20JUN86	7/292	2/83	0	0	0	0	0	9/375
	SL04	18SEP86	15/655	0	0	0	0	0	0	15/655
Smith Channel										
	SC01	18SEP86	34/1417	0	0	9/375	0	0	1/42	44/1834
	SC02	20JUN86	6/250	2/83	0	3/125	0	0	0	11/458
Bybee Lake										
	BL1	20JUN86	46/1917	18/750	1/42	0	0	0	0	65/2709
	BL1	18SEP86	20/833	4/167	0	7/292	1/42	0	0	32/1334
	BL10	18SEP86	3/125	3/125	0	0	0	0	1/42	7/292
Columbia Slough										
	CS1	25OCT86	1/42	0	0	0	0	0	0	1/42
	CS02	25OCT86	20/833	0	0	0	0	1/42	0	21/875
	CS04	25OCT86	24/1000	0	0	0	0	0	0	24/1000
	CS08	25OCT86	158/6584	0	0	0	0	1/42	7/292	166/6918

---

oligochaete = fresh water earthworm
Chironomid = midge fly
Chaoborus = phantom midge fly

TABLE F-6

BENTHIC SAMPLE SEDIMENT CHARACTERISTICS

STATION	DATE	% SILT	% SAND	% DETRITUS
SL1	20JUN86	78.1	21.9	5.8
SL01	20JUN86	90.2	9.8	N/A
SL04	20JUN86	97.5	2.5	0.4
SL04	18SEP86	96.4	3.6	0.2
SC01	18SEP86	80.3	19.7	1.5
SC02	20JUN86	47.9	52.1	N/A
BL1	18SEP86	94.3	5.7	1.1
BL10	18SEP86	98.9	1.1	0.3
CS1	25OCT86	1.6	98.2	0.0
CS02	25OCT86	3.7	95.5	5.0
CS04	25OCT86	72.3	27.7	2.1
CS08	25OCT86	66.5	33.5	11.2

The data presented by Clifton suggest that cladocerans were more abundant during June, and copepods were perhaps more abundant during the fall (the 1982 data are not analysed, merely presented as tables). Zooplankton data collected during 1986 for this study clearly indicate that cladocerans were the most abundant group during late May, while cyclopoid copepods were more abundant during September. Rotifers were very abundant in the sample from Smith Lake during September. Fish feeding data collected during 1986 also point to the abundance of cladocerans during early summer (Fishman Environmental Services 1986b).

The zooplankton data for Columbia Slough samples suggest an interesting pattern. The May sample at station CS1, the Lombard Road bridge, was collected on a rising tide, thus, the sample was from river water (Table F-4). The May samples at stations CS03 and CS05 were taken during a falling tide, and were from slough water. The relative abundance of taxa in the river water sample was very similar to that for both Smith and Bybee Lakes, with the exception of more abundant rotifers in river water. These samples were all dominated by cladocerans. The samples from slough water were dominated by rotifers, with much lower abundance of cladocerans. The sample from CS04, in North Slough, is more similar to the lake samples; this slough arm is a blind, low-flow channel that receives some water from the lakes.

The October slough samples are generally dominated by cladocerans, with rotifers much less abundant than in May (Table F-4). The sample from station CSO was in the Willamette River just upstream from the mouth of the Columbia Slough. The sample from station CS1, the Lombard bridge, was during a falling tide; the water sampled was likely a mixture of river and slough water. The other October slough samples, stations CS3 and CS4, were slough water sampled on a falling tide.

The abundances of certain species found in fall slough samples is explained by the seasonal die-off and subsequent downstream drift of filamentous algae, which these species inhabit. This group of species includes harpacticoid copepods, ostracods, nematode worms, midge fly larvae, and the cladoceran Pleuroxus (Vogel 1986).

4.2 Benthic Invertebrates

The USGS study of the lakes in 1982 reported on benthic invertebrate samples (Clifton 1983). The data tables presented for that study show a greater variety of benthic invertebrates than found in the few samples taken during

1986; the number of 1982 samples, however, was not much larger than the 1986 study.

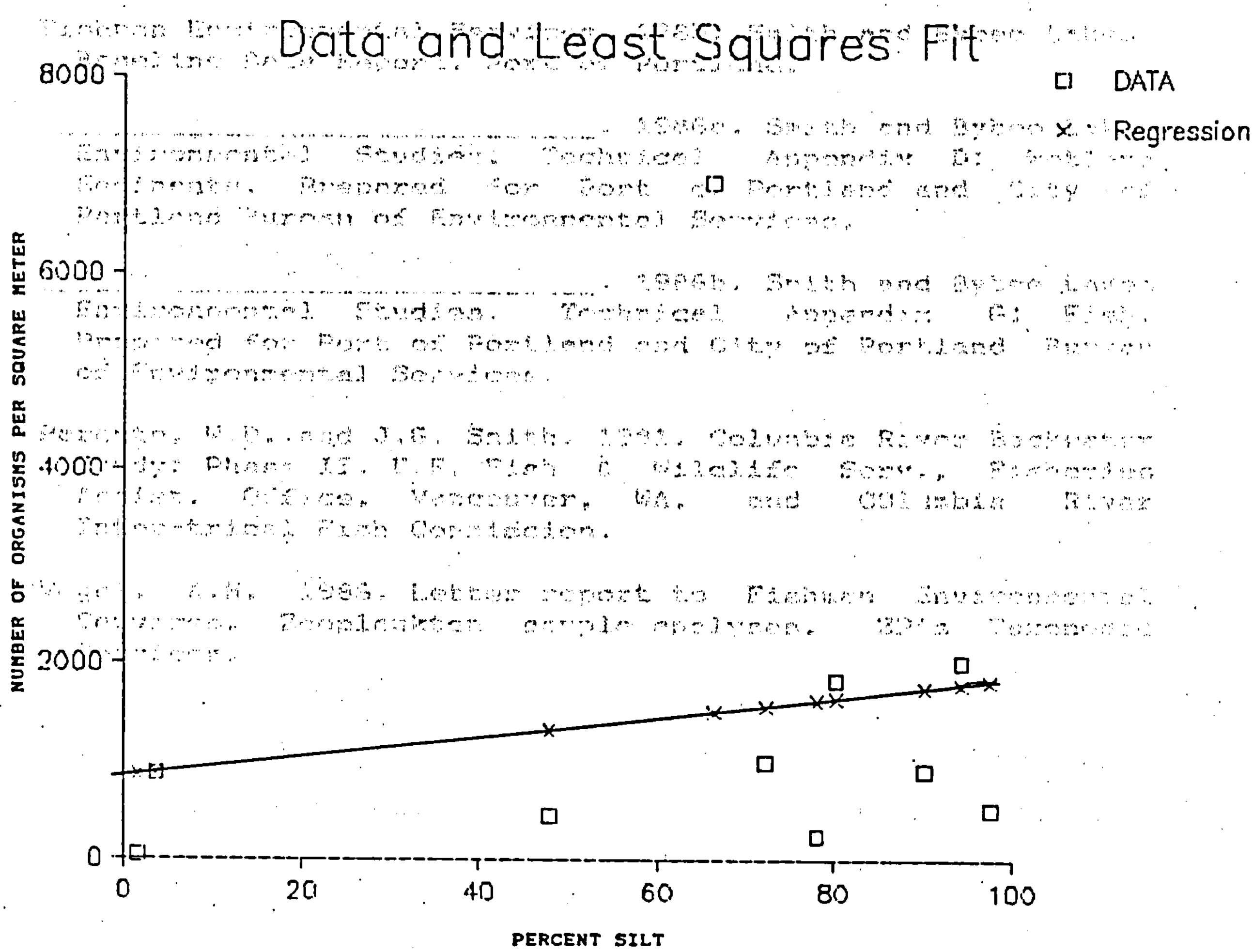
Oligocheates generally dominated the lake samples in 1982 as they did during 1986. The 2 samples from station SL04 in 1982 (their station SL1) had 1220 animals per square meter in July, and 184 per square meter in August. The June and September, 1986 values were 375 and 655 per square meter, respectively (see Table F-5). The 5 samples at station BL1 in Bybee Lake (their station BL3) during 1982 had total numbers of animals per square meter ranging from 312 to 3212 (5 monthly samples, June through October). The 2 samples from 1986 at this station had totals of 2709 and 1334 animals per square meter (June and September, respectively).

Another point of reference is the Columbia River backwater study, in which benthic invertebrates were sampled (Parente and Smith 1981). The total numbers of benthic organisms per square meter reported in that study were: 80 to 1380, June; 40 to 2900, August; and 20 to 2460, November/December.

The relationship between benthic invertebrate abundance and sediment characteristics was examined for the 1986 data. Examination of the data suggested that the total abundance of benthic animals might be related to the relative sand and silt composition of sediments. Calculation of the correlation coefficient for animal abundance and silt content resulted in a very low correlation (r=0.1734); results of this calculation are shown in Figure F-2.

The relationship between animal abundance and percent detritus (organic material) in samples was examined using correlation techniques. This result showed a very high correlation between these parameters (r=0.8981), as shown in Figure F-3. The samples with the lowest detritus volume had the lowest animal abundance. This relationship might be related to food supply or the physical matrix of detritus that provides a microhabitat for oligochaetes and other animals.

Populations of benthic organisms in sloughs and shallow lakes are extremely variable both spatially and seasonally. Perhaps the most important result of the present survey is the seeming greater diversity of organisms in Bybee Lake and Smith Channel compared with Smith Lake and the Columbia Slough. The relationship between animal abundance and detrital volume also suggests an explaination for the generally lower benthic invertebrate abundance in Smith Lake indicated by this survey.



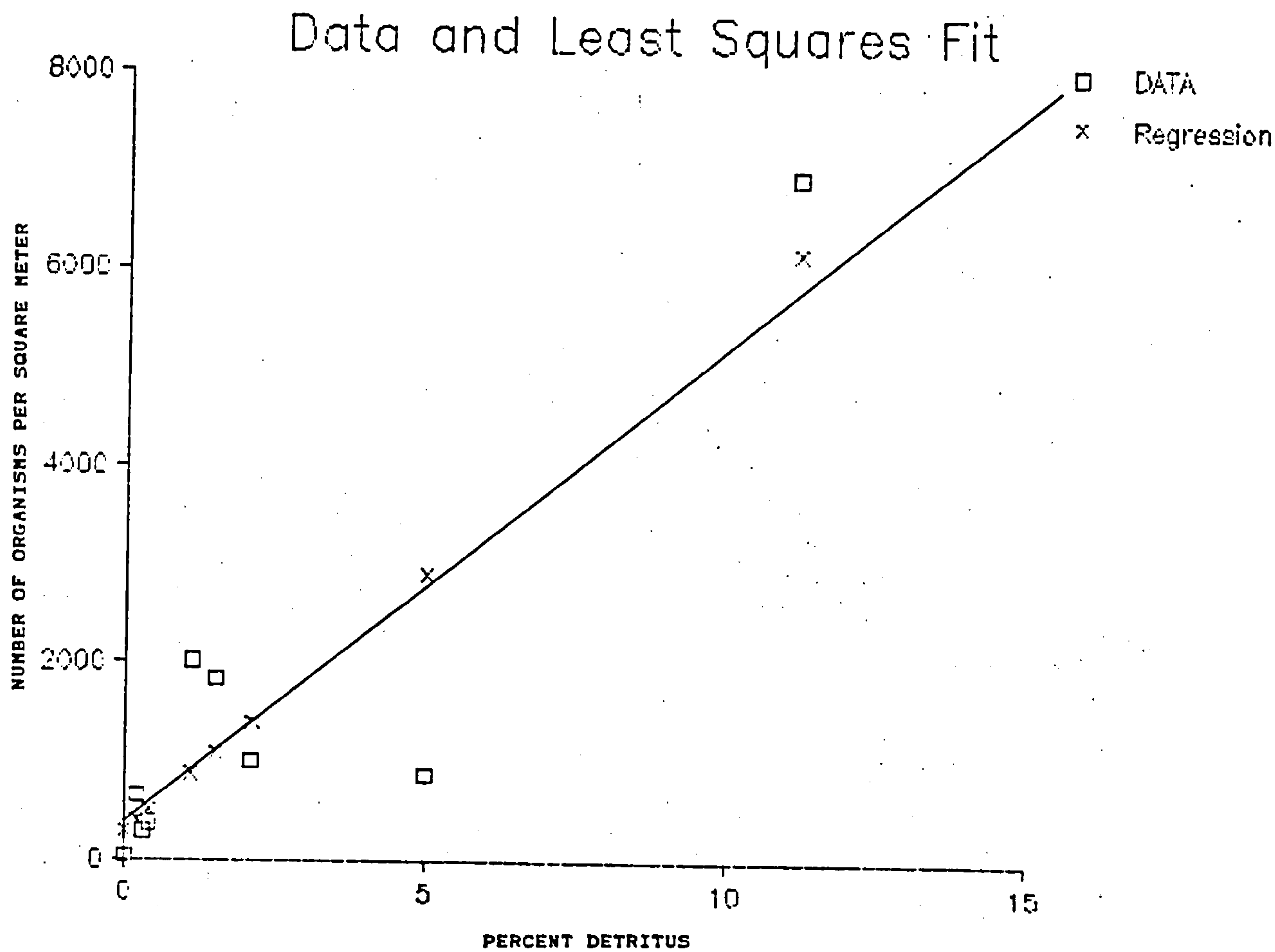
853.1803 = A (Intercept) ± 32354.51
9.959199 = B (Slope) ± 46.83621
.0300581 = R^2
.1733727 = R

4420730. = residual variance
2102.553 = s
2.341586 ≈ (t.025)

SMITH AND BYBEE LAKES
ENVIRONMENTAL STUDIES

REGRESSION ANALYSIS:
BENTHIC INVERTEBRATE ABUNDANCE
AND SEDIMENT SILT PERCENTAGE

DECEMBER, 1986 FIGURE F-2



289.5659 = A (Intercept) ± 295719.2
523.2526 = B (Slope) ± 232.5451
.8065224 = R^2
.8980659 = R

932673.3 = residual variance
996.3299 = s
2.400700 ≈ (t.025)

SMITH AND BYBEE LAKES ENVIRONMENTAL STUDIES

REGRESSION ANALYSIS:
BENTHIC INVERTEBRATE ABUNDANCE
AND SEDIMENT DETRITUS

DECEMBER, 1986 FIGURE F-3

5_REFERENCES

Clifton, D.G. 1983. Water-quality data for Smith and Bybee Lakes, Portland, Oregon: June to November 1982. U.S. Geol. Survey. Open-file Rept. 83-204.

Fishman Environmental Services. 1985. Smith and Bybee Lakes: Baseline Data Report. Port of Portland.

________________________________. 1986a. Smith and Bybee Lakes Environmental Studies. Technical Appendix D: Wetland Sediments. Prepared for Port of Portland and City of Portland Bureau of Environmental Services.

________________________________. 1986b. Smith and Bybee Lakes Environmental Studies. Technical Appendix G: Fish. Prepared for Port of Portland and City of Portland Bureau of Environmental Services.

Parente, W.D. and J.G. Smith. 1981. Columbia River Backwater Study: Phase II. U.F. Fish & Wildlife Serv., Fisheries Assist. Office, Vancouver, WA, and COlumbia River Inter-tribal Fish Commission.

Vogel, A.H. 1986. Letter report to Fishman Environmental Services. Zooplankton sample analyses. ZP's Taxonomic Services.

G FISH

FISHMAN ENVIRONMENTAL SERVICES
P.O. BOX 19023 PORTLAND, OR 97219

SMITH AND BYBEE LAKES ENVIRONMENTAL STUDIES

TECHNICAL APPENDIX G: FISH

Project Sponsored By:

Port of Portland

and

City of Portland, Bureau of Environmental Services

Prepared by:
Paul A. Fishman
Fishman Environmental Services

DECEMBER, 1986

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1 BACKGROUND AND OBJECTIVES

Little information is available concerning fish populations in the Smith and Bybee Lakes study area. Fish were sampled with gillnets in Smith Lake and Columbia Slough during 1973 and 1982, and in Bybee Lake during 1982 (Oregon State Game Commission 1973; J. Massey, ODFW, pers. commun.). These samples were limited in time and number, and provided only general indications of fish population characteristics in these waters.

The present study was designed to collect population and habitat utilization information for fish species in the study area. It was anticipated that study results would contribute to the development of a Management Plan for Smith and Bybee Lakes, particularly for planning related to recreational fisheries. The study would also provide data for a better understanding of wetland functions inherent in Smith and Bybee Lakes.

2 METHODS

The primary sampling method chosen for the study was the use of boat-mounted electrofishing equipment. A portable GPP Electrofisher [1] was used in an aluminum flat-bottom skiff. The equipment consisted of a gas-powered generator, an output-control circuit box, and an anode array mounted off the front of the boat. The aluminum boat acted as the cathode. Alternating current at 60 cycles per second was used; output voltage was adjusted to meet specific field conditions. An elapsed time counter was incorporated in the control unit.

Specific habitats were fished with the electrofisher for periods of ten minutes at the slowest speed possible using a 5-HP outboard motor. All aquatic habitats in the lakes and

----

1. The GPP (gas-powered pulsator) electrofisher is manufactured by Smith-Root, Inc., Vancouver, WA.

sloughs were sampled with this method; willow swamps could only be sampled along their edges. Fish stunned by the electric current were netted from the water and put in containers of water in the boat. At the end of each ten minute sampling period, fish were identified, counted and weighed; the information was recorded on field data sheets. Representative numbers of several species were kept for stomach content analysis; most fish were returned live to the lake or slough.

Environmental information generally recorded for each fish collection included average water depth, water temperature, and habitat type. Notes were also recorded concerning reproductive state of fish, disease and parasite problems, and other points of possible interest.

A total of 29 stations were sampled with electrofishing gear during the project; many of these were sampled seasonally. Station numbers and locations are shown on Figure G-1.

A small beach seine was used a few times during the study. A set net was also used to collect fish leaving the lakes through a breached dike on April 11, 1986.

Fish kept for feeding habits analysis were preserved in 10% buffered formalin. Each fish was measured for length in the laboratory, and stomach contents were examined. An estimate of stomach fullness was recorded, and stomach contents were identified to the level of major taxonomic groups. The percent of unidentifiable material and plant material in stomachs was also recorded.

Data analyses consisted of the following calculations:

- the total number and group weight of each species per sample

- the catch rate for each species, expressed as the mean number and mean weight per ten minutes electrofishing, for large areas (i.e. Smith Lake) by season, and specific habitats

- the total number and mean of each food item per fish species.

LEGEND

DATUM — ALL ELEVATIONS = USGS.

LANDFILL DIKE

CONTROL STRUCTURE

TREE / SHRUB LINE-SMITH & BYBEE LAKES, SHORELINE-COLUMBIA SLOUGH

STUDY AREA BOUNDARY / TOP OF BANK (APPROX. 30 FT.)

APPROX. LAKE SHORE LINE (10.5 FT. CONTOUR)

ELECTROFISHING STATIONS

Port of Portland

GRAPHIC SCALE IN FEET

500 0 500 1000 1500 2000 2500

DECEMBER, 1986

SMITH AND BYBEE LAKES
MANAGEMENT PLAN
ENVIRONMENTAL STUDIES
FISH COLLECTION STATIONS

SUBMITTED BY: SENIOR PLANNER, LAND DEVELOPMENT

DRAWING NO.: RG 86-511 23/23 (C-23)

FIGURE G-1

3 RESULTS

The sampling schedule and stations sampled are presented in Table G-1. A total of 55 electrofishing samples were conducted, totaling 9.2 hours of sampling.

A total of 747 fish were captured, representing 16 taxa. Length data were recorded for most of these fish. A list of fish taxa captured during the study is presented in Table G-2.

3.1 Catch Data

The effectiveness of electrofishing varies with species of fish, size of individual fish, conductivity and temperature of the water. An assumption was made that the effectiveness of the electrofishing technique was equal for the three sampling periods. This may not be a totally accurate assumption because environmental factors, particularly temperature, varied with sampling period. Water temperatures measured at collection stations during the late-April/early-May sampling period ranged from 13.0 degrees C to 15.0 degrees C. Water temperatures recorded during the late-June sampling ranged from 24.0 to 25.5 degrees C; October temperatures were again in the 15 degree C range.

Fish catch data are presented in Appendix G-A, Appendix Table G-A-1. Catch data were converted to mean number per 10-minutes and mean weight (grams) per 10-minutes in order to compare catch rates. A general comparison was made for five sampling areas in the Study Area: Bybee Lake, Smith Lake, Smith Channel (connecting the lakes), Columbia Slough, and the area on the lakes side of the water control structure (refered to as "Dam Pool"). These areas were chosen for their particular characteristics that appear to separate them into distinct areas of aquatic habitat. Mean catch data are presented in Appendix G-A, Appendix Table G-A-2, and graphically in Appendix G-A as Figures G-A-1 through G- A-15.

TABLE G-1
FISH SAMPLING SCHEDULE AND STATIONS
SMITH AND BYBEE LAKES STUDY AREA, 1986

SAMPLING STATION	APR 30	MAY 2	MAY 9	JUN 26	OCT 24	OCT 25
BL01	+			+	+	
BL02	+				+	
BL03	+					
BL04	+					
BL05	+					
BL06	+			+	+	
BL07	+					
BL08	+			+	+	
BL09				+		
BL10				+	+	
BL11					+	
SL01		+		+	+	
SL02		+				
SL03		+				
SL04		+		+	+	
SL05		+		+	+	
SL06		+				
SC01		+			+	
SC02		+		+	+	
SC03		+		+		
CS01			+			+
CS02			+			
CS03			+	+		+
CS04			+	+		+
CS05			+			
CS06			+	+		+
CS07			+			
CS08			+			+
CS09				+		

BL = Bybee Lake   SL = Smith Lake
SC = Smith Channel   CS = Columbia Slough

TABLE G-2
FISH SPECIES COLLECTED DURING 1986
SMITH AND BYBEE LAKES STUDY AREA

SCIENTIFIC NAME	COMMON NAME	CODE (a)
Family Salmonidae	trouts	
Oncorhynchus tshawytscha	chinook salmon	Ch
Family Cyprinidae	minnows and carps	
Carassius auratus	goldfish	Gf
Cyprinus carpio	carp	Cp
Mylocheilus caurinus	peamouth	Pm
Ptychocheilus oregonensis	northern squawfish	Sq
Family Catostomidae	suckers	
Catostomus macrocheilus	largescale sucker	LSu
Family Ictaluridae	freshwater catfishes	
Ictalurus nebulosus	brown bullhead	BrB
Family Poecillidae	livebearers	
Gambusia affinis	mosquitofish	Gm
Family Centrarchidae	sunfishes	Sf
Lepomis gibbosus	pumpkinseed	Ps
L. gulosus	warmouth	Wm
L. macrochirus	bluegill	Bg
Micropterus salmoides	largemouth bass	LB
Pomoxis annularis	white crappie	WC
P. nigromaculatus	black crappie	BC
Family Percidae	perches	
Perca flavescens	yellow perch	YP
Family Pleuronectidae	righteye flounders	
Platichthys stellatus	starry flounder	SF
Family Cottidae	sculpins	Cot

(a) Oregon Dept. of Fish and Wildlife codes, used for data records

Catch data expressed as numbers of fish are referred to as abundance data, while catch weights are biomass data. Because of the great weight differences between individuals of different fish species, abundance data present a clearer picture of the population sizes. Biomass data, on the other hand, are important for understanding aspects of energy flow in the ecosystem, or the amount of life sustained at different ecological levels. The following discussions deal with both abundance and biomass data.

3.1.1 Seasonal Comparisons: Abundance

Late Spring

Sampling conducted on April 30, May 2 and May 9 was the most intensive of the three seasonal efforts; this was primarily an attempt to sample a wide variety of habitats and locations.

The major distinguishing feature of abundance data for late spring sampling (April 30 - May 9) was the large number of juvenile salmon everywhere in the system (Table G-3). Salmon represented 13% of the catch in Bybee Lake, 12% in Smith Lake, 12% in Smith Channel, 29% in the Dam Pool, and 30% in Columbia Slough. Salmon were first observed in the system when a set net was placed across a breach in the water level control structure dike on April 11, 1986.[2] The net, a beach seine with a large small-mesh bag, effectively strained all water flowing from the lakes into North Slough. The net contents were examined every 30 minutes for a total of 3 hours between 7 and 10:AM. Fish captured included 14 juvenile salmon, 6 young peamouth, and 2 sculpins.

The spring freshet in early June raised slough water levels above lake levels, and water entered the lakes through the control structure. On June 5, juvenile salmon

----

2. High water in late February (about 18 feet MSL) inundated the land between North Slough and the lakes; the water control structure and its dike were completely submerged. When these flood waters receded, the control structure was intact, but a channel had been eroded in the dike alongside the structure. This channel was approximately 15 feet wide and 5 feet deep, as measured from the top of the dike. This condition existed, with the lakes tidally connected to North Slough, until April 22, when the Port repaired the dike.

TABLE G-3

FISH ABUNDANCE IN SMITH AND BYBEE LAKES STUDY AREA
DURING 1986

SPECIES	BYBEE LAKE	SMITH LAKE	SMITH CHANNEL	DAM POOL	COLUMBIA SLOUGH
	--------PERCENT WITHIN SAMPLING AREA--------				
30APR-9MAY					
	n=58	n=65	n=41	n=45	n=143
No. of stations	7	6	3	1	8
Bl.Crappie	0	12	0	0	0
Bluegill	4	8	7	0	2
Br. Bullhead	1	0	0	0	0
Chinook Salmon	13	12	12	29	30
Cottid (sculpin)	0	0	0	0	2
Carp	27	34	29	36	15
Goldfish	0	2	5	0	3
LM Bass	1	0	15	9	0
Ls sucker	1	2	0	9	19
Peamouth	0	2	0	13	2
Pumpkinseed	4	2	0	0	0
Squawfish	2	8	0	2	3
W. crappie	22	5	22	0	13
Warmouth	0	0	0	0	0
Yellow perch	25	17	9	2	10
26JUN					
	n=18	n=21	n=26	n=36	n=49
No. of stations	4	3	2	1	4
Bl. crappie	0	14	12	0	0
Bluegill	6	0	8	17	6
Br. bullhead	0	5	0	0	2
Chinook salmon	0	0	0	0	0
Cottid (sculpin)	0	0	0	0	0
Carp	44	43	46	64	39
Goldfish	0	0	0	0	14
LM bass	6	14	31	6	0
Ls sucker	0	0	0	0	10
Peamouth	0	14	0	3	0
Pumpkinseed	0	0	0	0	0
Squawfish	0	0	0	6	8
W. crappie	28	10	4	6	12
Warmouth	0	0	0	0	4
Yellow perch	17	0	0	3	4

TABLE G-3 (continued)

SPECIES	BYBEE LAKE	SMITH LAKE	SMITH CHANNEL	DAM POOL	COLUMBIA SLOUGH
	--------PERCENT WITHIN SAMPLING AREA--------				
24-25OCT					
	n=93	n=17	n=6	n=21	n=45
No. of stations	4	3	2	1	5
Bl. crappie	0	18	17	0	0
Bluegill	75	30	0	81	9
Br. bullhead	0	0	0	0	0
Chinook salmon	0	0	0	0	0
Cottid (sculpin)	0	0	17	0	2
Carp	6	24	33	10	13
Goldfish	0	6	0	0	27
LM bass	4	6	33	0	7
Ls sucker	0	6	0	0	11
Peamouth	0	6	0	0	0
Pumpkinseed	3	0	0	0	9
Sunfish, unid.	0	0	0	5	0
Star. flounder	0	0	0	0	4
Squawfish	0	0	0	0	7
W. crappie	9	0	0	0	4
Warmouth	0	0	0	0	0
Yellow perch	2	6	0	5	7

were observed around the control structure on the lake side and jumping out of the lake water and into the slough water cascading out of the vertical culvert of the control structure. No salmon were seen or collected during the June and October sampling periods.

Carp were the most abundant fish in Bybee Lake and Smith Lake (27% and 34%), Smith Channel (29%) and the Dam Pool (36%), but were third in abundance (15%) in the slough (salmon = 30%, largescale suckers = 19%).

White crappie were abundant in Bybee Lake and Smith Channel (22% each), and less so in Columbia SLough (13%). Yellow perch were abundant in Bybee Lake and Smith Lake samples (25% and 17%) but less abundant in other areas.

Summer

Analyses for the June 26 sampling are limited by the relatively small numbers of fish collected. Carp clearly dominated all 5 sampling areas, representing 39% to 64% of the individuals collected in the areas. White crappie and yellow perch were relatively abundant in Bybee Lake.

Autumn

The October 24-25 sampling was similar to the June effort in number of stations sampled, and in the low numbers of fish collected. Small bluegill were numerically dominant in Bybee Lake (75%), the Dam Pool (81%) and Smith Lake (30%). Goldfish were the most abundant species in Columbia Slough.

3.1.2 Seasonal Comparisons: Biomass

Late Spring

Carp accounted for the major portion of fish biomass in all sampling areas during spring sampling (Table G-4). The percentage of fish biomass sampled on the lakes side of the water level control structure ranged from 80% to 93% carp; Columbia Slough fish biomass was 64% carp. Largemouth bass accounted for 12% of fish biomass sampled in Smith Channel, this was primarily due to large bass taken near the remnant of an old cross-channel dike (Station SC03). Largescale sucker biomass was significant in Columbia Slough (29%) and the Dam Pool area, or station BL08 (11%). White crappie and yellow perch represented the greatest biomass of smaller fish species sampled.

TABLE G-4
FISH BIOMASS IN SMITH AND BYBEE LAKES STUDY AREA
DURING 1986

--------PERCENT WITHIN SAMPLING AREA--------

SPECIES	BYBEE LAKE	SMITH LAKE	SMITH CHANNEL	DAM POOL	COLUMBIA SLOUGH
30APR-9MAY					
	n=58	n=65	n=41	n=45	n=143
No. of stations	7	6	3	1	8
Bl.Crappie	0	1	0	0	0
Bluegill	<1	<1	1	0	<1
Br. Bullhead	1	0	0	0	0
Chinook Salmon	<1	<1	<1	1	1
Cottid (sculpin)	0	0	0	0	<1
Carp	92	93	81	80	64
Goldfish	0	<1	2	0	2
LM Bass	<1	0	12	6	0
Ls sucker	<1	<1	0	11	29
Peamouth	0	<1	0	3	3
Pumpkinseed	<1	<1	0	0	0
Squawfish	<1	<1	0	<1	<1
W. crappie	3	1	3	0	2
Warmouth	0	0	0	0	0
Yellow perch	2	2	1	<1	1
26JUN					
	n=18	n=21	n=26	n=36	n=49
No. of stations	4	3	2	1	4
Bl. crappie	0	1	<1	0	0
Bluegill	<1	0	2	1	<1
Br. bullhead	0	3	0	0	<1
Chinook salmon	0	0	0	0	0
Cottid (sculpin)	0	0	0	0	0
Carp	92	88	86	93	81
Goldfish	0	0	0	0	3
LM bass	4	3	11	5	0
Ls sucker	0	0	0	0	13
Peamouth	0	3	0	<1	0
Pumpkinseed	0	0	0	0	0
Squawfish	0	0	0	<1	<1
W. crappie	2	2	<1	<1	2
Warmouth	0	0	0	0	<1
Yellow perch	2	0	0	<1	<1

TABLE G-4 (continued)

--------PERCENT WITHIN SAMPLING AREA--------

SPECIES	BYBEE LAKE	SMITH LAKE	SMITH CHANNEL	DAM POOL	COLUMBIA SLOUGH
24-25OCT					
	n=93	n=17	n=6	n=21	n=45
No. of stations	4	3	2	1	5
Bl. crappie	0	3	<1	0	0
Bluegill	5	2	0	2	<1
Br. bullhead	0	0	0	0	0
Chinook salmon	0	0	0	0	0
Cottid (sculpin)	0	0	<1	0	<1
Carp	82	76	97	95	42
Goldfish	0	8	0	0	25
LM bass	8	1	3	0	2
Ls sucker	0	8	0	0	26
Peamouth	0	2	0	0	0
Pumpkinseed	1	0	0	0	1
Sunfish, unid.	0	0	0	<1	0
Star. flounder	0	0	0	0	<1
Squawfish	0	0	0	0	3
W. crappie	3	0	0	0	<1
Warmouth	0	0	0	0	0
Yellow perch	1	1	0	2	<1

Summer

More than 80% of the sampled biomass in all five areas was carp. Bass were again a significant portion (11%) of sampled biomass in the Smith Channel area, and suckers were an important component of Columbia Slough biomass (13%).

Autumn

Carp biomass was comparatively lower in both Smith and Bybee Lakes during late October (76% and 82%), and was 95% or greater in the Smith Channel and Dam Pool areas. Fish biomass in Columbia Slough, however, was divided between carp (42%), goldfish (25%) and suckers (26%).

3.1.3 Habitat Comparisons

Fish catch data were sorted by season and habitat to compare seasonal changes within habitat types, and to compare fish assemblages between habitats. A simple graphing technique, using the numbers of each species collected, was used to display these data for comparative purposes. The small numbers of fish collected during some sampling periods did not warrant a more complex analysis.

Six aquatic habitats were used for these analyses. These habitats are described below (symbols in parentheses refer to USFWS habitat classifications), and as shown in the Habitat Map, Technical Appendix E:

- Open Water (L2UB3): mid-lake areas in Bybee Lake, no emergent vegetation, little submerged vegetation; stations BL02, BL05, BL07, BL09.

- Open water/Smartweed (L2EM1/UB3): areas in the south and southwest portions of Smith Lake, smartweed patches interspersed with large areas of open water; stations SL04, SL05, SL06.

- Smartweed Swamp (L2EM1): areas in both lakes with dense stands of smartweed, only small patches of open water in the smartweed; stations BL04, BL10, SL01, SL02.

- No-flow Channel (PUB3): Smith Channel stations, little to no current, no emergent or submerged vegetation; stations SC01, SC02, SC03.

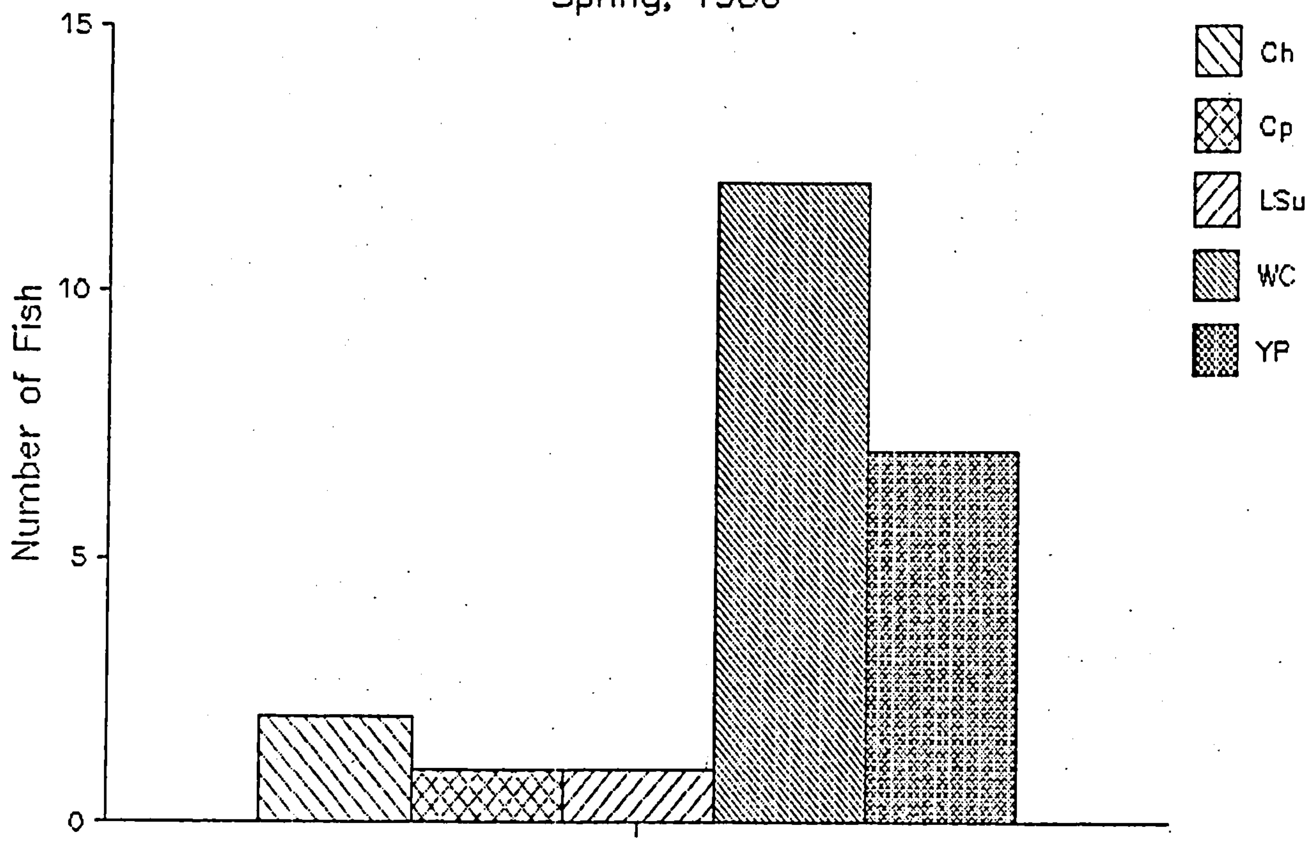
- Dam Pool (L2UB3): open water on the lakes side of the water level control structure; station BL08.

- Tidal Slough (R1UB3): stations in Columbia Slough, a tidal riverine habitat, no emergent vegetation; stations CS01 through CS09.

Open Water

White crappie, and then yellow perch were the most abundant fish in the open water habitat collections during spring (Figure G-2). Juvenile salmon, carp and largescale sucker were also present. No fish were collected in this habitat during summer and autumn sampling; however, only one station was fished in each of these seasons.

FISH ABUNDANCE: OPEN WATER
Spring, 1986



4 STATIONS, 10 MIN. EACH

BC = Black Crappie	LB = Largemouth Bass
Bg = Bluegill	LSu = Largescale Sucker
BrB = Brown Bullhead	Pm = Peamouth
Ch = Chinook salmon	SF = Starry Flounder
Cot = sculpin	Sq = Squawfish
Cp = Carp	WC = White Crappie
Gf = Goldfish	YP = Yellow Perch

SMITH AND BYBEE LAKES ENVIRONMENTAL STUDIES

FISH ABUNDANCE IN OPEN WATER HABITAT

Open Water/Smartweed

Carp, and then juvenile salmon were the most abundant species in this habitat during spring, followed by yellow perch, white crappie and squawfish (Figure G-3). Goldfish, peamouth and suckers were also present. Carp was the most abundant species in summer collections, followed by black crappie; bass, brown bullhead and white crappie were also present. Bluegill were most abundant in autumn samples, followed by black crappie. Carp, goldfish and bass were also present.

Smartweed Swamp

Carp was the most abundant species in smartweed swamp samples during spring (Figure G-4). Black crappie and yellow perch were much less abundant, but more numerous than bluegill, juvenile salmon, peamouth, and squawfish. Summer samples had carp and peamouth equally abundant, followed by white crappie and yellow perch; bass were also present. Carp was again the most numerous species in autumn samples, with black crappie, bluegill, sucker, peamouth and yellow perch present as well.

No-flow Channel

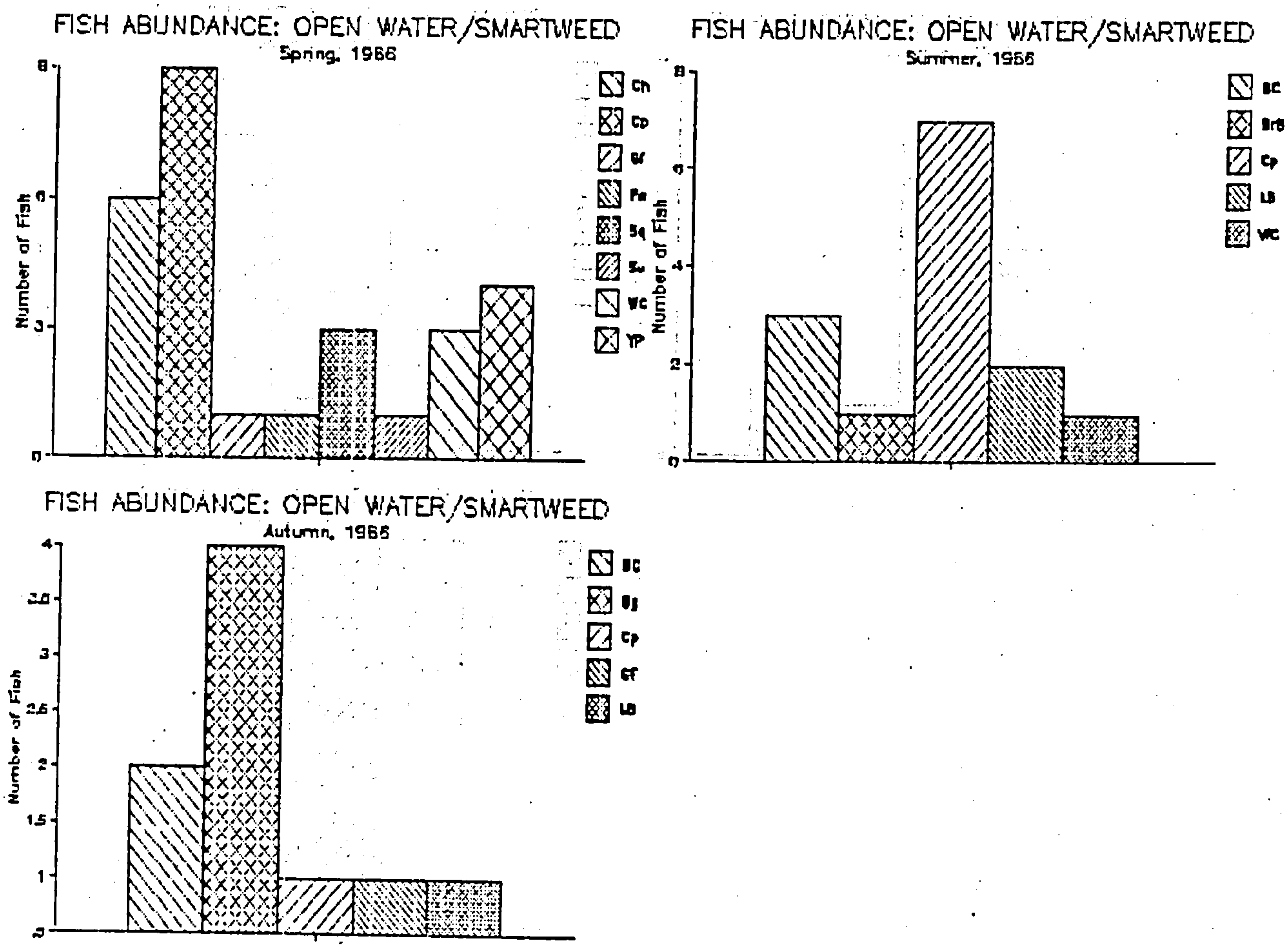
Carp was the most abundant species during spring, followed by white crappie and bass, and lower numbers of juvenile salmon, yellow perch, bluegill and goldfish (Figure G-5). The most abundant species in summer samples was carp, followed by bass; black crappie, bluegill and white crappie were present in lower numbers. Carp and bass were also most abundant, but much fewer, during autumn sampling; black crappie and sculpin were present.

Dam Pool

Carp and juvenile salmon dominated the spring sample, followed by peamouth and bass; squawfish and perch were present (Figure G-6). Carp was clearly the most abundant species in the summer sample, with bluegill much less abundant; squawfish, white crappie, peamouth and perch were present. The autumn sample was dominated by small bluegill; carp were much less abundant, and perch and an unidentified sunfish were present.

Tidal Slough

Juvenile salmon was clearly the most abundant species in spring samples, followed by sucker and then carp (Figure G-7). White crappie and perch were also abundant; bluegill, sculpin, goldfish, peamouth and squawfish were present. Carp dominated the summer samples, with goldfish and white crappie less numerous. Several other species were of less



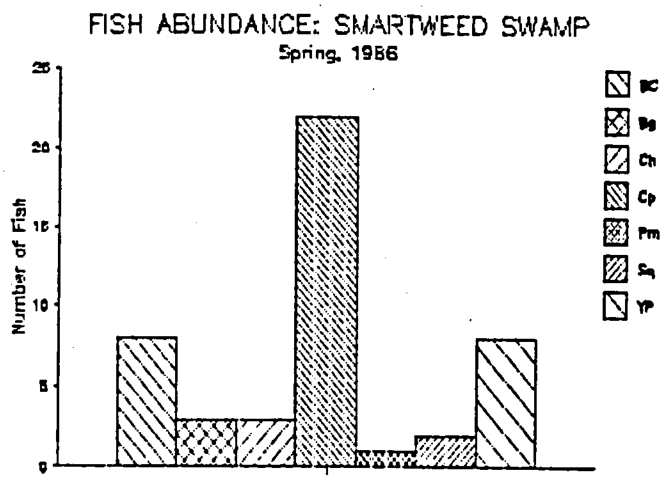
SPRING: 3 STATIONS, 10 MIN. EACH
SUMMER: 2 STATIONS, 10 MIN. EACH
AUTUMN: 2 STATIONS, 10 MIN. EACH

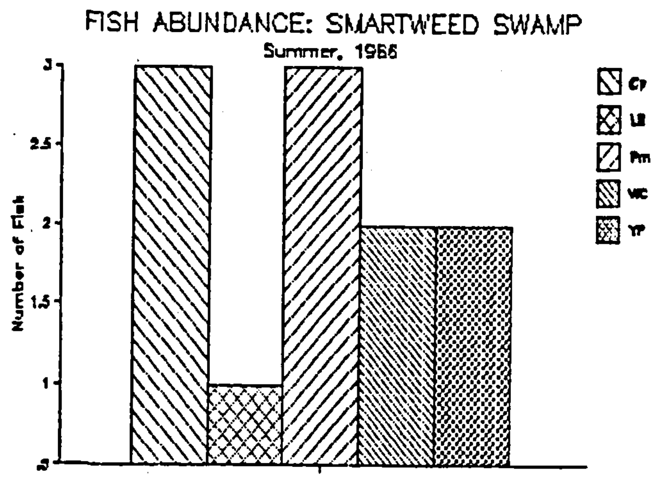
BC = Black Crappie	LB = Largemouth Bass
Bg = Bluegill	LSu = Largescale Sucker
BrB = Brown Bullhead	Pm = Peamouth
Ch = Chinook salmon	SF = Starry Flounder
Cot = sculpin	Sq = Squawfish
Cp = Carp	WC = White Crappie
Gf = Goldfish	YP = Yellow Perch

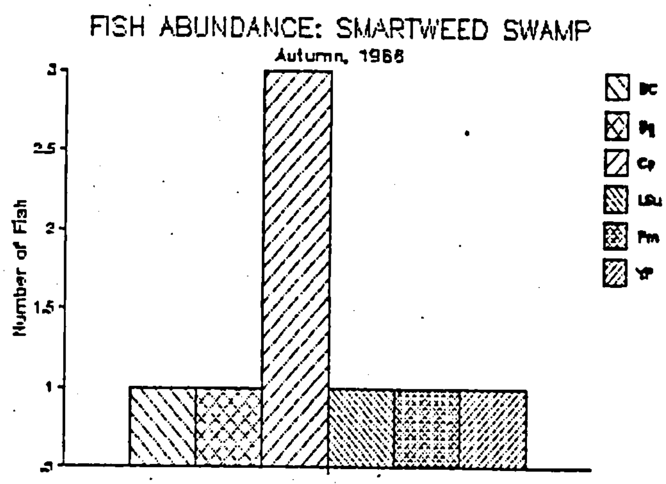
SMITH AND BYBEE LAKES ENVIRONMENTAL STUDIES

FISH ABUNDANCE IN OPEN WATER, SMARTWEED HABITAT

DECEMBER, 1986 FIGURE 6-3





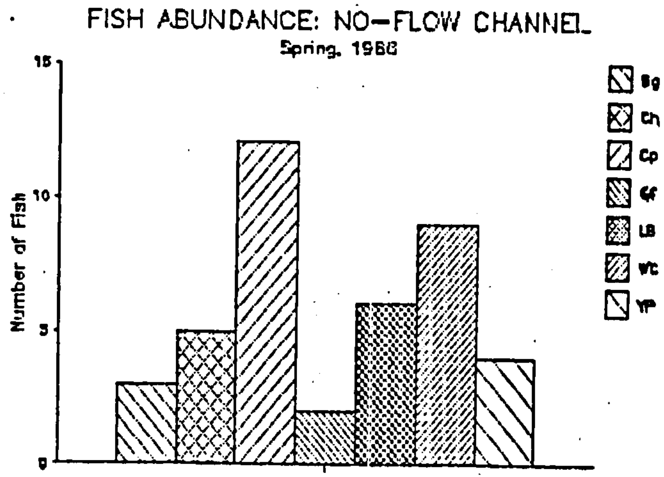


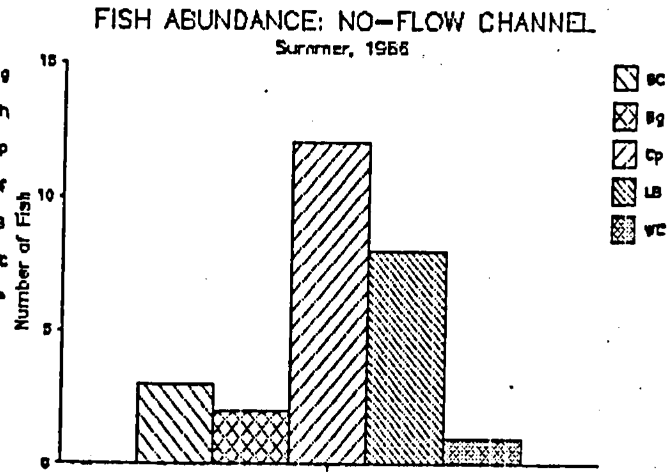
SPRING: 3 STATIONS, 10 MIN. EACH
SUMMER: 2 STATIONS, 10 MIN. EACH
AUTUMN: 1 STATION, 10 MIN.

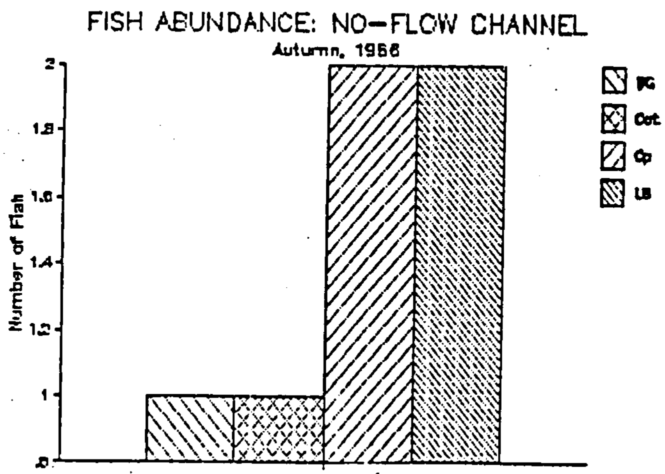
BC = Black Crappie
Bg = Bluegill
BrB = Brown Bullhead
Ch = Chinook salmon
Cot = sculpin
Cp = Carp
Gf = Goldfish
LB = Largemouth Bass
LSu = Largescale Sucker
Pm = Peamouth
SF = Starry Flounder
Sq = Squawfish
WC = White Crappie
YP = Yellow Perch

SMITH AND BYBEE LAKES ENVIRONMENTAL STUDIES

FISH ABUNDANCE IN SMARTWEED SWAMP HABITAT







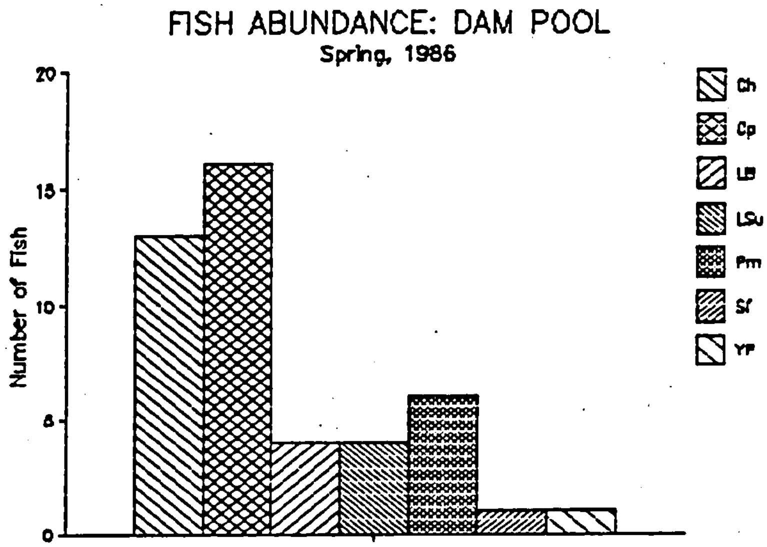
SPRING: 3 STATIONS, 10 MIN. EACH
SUMMER: 2 STATIONS, 10 MIN. EACH
AUTUMN: 2 STATIONS, 10 MIN. EACH

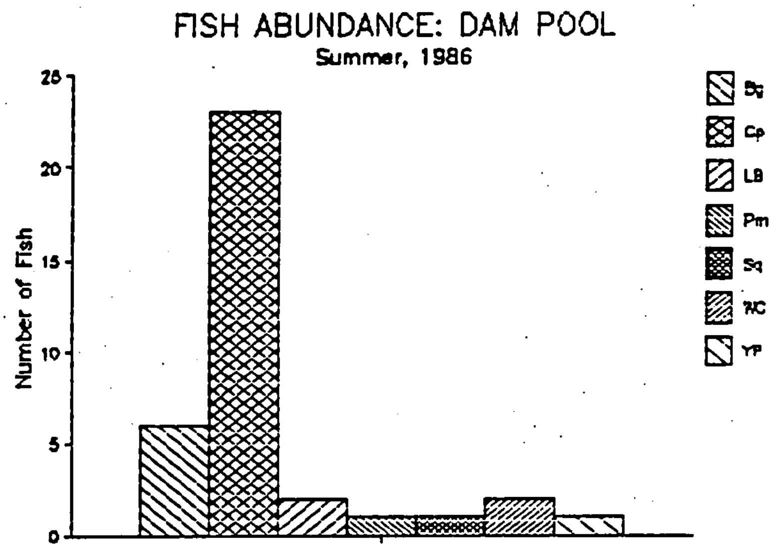
BC = Black Crappie
Bg = Bluegill
BrB = Brown Bullhead
Ch = Chinook salmon
Cot = sculpin
Cp = Carp
Gf = Goldfish
LB = Largemouth Bass
LSu = Largescale Sucker
Pm = Peamouth
SF = Starry Flounder
Sq = Squawfish
WC = White Crappie
YP = Yellow Perch

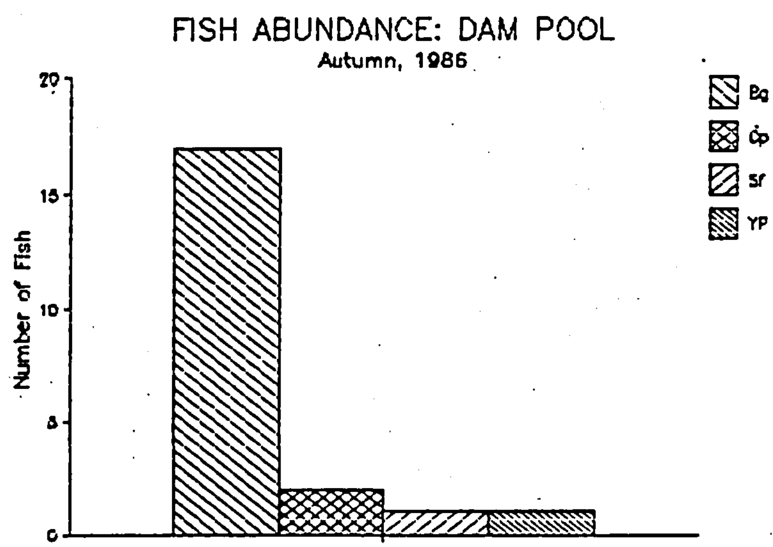
SMITH AND BYBEE LAKES ENVIRONMENTAL STUDIES

FISH ABUNDANCE IN NO-FLOW CHANNEL HABITAT

DECEMBER, 1986 FIGURE 6-5







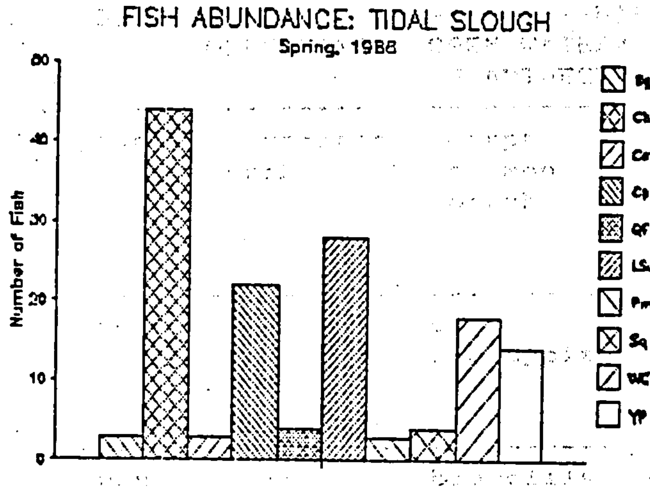
SMITH AND BYBEE LAKES ENVIRONMENTAL STUDIES

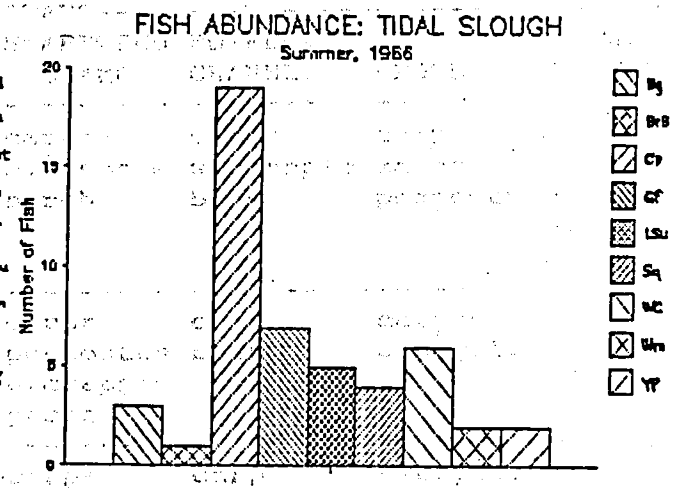
FISH ABUNDANCE IN DAM POOL HABITAT

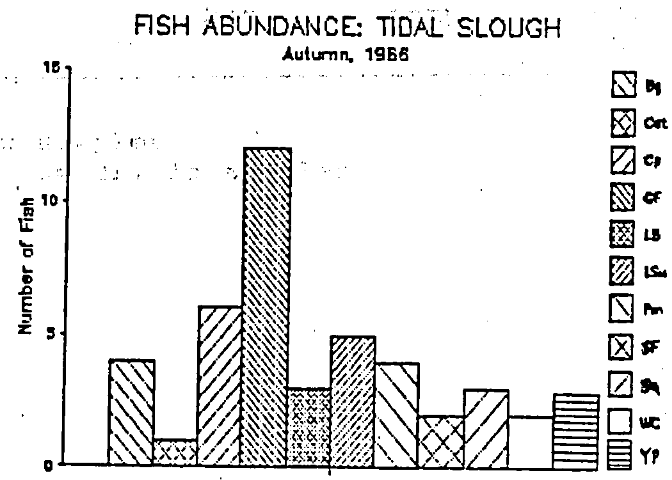
DECEMBER, 1986

FIGURE 6-6

FISHMAN ENVIRONMENTAL SERVICES







SPRING: 8 STATIONS, 10 MIN. EACH
SUMMER: 4 STATIONS, 10 MIN. EACH
AUTUMN: 5 STATIONS, 10 MIN. EACH

BC = Black Crappie
Bg = Bluegill
BrB = Brown Bullhead
Ch = Chinook salmon
Cot = sculpin
Cp = Carp
Gf = Goldfish
LB = Largemouth Bass
LSu = Largescale Sucker
Pm = Peamouth
SF = Starry Flounder
Sq = Squawfish
WC = White Crappie
YP = Yellow Perch

SMITH AND BYBEE LAKES
ENVIRONMENTAL STUDIES

FISH ABUNDANCE IN TIDAL
SLOUGH HABITAT

DECEMBER, 1986 FIGURE 6-7

importance. Goldfish was the most abundant species in autumn collections; carp and sucker were less numerous, followed by bluegill and peamouth, and several other species.

Dominant Species

The species that were numerically dominant within each habit, by season, are shown in Table G-5. Carp were clearly dominant in all lake habitats, except open water, during spring and summer. Young-of-the-year bluegill were numerically dominant in the open water/smartweed and dam pool habitats during autumn. This dominance by carp was not always the case in Columbia Slough, where other species were relatively very abundant.

TABLE G-5
DOMINANT FISH SPECIES IN AQUATIC HABITATS
BY SEASON

SEASON	HABITATS					
	OPEN WATER	OPEN WATER/ SMARTWEED	SMARTWEED SWAMP	NO-FLOW CHANNEL	DAM POOL	TIDAL SLOUGH
Spring	w. crappie perch	carp* salmon perch	carp** b.crappie perch	carp* w.crappie bass	carp* salmon peamouth	salmon* sucker carp w.crappie perch
Summer	--	carp* b.crappie	carp* peamouth* w.crappie perch	carp* bass	carp** bluegill	carp** goldfish w.crappie sucker
Autumn	--	bluegill* b.crappie	carp*	carp bass	bluegill** carp	goldfish* carp sucker

* = most abundant species in samples
** = most abundant, by large number, in samples

3.2 Species Accounts

3.2.1 Length and Food Habits Data

Data on length and feeding habits were collected for many of the fish species in the study area. Analyses of these data are presented in the following sections for each species. Complete data tables are found in Appendix G-A. Fish ages can only be estimated from length data and accounts in the literature; the scope of this project did not include age determination from scale examinations.

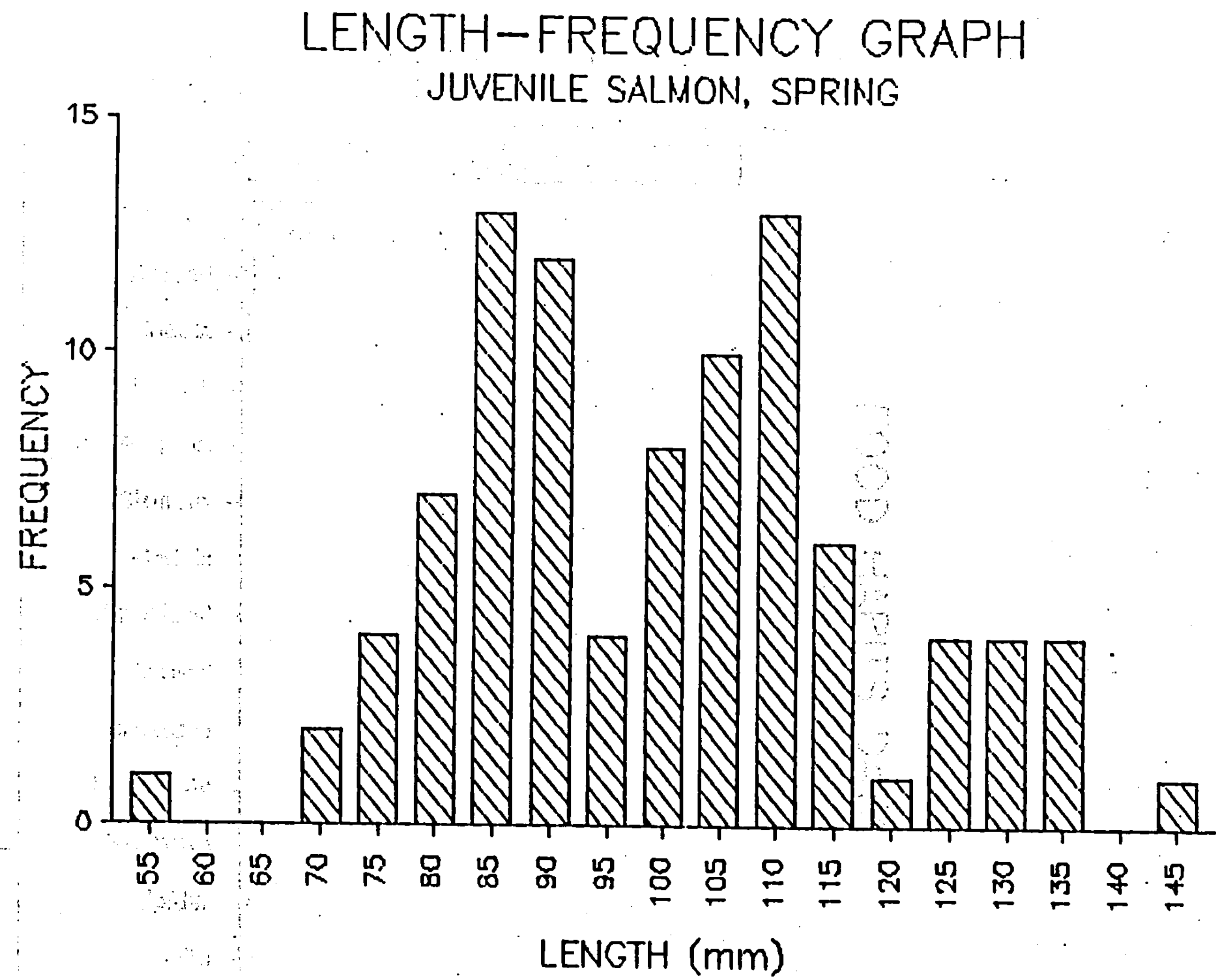
Juvenile Salmon

Juvenile salmon were captured only during the late-April and early-May collections; all verified identifications were chinook. These fish ranged in size from 59 to 146 mm (fork length); the 95 fish measured had a mean length of 102.16 mm (Figure G- 8). Fish sampled in the lakes system were generally larger than those collected from Columbia Slough. Lake system samples were obtained on April 11 and 30, and May 2; Slough samples were obtained on May 9. The 51 fish measured from the lakes had a mean length of 114.31 mm; fish from the Slough averaged 88.07 mm length (Figure G- 9). At least two explanations can account for this difference: (1) fish in the lakes represented a different hatchery release than those in the slough, or (2) conditions in the lakes were more favorable for growth. The available data are not sufficient to explain this size difference.

The 21 salmon examined for diet had fed primarily on cladocerans (81% of identifiable stomach contents), and then copepods (15%), with minor amounts of ostracods, insects, spiders and mites (Figure G-10). Only three fish had relatively empty stomachs. Many fish had consumed hundreds of cladocerans (as many as 1200 in one stomach), while copepod consumption by individual fish was relatively low (with the exception of one stomach containing 1200 copepods). No benthic organisms were found in salmon stomachs, indicating a clear preference for planktonic and floating food.

Goldfish

The 27 goldfish measured ranged from 59 to 270 mm length, with a mean of 202.37 mm. Goldfish diets were not examined.



n = 95

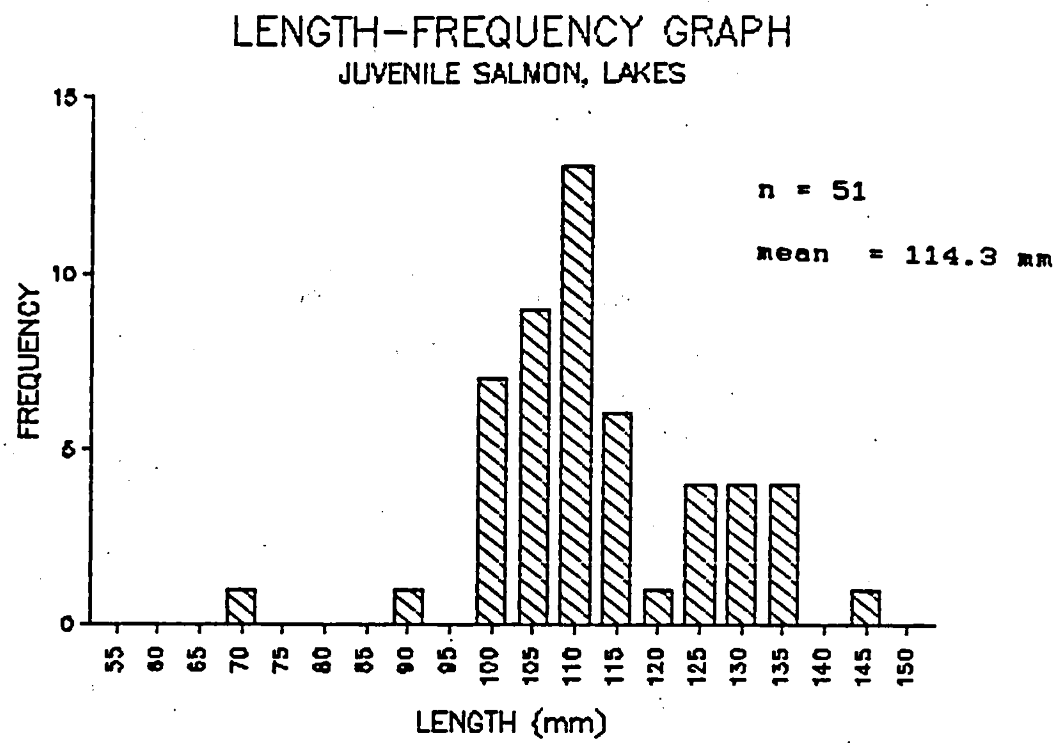
mean = 102.2 mm

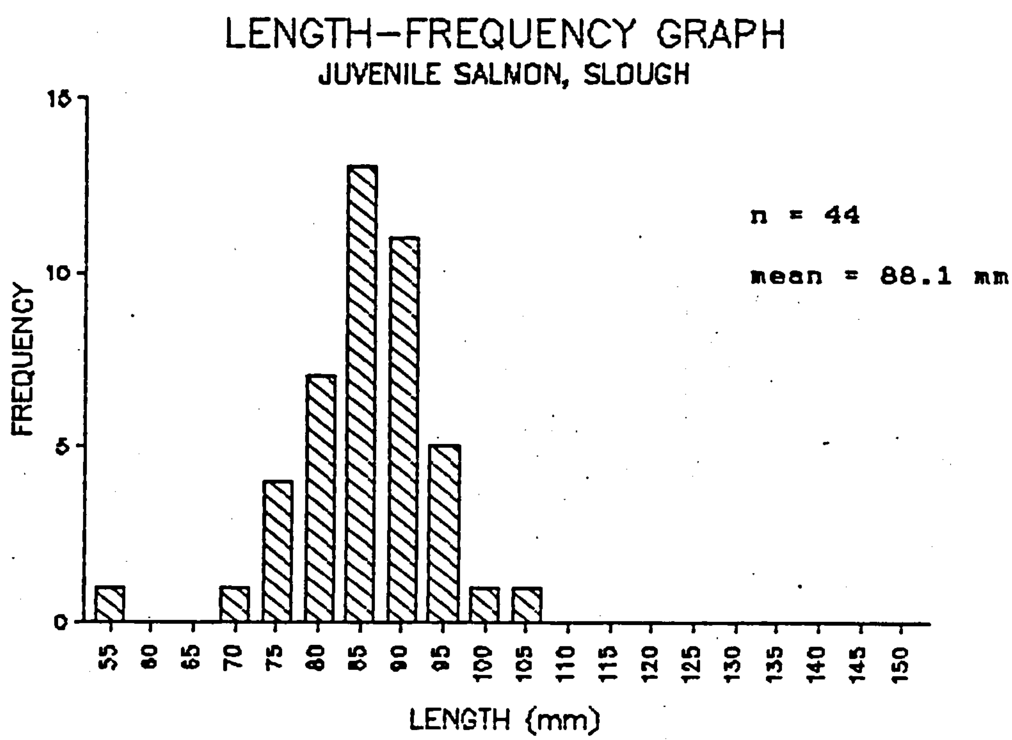
SMITH AND BYBEE LAKES ENVIRONMENTAL STUDIES

SALMON LENGTH FREQUENCY

FISHMAN ENVIRONMENTAL SERVICES

DECEMBER, 1986 FIGURE 6-8





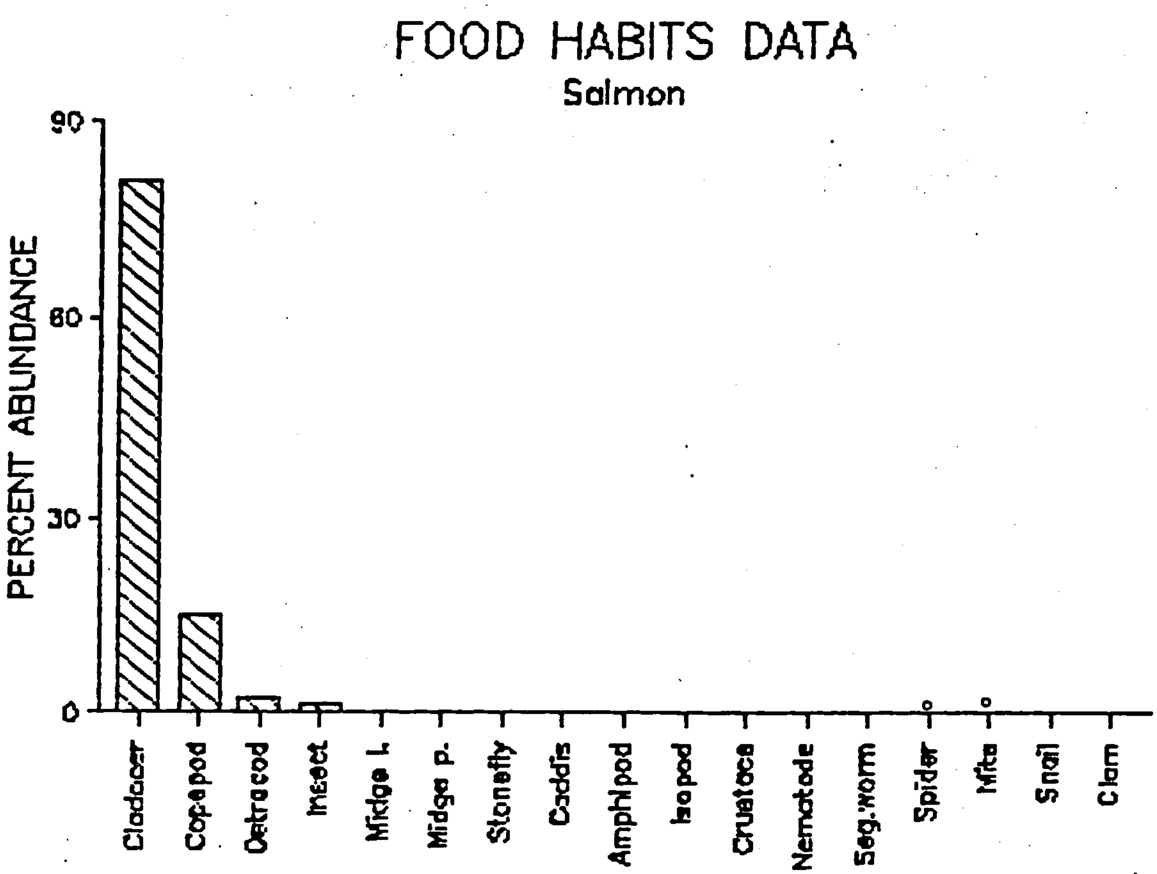
SMITH AND BYBEE LAKES ENVIRONMENTAL STUDIES

SALMON LENGTH FREQUENCY FOR LAKES AND SLOUGH

FISHMAN ENVIRONMENTAL SERVICES

DECEMBER, 1986

FIGURE 6-9



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SMITH AND BYBEE LAKES
ENVIRONMENTAL STUDIES

SALMON FEEDING HABITS

DECEMBER, 1986

FIGURE G-10

Carp

A total of 174 carp lengths were obtained during the study. These fish ranged from 255 to 590 mm length, with a mean of 409.74 mm. Length-frequency graphs for carp collected during spring, summer and autumn are shown in Figure G-11. The seasonal means for carp length are similar. The carp population in the lakes and slough is dominated by fish in the 350 to 450 mm length range; these fish are at least two or more years old.

Spawning carp were observed in shallow, grassy areas of the lakes during summer. Fish in reproductive condition were noted in the electrofishing data base for collections in Smith Lake and Columbia Slough during early May, and in Smith Lake during late June. No young-of-the-year carp were seen during the study, nor were any collected considered to be younger than 2 or 3 years.

Food habits of carp were not investigated.

Peamouth

The 21 peamouth measured ranged from 79 to 270 mm length, with a mean of 173.8 mm. These fish were all in the lakes system.

The stomach contents of 10 peamouth were examined. Most of the stomach contents of these fish were unidentifiable; however, some stomachs did contain identifiable organisms. One stomach contained several hundred cladocerans, another had 34 segmented worms. Midge fly (Chironomidae) larvae were found in 2 stomachs.

Squawfish

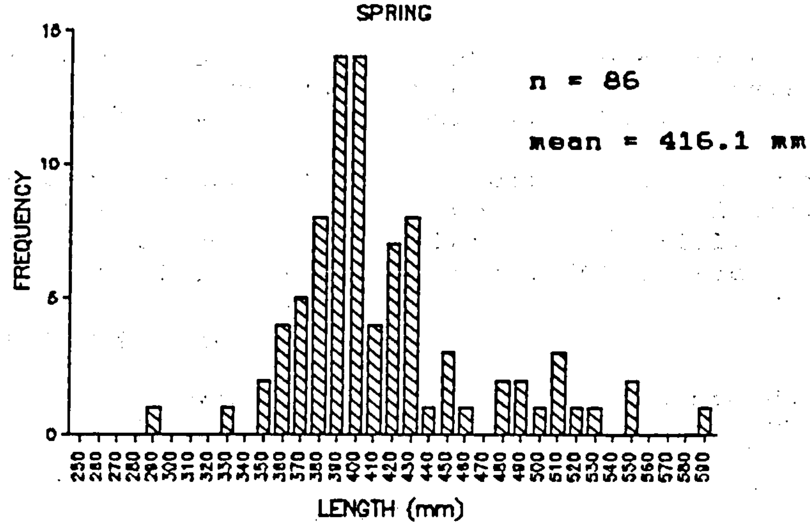
The 18 squawfish measured ranged from 56 to 330 mm length, with a mean of 115.3 mm. The smallest fish were generally collected in Columbia Slough, as was the largest individual. This species was only found in the lakes during the spring sampling.

Feeding habits of squawfish were not examined.

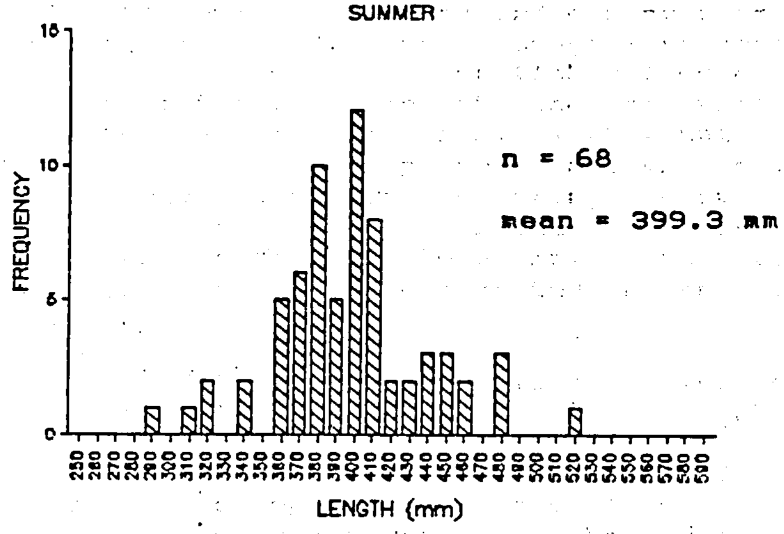
Largescale sucker

Largescale sucker lengths ranged from 71 to 480 mm, with a mean of 353.3 mm for the 52 fish measured. The graph of length frequencies for this species (Figure G-12) indicates at least 3 distinct age groups; fish with lengths about 100 mm, 200 mm, and 400 mm. Squawfish length data from British

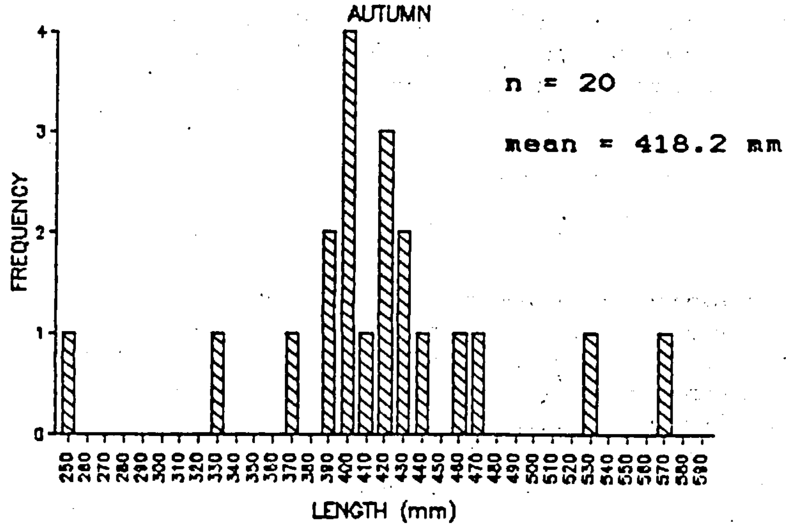
CARP LENGTH FREQUENCY
SPRING



CARP LENGTH FREQUENCY
SUMMER



CARP LENGTH FREQUENCY
AUTUMN



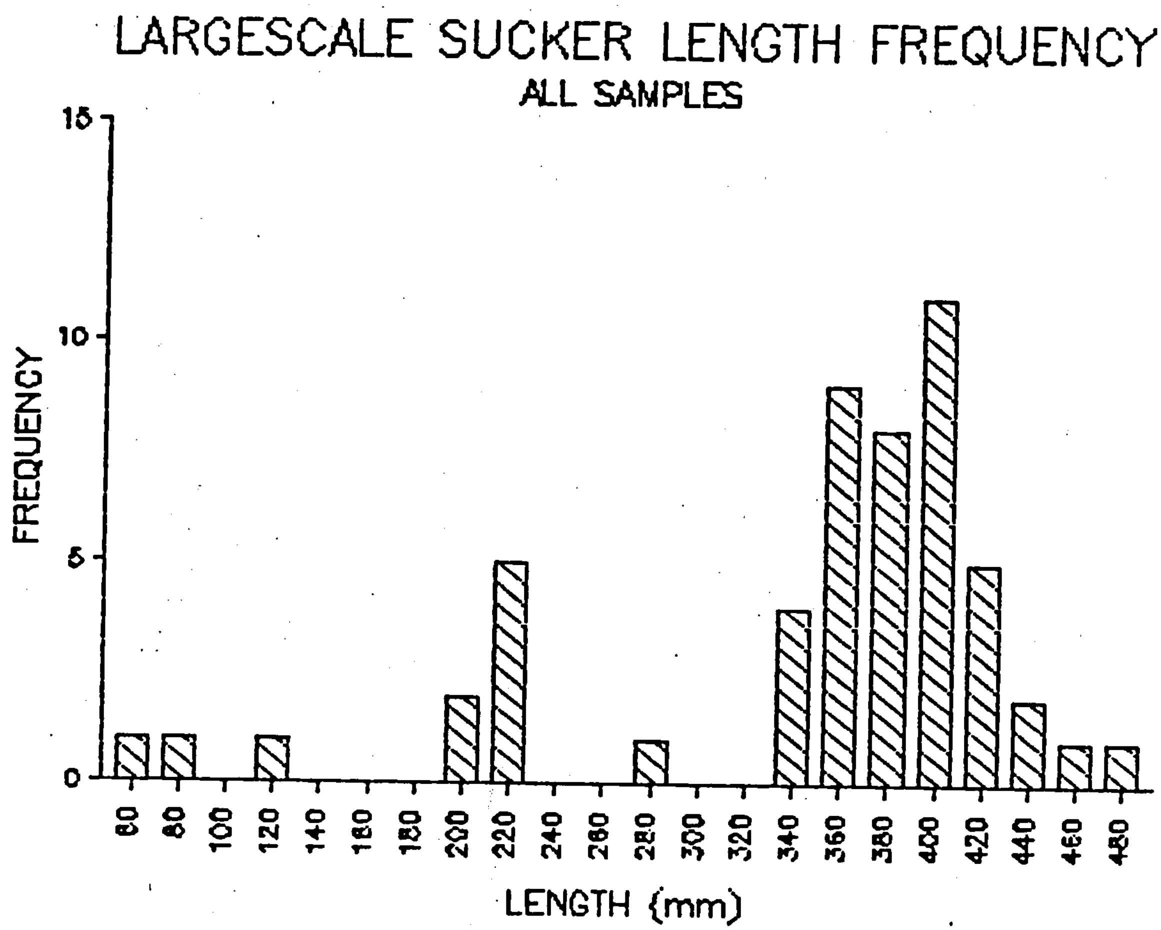
SMITH AND BYBEE LAKES ENVIRONMENTAL STUDIES

CARP LENGTH FREQUENCY

DECEMBER, 1986

FIGURE G-11

FISHMAN ENVIRONMENTAL SERVICES



n = 52

mean = 353.3 mm

SMITH AND BYBEE LAKES ENVIRONMENTAL STUDIES

LARGESCALE SUCKER LENGTH FREQUENCY

DECEMBER, 1986 FIGURE G-12

Columbia and Montana show fish of these sizes to be between ages 2 to 3 years, 4 to 6 years, and 6 years or older, respectively (Wydoski and Whitney 1979).

The stomach contents of 3 large suckers were examined. The contents of 2 stomachs were totally unidentifiable; the third contained 75% plant material, about 25% unidentifiable, and approximately 700 ostracods.

Pumpkinseed sunfish

Length data were obtained for 11 pumpkinseed. They ranged from 74 to 135 mm length, with a mean of 105 mm. Stomach contents were not examined.

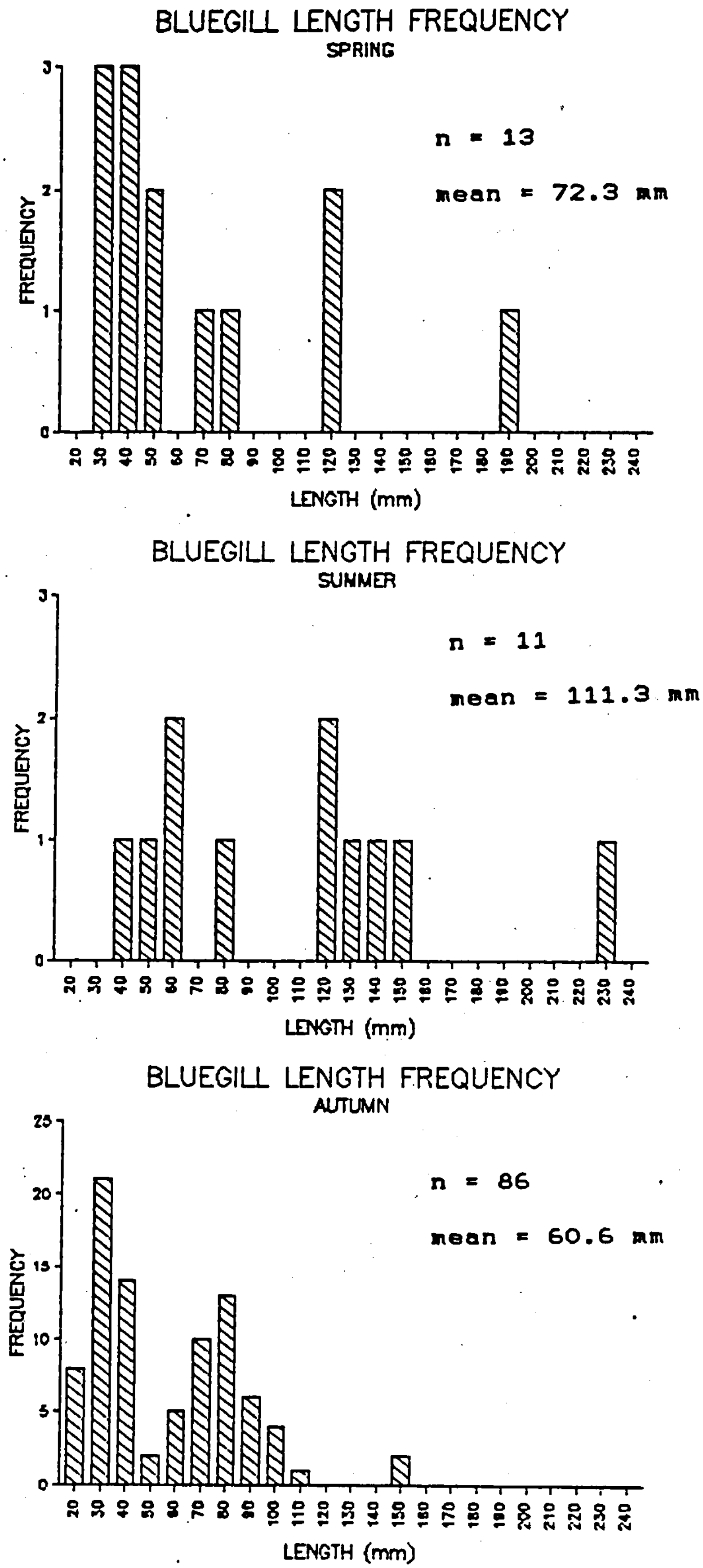
Bluegill

The 110 bluegill lengths recorded ranged from 22 to 238 mm, with a mean of 67.03 mm. Length-frequency graphs are presented in Figure G-13 for fish collected during spring, summer and autumn. These data indicate that the population is dominated by smaller fish, with young-of-the-year fish very abundant in the September (autumn) collection. The data, although scant for the spring and summer collections, probable show the growth of the age 1 fish between spring (30 to 50 mm), summer (40 to 60 mm), and autumn (60 to 100 mm). The 1986 spawn is represented by the 20 to 40 mm fish shown in the autumn data.

Food habit data for 25 bluegill are summarized in Figure G-14. The overall diet, based on numerical abundance of food items, was dominated by copepods (54%) and cladocerans (36%). Fish collected during spring had fed heavily on both cladocerans and copepods, whereas fish taken during autumn had virtually no cladocerans in their guts. This seasonal change in importance of food items is a reflection of changes in zooplankton populations in the lakes (see Technical Appendix F). Bluegill collected in autumn had fed more on midge fly larvae and amphipods than fish taken in spring. These food items are very important in the autumn diet, especially if their weight (and caloric content) is considered compared to individual planktonic organisms.

Largemouth bass

The lengths of the 37 bass measured ranged from 25 to 400 mm, with a mean of 220.08 mm. Length-frequency data are graphed for spring, summer and autumn in Figure G-15. Again, although data are scanty, they indicated reproducing population with several age classes. Growth of age 1 fish can be seen in the graphs from 80 mm in spring, to about 120 mm in summer, and about 170 mm in autumn. Age 0



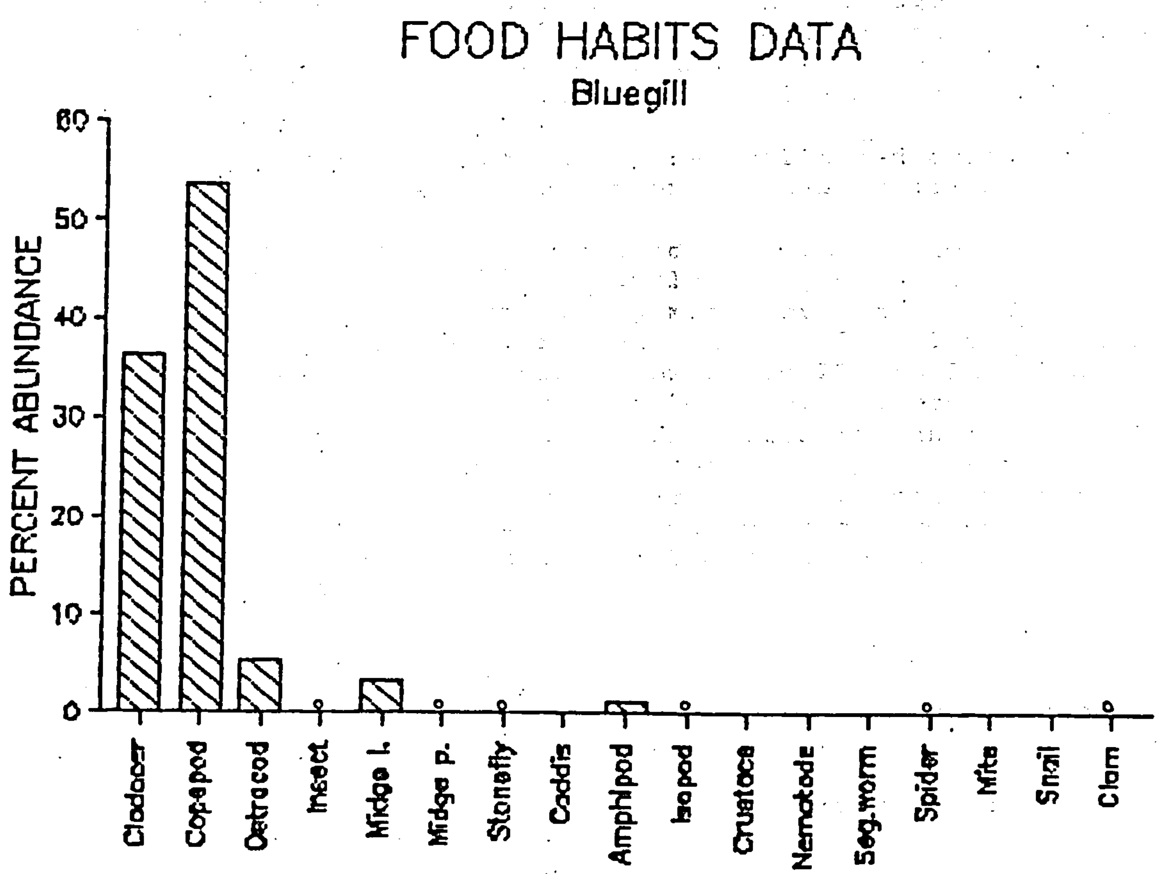
SMITH AND BYBEE LAKES ENVIRONMENTAL STUDIES

BLUEGILL LENGTH FREQUENCY

DECEMBER, 1986

FIGURE G-13

FISHMAN ENVIRONMENTAL SERVICES



° <1%

SMITH AND BYBEE LAKES
ENVIRONMENTAL STUDIES

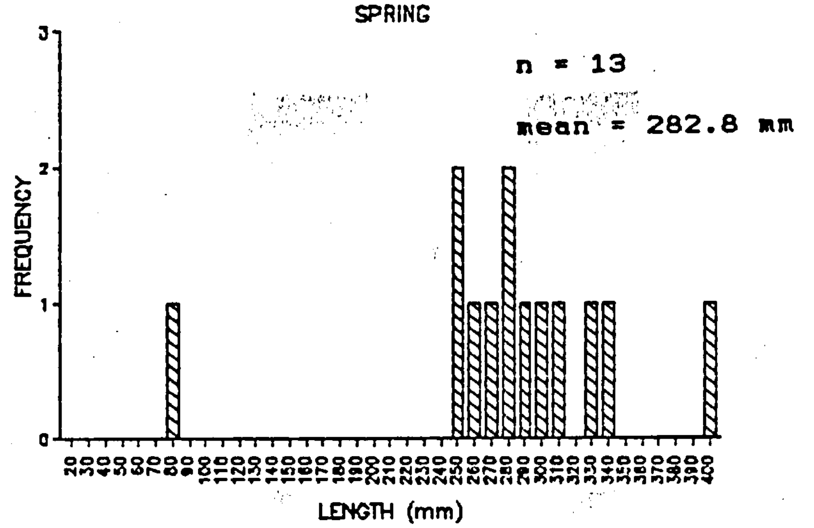
BLUEGILL FEEDING HABITS

FISHMAN ENVIRONMENTAL SERVICES

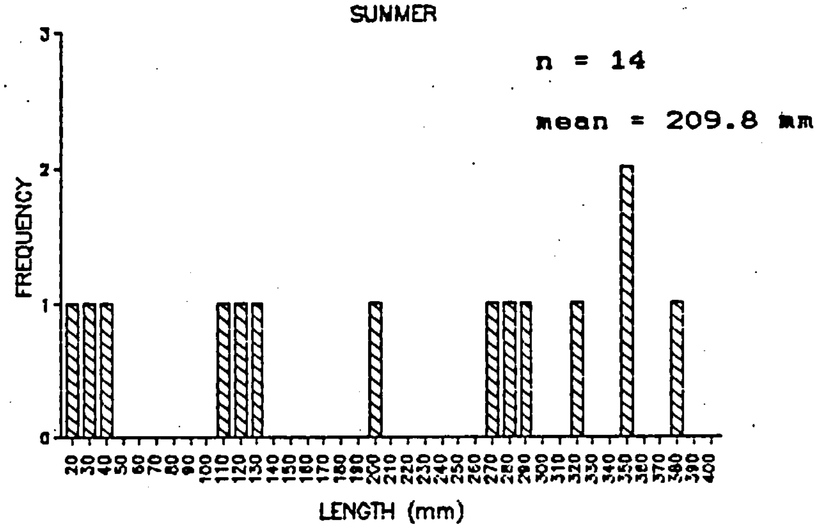
DECEMBER, 1986

FIGURE 6-14

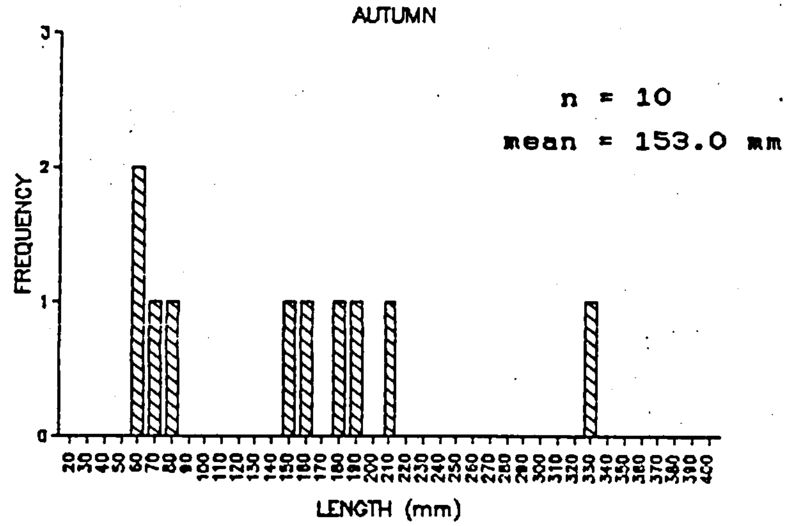
LARGEMOUTH BASS
SPRING



LARGEMOUTH BASS
SUMMER



LARGEMOUTH BASS
AUTUMN



SMITH AND BYBEE LAKES ENVIRONMENTAL STUDIES

LARGEMOUTH BASS LENGTH FREQUENCY

DECEMBER, 1986

FIGURE G-15

FISHMAN ENVIRONMENTAL SERVICES

(young-of-the-year) fish were about 30 mm in summer and about 70 mm in autumn.

The stomachs of 8 bass were examined. The 5 fish taken in Bybee Lake on April 30 all had empty stomachs; these fish ranged from 205 to 305 mm length. Two of the three fish examined from the autumn collection had empty stomachs, the third had eaten cladocerans (86%) and copepods (14%). These later fish ranged from 62 to 83 mm length (age 0).

White Crappie

The 74 white crappie lengths recorded ranged from 55 to 256 mm, with a mean of 147.08 mm. Length-frequency graphs for the three sampling seasons are presented in Figure G-16. The spring data show four or five distinct age classes in the sampled population; the summer and autumn data are too scant to follow growth in these classes. The 55 to 75 mm fish collected in autumn represent the 1986 spawn.

Gravid female white crappie were collected during early May, indicating spring reproduction for this species.

Stomach contents were examined for 18 white crappie. These fish were almost exclusively plankton eaters, with cladocera and copepods comprising most of the food items identified (50% and 48%, respectively). The larger fish sampled during spring, ranging from 87 to 235 mm length, fed most heavily on cladocerans, followed by copepods and then ostracods (Figure G-17). These fish also ate an occasional midge fly larva or pupa. The smaller fish sampled in autumn, ranging from 29 to 67 mm length, ate primarily copepods and ostracods, with few cladocerans present in the samples. This is a reflection of the decline in cladoceran populations in the lakes.

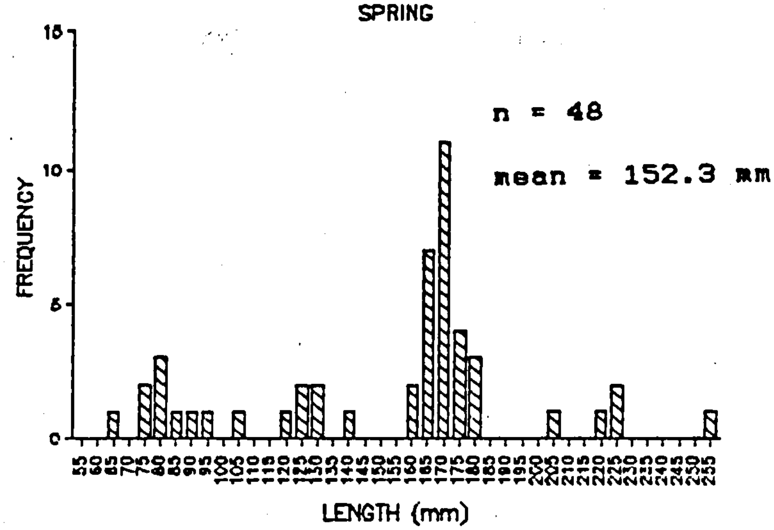
Black crappie

A total of 18 black crappie were measured, ranging from 33 to 206 mm length, with a mean of 118.78 mm.

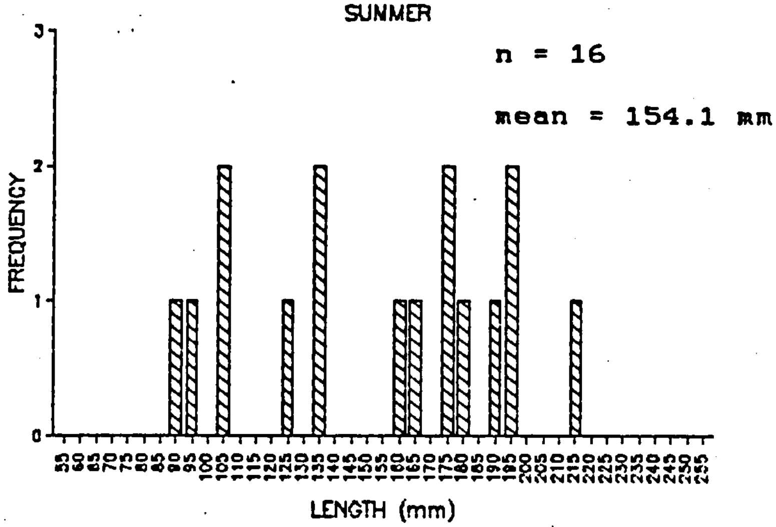
Male and female black crappie in reproductive condition were observed during early May.

Stomach contents were examined for 4 black crappie ranging from 153 to 171 mm length. These fish had eaten cladocerans (77%), copepods (11%), and ostracods (11%). Amphipods were also important in the diets of these fish; although numerically this prey item was only 1% of the total food items, individual fish contained as many as 99 amphipods. This is a significant volume of food in these diets. Midge fly larvae and pupae were also present in small numbers.

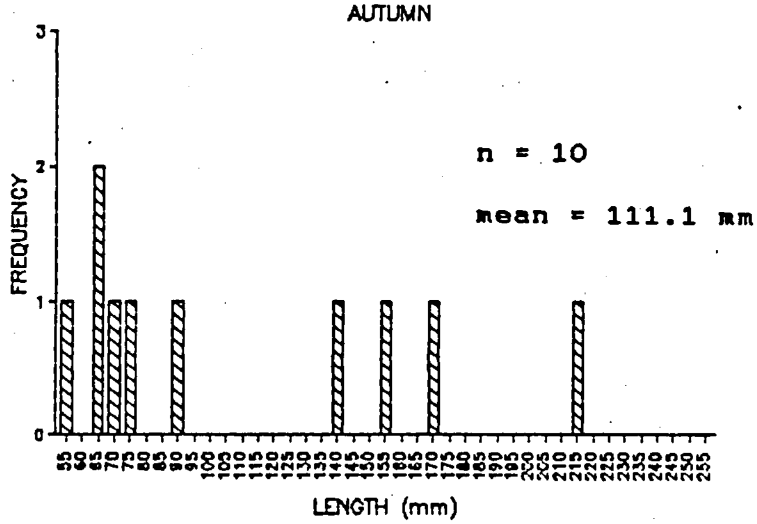
WHITE CRAPPIE LENGTH FREQUENCY
SPRING



WHITE CRAPPIE LENGTH FREQUENCY
SUMMER



WHITE CRAPPIE LENGTH FREQUENCY
AUTUMN



SMITH AND BYBEE LAKES
ENVIRONMENTAL STUDIES

WHITE CRAPPIE LENGTH FREQUENCY

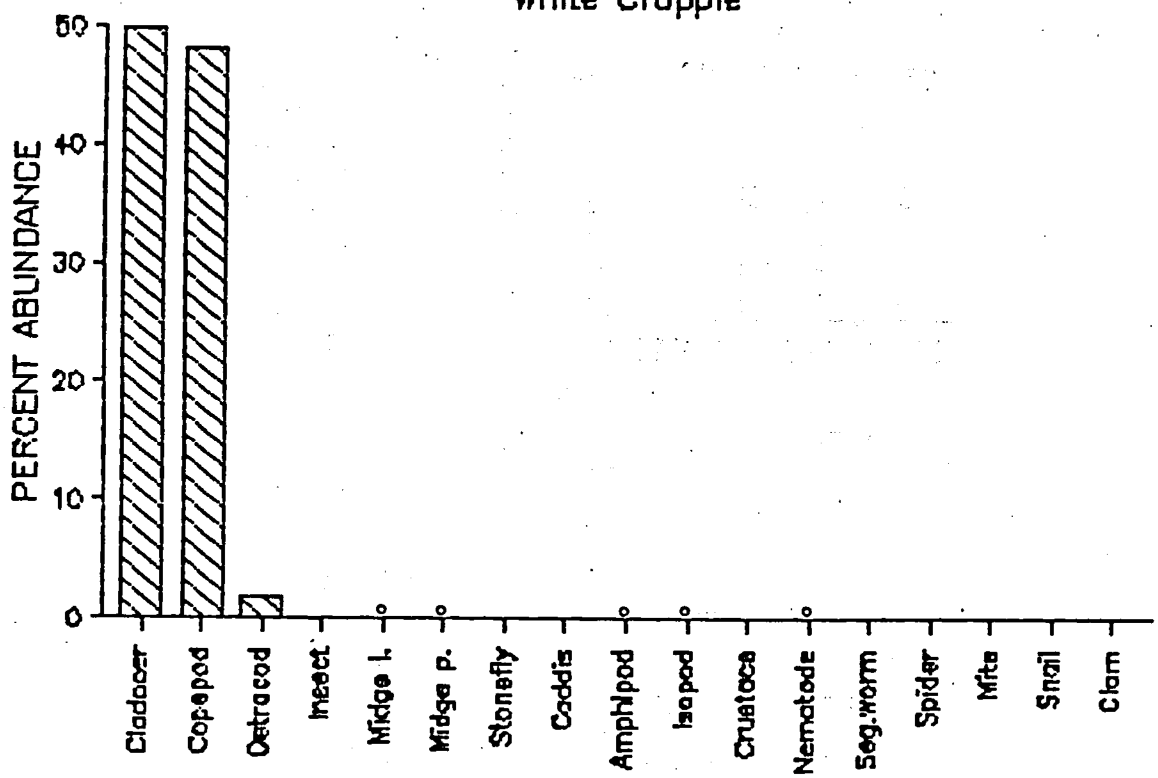
DECEMBER, 1986

FIGURE G-16

FISHMAN ENVIRONMENTAL SERVICES

FOOD HABITS DATA

White Crappie



° < 1 %

SMITH AND BYBEE LAKES ENVIRONMENTAL STUDIES

WHITE CRAPPIE FOOD HABITS

FISHMAN ENVIRONMENTAL SERVICES G-37

DECEMBER, 1986 FIGURE 6-17

Yellow perch

The 71 perch lengths recorded ranged from 77 to 224 mm length, with a mean of 147.32 mm. Most perch were taken during the spring collection, as seen in the length-frequency graphs in Figure G-18. The spring collection had 4 or 5 distinct age classes; these are not clearly represented in the few fish sampled during summer and autumn collections.

Stomach contents were examined for 28 perch,, ranging in size from 79 to 215 mm. All but 2 of these fish were from spring collections. Perch stomachs contained a wide variety of food items (Figure G-19). The numerically dominant item was copepods (79%), followed by midge fly larvae (13%). Cladocera, ostracods and spiders each comprised about 2% of the stomach contents. Perch also had eaten stonefly nymphs, amphipods, isopods, and snails.

Starry flounder

Two starry flounder were collected in the lower part of Columbia Slough during October, a third was seen but not captured. The 2 fish captured were 161 and 192 mm long. The stomachs of these fish were examined; one was empty, the other contained 2 isopods.

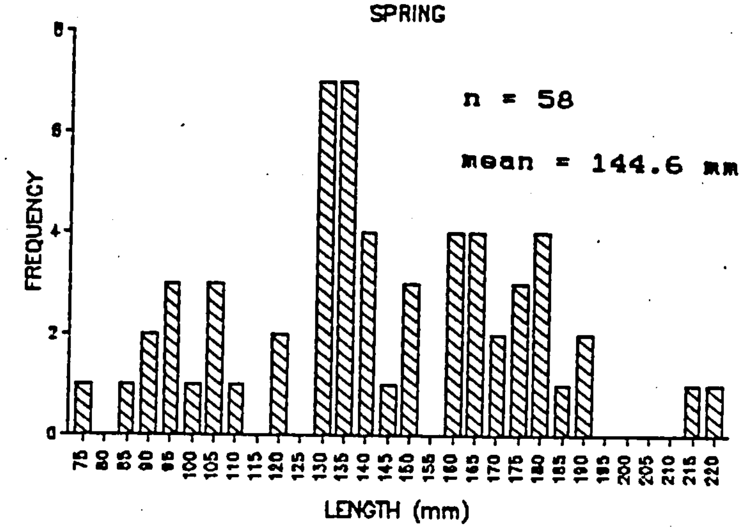
3.2.2 Fish Health

Observations were recorded in the field notes concerning fish health. Fin parasites were noted for several pumpkinseed sunfish in Bybee Lake on April 30, and on one peamouth in Smith Lake on June 26. Open body sores, perhaps resulting from wounds, were noted for a goldfish in Columbia Slough on May 9, and a brown bullhead in North Slough on June 26.

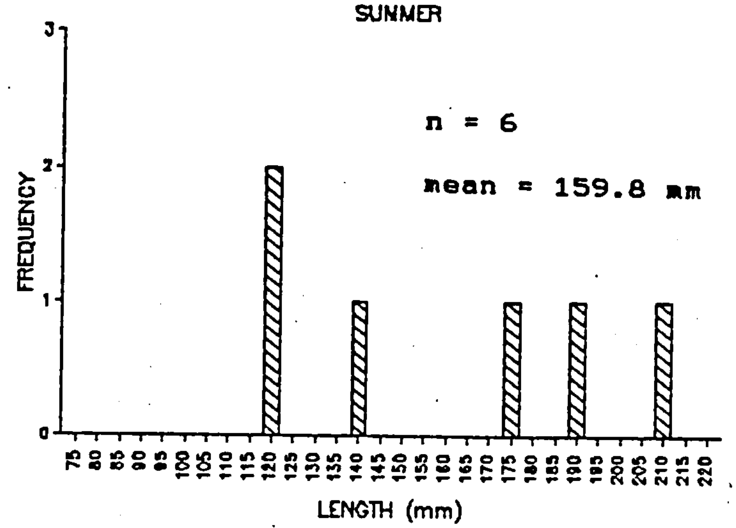
Eroded or rotted fins were noted for 2 carp on June 26 in Bybee Lake and Columbia Slough; this condition was also noted for a yellow perch and bluegill in Columbia Slough on that date. Three white crappie collected in North Slough on June 26 had very severe fin erosion.

The Oregon Department of Environmental Quality (DEQ) has collected and analysed fish tissue for toxic compounds annually between 1979 and 1982 throughout the state. Data for Columbia Slough stations are included in Appendix G-B. Interpretation of these data is not attempted in this report.

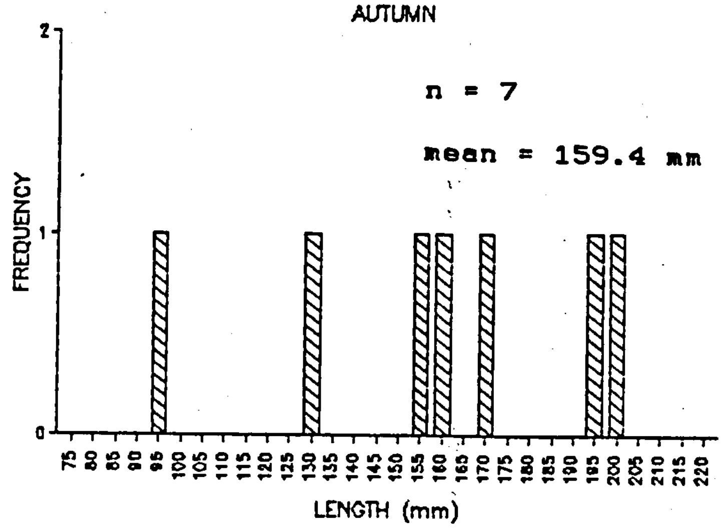
YELLOW PERCH LENGTH FREQUENCY
SPRING



YELLOW PERCH LENGTH FREQUENCY
SUMMER



YELLOW PERCH LENGTH FREQUENCY
AUTUMN

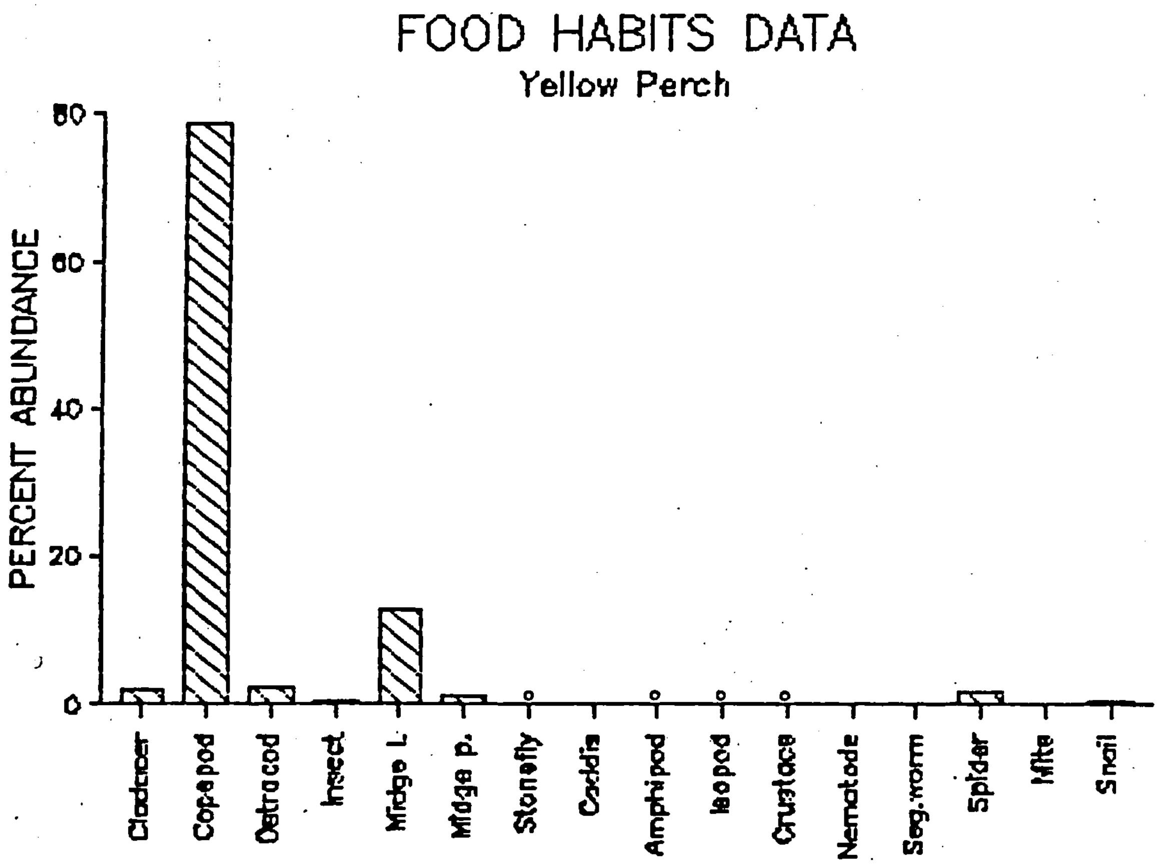


SMITH AND BYBEE LAKES
ENVIRONMENTAL STUDIES

YELLOW PERCH LENGTH FREQUENCY

DECEMBER, 1986 ; FIGURE G-18

FISHMAN ENVIRONMENTAL SERVICES



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SMITH AND BYBEE LAKES ENVIRONMENTAL STUDIES

YELLOW PERCH FOOD HABITS

DECEMBER, 1986

FIGURE 6-19

4 DISCUSSION

Smith and Bybee Lakes, and Columbia Slough, are populated by a variety of fish species. While carp dominate most habitats throughout the year, populations of game fish species are fairly well developed, particularly in the lakes. A modest recreational fishery is presently supported by largemouth bass, crappie and catfish.

4.0.1 Comparison with Similar Lakes

Limited information is available for fish populations in similar lakes in the Portland area. Fish were collected in Sturgeon Lake (Sauvie's Island) over a 2-day period in July, 1981 using gill nets and traps (Klingeman et al. 1982). The most abundant fish in these samples were white crappie, followed by carp. Other abundant species included black crappie, and brown bullhead. Most of the species found in Smith and Bybee Lakes were sampled in Sturgeon Lake. An additional 6 species were found in Sturgeon Lake that were not found in Smith and Bybee Lakes: redside shiner, chiselmouth, stickleback, channel catfish, rainbow trout, and walleye.

The data for Sturgeon Lake suggest a similar but more diverse fish fauna in that system. The length ranges of species compared between the two systems are generally similar, with a major exception. The Smith and Bybee Lake samples contained smaller fish for many species. This difference is likely a result of sampling technique and sampling season. One interesting point is that carp in Sturgeon Lake ranged from 7.7 cm to larger lengths, while the smallest carp sampled in Smith and Bybee Lakes was 25.5 cm. This absense of small carp in Smith and Bybee, and Columbia Slough, is an interesting point in the data.

A report by Fies (1971) presented fish data for sloughs of the lower Columbia River. Areas sampled during spring, 1970 near Portland included: Cunningham and Willow Bar Sloughs on Sauvie's Island, and Government Island Slough. Cunningham Slough samples were dominated by Columbia River chub (not found in Smith and Bybee Lakes study area), Coarsescale (Largescale) sucker, and carp, with smaller numbers of bullhead, white and black crappie, and yellow perch. Willow Bar Slough samples were dominated by white crappie, Columbia River chub, and carp, with fewer numbers of squawfish, sucker, black crappie and perch. The Government Island Slough samples were dominated by suckers, perch and white crappie, followed by fewer numbers of bullhead, chub and black crappie.

An interesting aspect of the sloughs study was the arbitrary designation of "minimum acceptable size", used to provide a measure of value to anglers. These values can be applied to the Smith and Bybee Lakes study area data. Twelve of the thirteen bass sampled in spring were above the minimum acceptable size (8.0 inches, or 203 mm), as were eight of the fourteen sampled in summer. Most bass sampled during august were below this size limit. Only 2 of the 18 black crappie sampled in the study area were above the minimum acceptable size (7.0 in, or 177.8 mm).

Only 8 of the 110 bluegill sampled in the Smith and Bybee Lakes study area were above the minimum acceptable size. The minimum acceptable size for white crappie (7.0 in, or 177.8 mm) was exceeded by 20 of the 74 fish sampled in the study area; and 17 of the 71 perch sampled exceeded the minimum acceptable size for that species (7.0 in, or 177.8 mm).

Based on the sampling data and minimum acceptable size values, the Smith and Bybee Lakes study area appears to have a good angling potential for bass, and a moderate to good angling potential for white crappie and yellow perch. The angling potential for bluegill and black crappie appears poor. It must be kept in mind that this acceptable size value is arbitrary, and many fish below these sizes are probably kept by anglers. Fishermen interviewed at Smith and Bybee Lakes report good success for bass and white crappie.

A study of Columbia River backwaters above Bonneville Dam was reported by Parente and Smith (1981). The study was directed toward determining the use of these backwaters by juvenile salmonids. General conclusions were that juvenile salmon abundance in the backwater areas of the Columbia River corresponded with hatchery releases and, in a few cases, assumed natural spawning cycles. Fish tended to remain longer in culverted backwaters than in those with channel entrances. Very little predation on juvenile salmon was found for assumed predators such as bass and crappie.

Stomach analyses for juvenile salmon in backwaters found a variety of insect and crustacean prey items, with the quantity and availablity of prey generally determining the feeding habits of the fish. For most sampling areas, insects were the numerically dominant food item during winter. During spring and summer, insects dominated stomach contents in some backwaters, while crustaceans (mostly planktonic) were most abundant numerically in other backwaters. The results of feeding habit analyses in Smith and Bybee Lakes indicated a great reliance on planktonic crustaceans over insects during spring; this agrees with the results of benthic and plankton sampling that showed low diversity and abundance of benthic organisms and high populations of zooplankton (see Fishman Environmental Services 1986).

A fisheries monitoring program in Vancouver Lake, WA, described resident and migratory fish populations in that system and the Columbia River (Knutzen and Cardwell 1984). The numerically dominant species in the lake were black and white crappie; carp were dominant in terms of biomass. Fish populations in the Columbia River during the same sampling periods were dominated numerically by American shad, threespine stickleback and chinook salmon juveniles, while largescale sucker, carp and peamouth were dominant in terms of biomass.

The Vancouver Lake study concluded that juvenile salmon have historically entered Vancouver Lake during early spring, traveling 10 miles up Lake River from the Columbia River. The construction and opening of a flushing channel into the lake provides a new entry and exit point for these fish. Juvenile chinook salmon sampled in the lake during June and July were larger than fish sampled concurrently in the Columbia River, indicating good growth for fish in the Lake.

The Vancouver Lake study also found that juvenile salmon in the lake congregated near the flushing channel entrance in late June and July, likely due to an attraction to cooler Columbia River water. The abundance of salmonids in the Lake declined markedly by July; it was inferred, although not proven, that fish had left the lake through the flushing channel culverts and Lake River. Predation on juvenile salmon appeared to be minimal in the lake.

Feeding habits of juvenile salmon in Vancouver Lake were similar to those described for Smith and Bybee Lakes; zooplankton, especially cladocerans, was the major food category.

The Vancouver Lake study lends support to our conclusion that Smith and Bybee Lakes provide a good rearing environment for juvenile salmon during spring and early summer; food is abundant and predation is minimal. It appears that juvenile salmon entered Smith and Bybee Lakes during the late February freshet, and likely left the system during the early June freshet.

The Vancouver Lake fish community was numerically dominated by white crappie (35%) and black crappie (18%); unidentified crappie accounted for another 7% of the average monthly densities between November, 1982 and September, 1984. All other species, including carp, perch, shad, bass, peamouth, salmonids and others accounted for less than 10% each (Knutzen and Cardwell 1984). Smith and Bybee Lakes data show a very different composition, the averages for all samples over the three sampling periods show carp most abundant (about 33%), followed by bluegill (19.&%) and bass (10.4%). All other species represented less than 10% of the average abundance each; white crappie accounted for about 8%, black crappie were about 6%.

The Lake River fish data (from the Vancouver Lake study) show a very different fish fauna compared with Columbia Slough. Lake River samples were numerically dominated by black crappie (44%), white crappie (36.5%) and carp (10.4%), with much fewer suckers, sturgeon, salmonids and others (Knutzen and Cardwell 1984). Columbia Slough samples from this study were dominated by carp (22.3%), goldfish (14.7%) and largescale suckers (13.3%). Juvenile salmon accounted for 10% of average fish abundance in Columbia Slough, white crappie was 9.7%; no black crappies were taken from Columbia Slough.

While similarities exist between the Smith and Bybee Lakes fish fauna and the other area lakes discussed above, some interesting differences are evident. Smith and Bybee Lakes, and Columbia Slough, appear to have larger populations of carp, suckers and other "rough" fish species. On the other hand, Smith and Bybee Lakes appear to have a more well developed warm-water game fish fauna dominated by bass and crappie, with a good base of small bluegill available as forage. Vancouver and Sturgeon Lakes contain species typical of the Columbia River such as shad, sturgeon, sticklebacks and chubs; these were not found in Smith and Bybee.

4.0.2 Seasonal and Habitat Relationships

The population dynamics of the fish fauna in the Smith and Bybee Lakes - Columbia Slough system are driven by a combination of hydrological conditions and habitat variables. The presence of a water control structure that separates the lakes from the slough during most of the year has certainly had a profound effect on the fish fauna since 1982. Unfortunately, little is known about the fish fauna in the lakes prior to 1982, except for the experience of local fishermen.

The water control structure has essentially created an impoundment in a system that was previously a tidal wetland (Bybee Lake) and bottomland lake (Smith Lake). This impoundment of water has increased the area of certain fish habitat, such as open, deeper water, and restricted the movement of fish between the lakes and the Columbia/Willamette Rivers (through Columbia Slough). The extent of movement between the lakes and rivers is totally dependent on the timing and height of high water events in the rivers. During the sampling period, 1986, fish were able to move between the rivers and lakes during late February and early June.

The spring samples (late April - early May) were characterized by juvenile salmon everywhere in the system. Carp were numerically dominant in the lakes, but not in the slough; this might reflect their movement into shallow, vegetated areas for spawning. White crappie and yellow perch were also abundant in the lakes.

The summer samples (late June) can be described in a word: carp. These fish were dominant everywhere fish were found. In general, fish abundance was much lower in summer and autumn samples than spring. The autumn samples (October) in the lakes were dominated by the past summer's bluegill hatch, while goldfish were numerically dominant in Columbia Slough.

Carp were dominant, in terms of biomass, during all seasons and in all areas. They were less dominant in the slough than in the lakes; suckers and goldfish represented significant biomass in the slough.

Carp also were dominant in all habitats throughout the sampling season, with the exception of small bluegill in the open water/smartweed and dam pool habitats during autumn. Bass were more abundant in the no-flow channel habitat than they were in any other habitat. Perch were most abundant in the smartweed and open water/smartweed habitats than they were elsewhere. Black crappie were more abundant in habitats with smartweed than without; white crappie were in these habitats as well as the open water, channel and slough habitats.

4.0.3 Faunal Composition: General Comments

Carp is certainly the dominant species in both the Columbia Slough and Smith and Bybee Lakes. The low numbers or absence of game fish species in the slough, when compared with the lakes, is a reflection of habitat structure and quality. The turbid water, unconsolidated bottom, lack of rooted aquatic vegetation, and perhaps water quality in the slough provide conditions more suited to the "rough" fish species than game fish. It is interesting to note that perch and crappie were more abundant in North Slough than in the main slough; this could be due to the abundance of logs, snags, debris and a grounded barge in North Slough. Ponded areas of a dead-end side channel of Columbia Slough, east of the landfill on the south side of the slough, were sampled during a previous study (Fishman Environmental Services 1985). These areas, which contained rooted submerged and emergent aquatic vegetation, contained a variety of small game fish species, as well as carp.

Smith and Bybee Lakes, while generally dominated by carp, support a fairly diverse and apparently "healthy" fauna of warm-water game fish species. Length data presented in this report indicate a good spread of age classes and good reproduction for these species. Abundant plankton and insects provide food for these species. Carp are not direct competitors with game species for food and habitat resources, neither are they predators on these species. The major interaction beween carp and the game fish is probably the secondary effects of habitat disturbance, such as increased turbidity from carp feeding on mud bottoms. While carp were observed spawning in the lakes, no carp younger than 2 or more years were taken in any of the samples.

5 RECOMMENDATIONS

A Management Plan for Smith and Bybee Lakes should consider two primary aspects of fish populations in the lakes: the importance of the lakes as fish habitat, and the use of the lakes for recreational fishing. Recommendations are based on these two aspects.

1. An in-depth study should be conducted to assess the use of the lakes by juvenile salmon. Data from the present study indicate that the lakes and Columbia Slough are heavily utilized by juvenile salmon during the spring. Abundant zooplankton provide food, and warmer temperatures favor rapid growth of these young fish. There is some evidence of more rapid growth in the lakes compared with the slough. The impoundment of high water during the freshet potentially traps these fish in the lakes rather than allowing them to continue their migration. Water level management should allow for the release of juvenile salmon from

the lakes during June.

2. Carp is the dominant species in the lake and slough system, and contributes to poor water quality by re-suspending bottom sediments. Since it would be virtually impossible to eliminate carp from the system, water levels should be managed to reduce populations in the lakes when possible. It was evident during the summer of 1986 that large numbers of carp were attempting to return to Columbia Slough from the lakes, but were trapped by the water control structure. Selective releases of water from the lakes could reduce the carp populations. Although carp are often considered "rough fish" they are actually a desired sport species and food item within certain communities. Encouraging a sport fishery for carp in the lakes should also be part of a Management Plan.

3. Habitat enhancement efforts should be planned to provide more habitat for largemouth bass, bluegill and crappie. These enhancements could include: maintenence of channels through smartweed areas, construction of brush piles in open water areas, and placement of sediments suitable for spawning.

6 REFERENCES

Fies, T.T. 1971. Surveys of some sloughs of the lower Columbia River. Oregon State Game Commission, Fishery Division.

Fishman Environmental Services. 1985. Wetland Assessment. Prep. for Columbia Steel Casting Co., Inc. Portland, OR.

Fishman Environmental Services. 1986. Smith and Bybee Lakes Environmental Studies. Technical Appendix F: Aquatic Invertebrates. Sponsored by Port of Portland and City of Portland Bureau of Environmental Services.

Klingeman, P.C., R.L. Jarvis, D.A. Bella and P.O. Nelson. 1982. Physical, chemical and biological description of Sturgeon Lake. Technical Report 1, Sturgeon Lake Restoration: Phase I Diagnostic/Feasibility Study under 314 Clean Lakes Grant Program. Water Resources Research Institute. Oregon State Univ. Corvallis.

Knutzen, J.A. and R.D. Cardwell. 1984. Revised Draft Final Report for the Fiosheries Monitoring Program, Vancouver Lake Restoration Project. Envirosphere Co. for Cooper Consultants, Inc. Portland, OR.

Oregon State Game Commission. 1973. Fish population investigations in Columbia Slough and adjacent waters. March 15 to April 6, 1973.

Parente, W.D. and J.G. Smith. 1981. Columbia River Backwater Study: Phase II. U.S. Fish & Wildlife Serv., Fisher. Assist. Office, Vancouver, WA and Columbia River Inter-tribal Fish Commission.

Wydoski, R.S. and R.R. Whitney. 1979. Inland Fishes of Washington. Univ. of Washington Press. Seattle.

APPENDIX G-A

NOTE: READ PIE FIGURES COUNTER-CLOCKWISE
BEGINNING FROM THE 3 O'CLOCK POSITION

FISH CATCH DATA FOR SMITH AND BYBEE LAKES STUDY AREA, 1986

TABLE G-A-1 FISH CATCH DATA

DATE MMDDYY	HAUL	STATION	GEAR	TIME 24hr	DURATION min	DEPTH m	TEMP C	HABITAT	SPECIES	NUMBER	G-WGHT gram
043086	1	BL01	EF	1200	10	1.0	14.0	PSS1	Cp	6	9534
043086	1	BL01	EF	1200	10	1.0	14.0	PSS1	BrB	1	361
043086	1	BL01	EF	1200	10	1.0	14.0	PSS1	YP	5	188
043086	1	BL01	EF	1200	10	1.0	14.0	PSS1	WC	3	78
043086	1	BL01	EF	1200	10	1.0	14.0	PSS1	Bg	1	14
043086	2	BL02	EF	1330	10	2.0		L2UB3	WC	10	610
043086	2	BL02	EF	1330	10	2.0		L2UB3	YP	4	111
043086	3	BL03	EF	1400	9	1.0		L2EM1*	WC	3	182
043086	3	BL03	EF	1400	9	1.0		L2EM1*	YP	1	29
043086	3	BL03	EF	1400	9	1.0		L2EM1*	Sq	1	5
043086	3	BL03	EF	1400	9	1.0		L2EM1*	LB	1	6
043086	3	BL03	EF	1400	9	1.0		L2EM1*	Ps	3	140
043086	3	BL03	EF	1400	9	1.0		L2EM1*	Sf	1	2
043086	3	BL03	EF	1400	9	1.0		L2EM1*	Cp	2	2542
043086	4	BL04	EF	1500	10	1.0		L2EM1	Cp	10	13166
043086	4	BL04	EF	1500	10	1.0		L2EM1	YP	3	94
043086	4	BL04	EF	1500	10	1.0		L2EM1	Ch	1	11
043086	4	BL04	EF	1500	10	1.0		L2EM1	Bg	1	3
043086	5	BL05		1530	10			L2UB3	Cp	1	
043086	5	BL05		1530	10			L2UB3	LSu	1	
043086	5	BL05		1530	10			L2UB3	YP	1	
043086	5	BL05		1530	10			L2UB3	WC	2	
043086	5	BL05		1530	10			L2UB3	Ch	1	
043086	6	BL06		1600	10			PSS/EM1	Cp	4	8762
043086	6	BL06		1600	10			PSS/EM1	YP	5	256
043086	6	BL06		1600	10			PSS/EM1	Ch	8	117
043086	6	BL06		1600	10			PSS/EM1	Bg	1	1
043086	7	BL07		1700	10		15.0	L2UB3	YP	2	N/A
043086	7	BL07		1700	10		15.0	L2UB3	Ch	1	N/A
043086	8	BL08		1800	10			L2UB3*	Cp	16	20430
043086	8	BL08		1800	10			L2UB3*	LSu	4	2724
043086	8	BL08		1800	10			L2UB3*	Pm	6	746
043086	8	BL08		1800	10			L2UB3*	LB	4	1415
043086	8	BL08		1800	10			L2UB3*	Ch	13	228
043086	8	BL08		1800	10			L2UB3*	YP	1	42
043086	8	BL08		1800	10			L2UB3*	Sf	1	4
050286	1	SL01		1130	10	1.3	13.8	L2EM1	Cp	7	8308
050286	1	SL01		1130	10	1.3	13.8	L2EM1	Pm	1	205
050286	1	SL01		1130	10	1.3	13.8	L2EM1	Ch	2	25
050286	1	SL01		1130	10	1.3	13.8	L2EM1	YP	2	93
050286	1	SL01		1130	10	1.3	13.8	L2EM1	BC	3	212
050286	2	SL02		1230		1.3	13.8	L2EM1	Cp	5	5675
050286	2	SL02		1230		1.3	13.8	L2EM1	YP	3	252
050286	2	SL02		1230		1.3	13.8	L2EM1	BC	5	157
050286	2	SL02		1230		1.3	13.8	L2EM1	Bg	2	61

050286	2	SL02	1230		1.3	13.8	L2EM1	Sq	2	109
050286	3	SL03	1300	2	1.3		PSS/EM1	YP	2	N/A
050286	3	SL03	1300	2	1.3		PSS/EM1	Bg	2	N/A
050286	3	SL03	1300	2	1.3		PSS/EM1	Cp	1	N/A
050286	4	SL04	1335	10	1.7		L2EM1/UB3	Cp	2	3450
050286	4	SL04	1335	10	1.7		L2EM1/UB3	Ch	2	44
050286	4	SL04	1335	10	1.7		L2EM1/UB3	WC	2	266
050286	4	SL04	1335	10	1.7		L2EM1/UB3	YP	1	36
050286	5	SL05	1400	10	1		L2EM1/UB3	Cp	5	6265
050286	5	SL05	1400	10	1		L2EM1/UB3	YP	3	235
050286	5	SL05	1400	10	1		L2EM1/UB3	Ch	1	24
050286	5	SL05	1400	10	1		L2EM1/UB3	Ps	1	34
050286	5	SL05	1400	10	1		L2EM1/UB3	WC	1	7
050286	5	SL05	1400	10	1		L2EM1/UB3	Su	1	3
050286	5	SL05	1400	10	1		L2EM1/UB3	Gf	1	127
050286	6	SL06	1500	10	1.8		L2EM1/UB3	Cp	2	2315
050286	6	SL06	1500	10	1.8		L2EM1/UB3	Sq	3	87
050286	6	SL06	1500	10	1.8		L2EM1/UB3	Ch	3	43
050286	6	SL06	1500	10	1.8		L2EM1/UB3			
050286	7	SC01	1600	10	1.8		PUB3	Cp	1	5448
050286	7	SC01	1600	10	1.8		PUB3	Gf	2	494
050286	7	SC01	1600	10	1.8		PUB3	Ch	2	33
050286	7	SC01	1600	10	1.8		PUB3	WC	1	14
050286	7	SC01	1600	10	1.8		PUB3	Bg	1	4
050286	8	SC02	1640	10	1.5	15	PUB3	LB	1	1135
050286	8	SC02	1640	10	1.5	15	PUB3	Cp	3	4858
050286	8	SC02	1640	10	1.5	15	PUB3	WC	7	818
050286	8	SC02	1640	10	1.5	15	PUB3	YP	2	154
050286	8	SC02	1640	10	1.5	15	PUB3	Bg	1	47
050286	8	SC02	1640	10	1.5	15	PUB3	Ch	1	17
050286	9	SC03	1710	10	2		PUB3	Cp	8	13302
050286	9	SC03	1710	10	2		PUB3	LB	5	2257
050286	9	SC03	1710	10	2		PUB3	Bg	1	197
050286	9	SC03	1710	10	2		PUB3	WC	1	150
050286	9	SC03	1710	10	2		PUB3	YP	2	152
050286	9	SC03	1710	10	2		PUB3	Ch	2	33
050986	1	CS01	1030	10	2	13	R1UB3	LSu	1	690
050986	1	CS01	1030	10	2	13	R1UB3	Sq	1	16
050986	2	CS02	1100	10	2	13	R1UB3	Ch	2	17
050986	3	CS03	1115	10	2		R1UB3	Cp	2	2769
050986	3	CS03	1115	10	2		R1UB3	LSu	4	2267
050986	3	CS03	1115	10	2		R1UB3	Pm	2	118
050986	3	CS03	1115	10	2		R1UB3	Gf	1	292
050986	3	CS03	1115	10	2		R1UB3	WC	2	177
050986	3	CS03	1115	10	2		R1UB3	YP	1	53
050986	3	CS03	1115	10	2		R1UB3	Ch	4	52
050986	4	CS04	1200	10	1	15.8	R1UB3	YP	1	14
050986	4	CS04	1200	10	1	15.8	R1UB3	WC	3	223
050986	4	CS04	1200	10	1	15.8	R1UB3	Ch	5	34
050986	4	CS04	1200	10	1	15.8	R1UB3	Bg	3	9

050986	5	CS05	1330	10	2	15.8	R1UB3	Cp	4	7854
050986	5	CS05	1330	10	2	15.8	R1UB3	LSu	1	1135
050986	5	CS05	1330	10	2	15.8	R1UB3	Gf	2	268
050986	5	CS05	1330	10	2	15.8	R1UB3	YP	7	327
050986	5	CS05	1330	10	2	15.8	R1UB3	Cot	3	76
050986	5	CS05	1330	10	2	15.8	R1UB3	WC	3	201
050986	5	CS05	1330	10	2	15.8	R1UB3	Ch	2	7
050986	6	CS06	1430	10		15.8	R1UB3	Cp	4	7536
050986	6	CS06	1430	10		15.8	R1UB3	LSu	11	3674
050986	6	CS06	1430	10		15.8	R1UB3	Gf	1	274
050986	6	CS06	1430	10		15.8	R1UB3	WC	5	276
050986	6	CS06	1430	10		15.8	R1UB3	YP	3	56
050986	6	CS06	1430	10		15.8	R1UB3	Ch	3	44
050986	7	CS07	1515	10	1	15.5	R1UB3	Ch	19	224
050986	7	CS07	1515	10	1	15.5	R1UB3	WC	4	120
050986	7	CS07	1515	10	1	15.5	R1UB3	LSu	8	3788
050986	7	CS07	1515	10	1	15.5	R1UB3	Sq	1	3
050986	7	CS07	1515	10	1	15.5	R1UB3	YP	2	38
050986	7	CS07	1515	10	1	15.5	R1UB3	Cp	9	11532
050986	8	CS08	1615	10	1.5		R1UB3	Cp	3	6538
050986	8	CS08	1615	10	1.5		R1UB3	LSu	3	1861
050986	8	CS08	1615	10	1.5		R1UB3	Ch	9	86
050986	8	CS08	1615	10	1.5		R1UB3	WC	1	69
050986	8	CS08	1615	10	1.5		R1UB3	Sq	2	21
050986	8	CS08	1615	10	1.5		R1UB3	Pm	1	10
062686	1	BL01	1000	10	1.5	24	PSS1	Cp	3	4268
062686	1	BL01	1000	10	1.5	24	PSS1	WC	3	102
062686	2	BL06	1030	10	1.5		PSS/EM1	LB	1	379
062686	2	BL06	1030	10	1.5		PSS/EM1	WC	1	79
062686	2	BL06	1030	10	1.5		PSS/EM1	YP	1	32
062686	2	BL06	1030	10	1.5		PSS/EM1	Bg	1	5
062686	2	BL06	1030	10	1.5		PSS/EM1	Cp	4	4495
062686	3	BL09	1100	10	2		L2UB3	N/A	N/A	N/A
062686	4	BL10	1130	10	2		L2EM1	WC	1	26
062686	4	BL10	1130	10	2		L2EM1	YP	2	182
062686	4	BL10	1130	10	2		L2EM1	Cp	1	863
062686	5	SL01	1230	10	1.7		L2EM1	Pm	3	386
062686	5	SL01	1230	10	1.7		L2EM1	WC	1	79
062686	5	SL01	1230	10	1.7		L2EM1	LB	1	24
062686	5	SL01	1230	10	1.7		L2EM1	Cp	2	3087
062686	6	SL04	1300	10	1.7		24L2EM1/UB3	Cp	2	2134
062686	6	SL04	1300	10	1.7		24L2EM1/UB3	WC	1	165
062686	6	SL04	1300	10	1.7		24L2EM1/UB3	BC	1	87
062686	6	SL04	1300	10	1.7		24L2EM1/UB3	LB	1	37
062686	7	SL05	1400	20			L2EM1/UB3	Cp	5	6038
062686	7	SL05	1400	20			L2EM1/UB3	BrB	1	351
062686	7	SL05	1400	20			L2EM1/UB3	LB	1	324
062686	7	SL05	1400	20			L2EM1/UB3	BC	2	39
062686	8	SC02	1435	10	1.5	25.5	PUB3	Bg	1	314
062686	8	SC02	1435	10	1.5	25.5	PUB3	BC	3	78

062686	8	SC02	1435	10	1.5	25.5	PUB3	WC	1	32
062686	8	SC02	1435	10	1.5	25.5	PUB3	LB	4	104
062686	8	SC02	1435	10	1.5	25.5	PUB3	Cp	6	8081
062686	9	SC03	1518	10	2	25.5	PUB3	Bg	1	55
062686	9	SC03	1518	10	2	25.5	PUB3	LB	4	1659
062686	9	SC03	1518	10	2	25.5	PUB3	Cp	6	5947
062686	10	BL08	1600	10			L2UB3*	LB	2	1362
062686	10	BL08	1600	10			L2UB3*	Cp	23	24380
062686	10	BL08	1600	10			L2UB3*	Pm	1	136
062686	10	BL08	1600	10			L2UB3*	Sq	1	37
062686	10	BL08	1600	10			L2UB3*	YP	1	76
062686	10	BL08	1600	10			L2UB3*	Bg	6	215
062686	10	BL08	1600	10			L2UB3*	WC	2	72
062686	11	CS04	1800	10			R1UB3	Cp	11	11986
062686	11	CS04	1800	10			R1UB3	LSu	2	1172
062686	11	CS04	1800	10			R1UB3	Gf	5	803
062686	11	CS04	1800	10			R1UB3	WC	4	287
062686	11	CS04	1800	10			R1UB3	BrB	1	163
062686	11	CS04	1800	10			R1UB3	Sq	1	2
062686	11	CS04	1800	10			R1UB3	Wm	2	40
062686	11	CS04	1800	10			R1UB3	Bg	1	6
062686	12	CS03	1900	10			R1UB3	LSu	2	1725
062686	12	CS03	1900	10			R1UB3	Cp	1	1135
062686	12	CS03	1900	10			R1UB3	YP	1	27
062686	13	CS06	1930	10			R1UB3	Cp	2	2951
062686	13	CS06	1930	10			R1UB3	Gf	1	7
062686	13	CS06	1930	10			R1UB3	Sq	1	3
062686	13	CS06	1930	10			R1UB3	Bg	1	11
062686	13	CS06	1930	10			R1UB3	YP	1	29
062686	14	CS09	2000	10			R1UB3	Cp	5	6401
062686	14	CS09	2000	10			R1UB3	LSu	1	726
062686	14	CS09	2000	10			R1UB3	Gf	1	155
062686	14	CS09	2000	10			R1UB3	WC	2	173
062686	14	CS09	2000	10			R1UB3	Sq	2	19
062686	14	CS09	2000	10			R1UB3	Bg	1	47
102486	1	SL04	930	10	1.2		15L2EM1/UB3	Bg	3	44
102486	1	SL04	930	10	1.2		15L2EM1/UB3	Gf	1	681
102486	2	SL05	1020	10	1.1		L2EM1/UB3	BC	2	148
102486	2	SL05	1020	10	1.1		L2EM1/UB3	LB	1	61
102486	2	SL05	1020	10	1.1		L2EM1/UB3	Bg	1	2
102486	2	SL05	1020	10	1.1		L2EM1/UB3	Cp	1	1362
102486	3	SL01	1100	10	1.1		L2EM1	Bg	1	91
102486	3	SL01	1100	10	1.1		L2EM1	BC	1	90
102486	3	SL01	1100	10	1.1		L2EM1	YP	1	51
102486	3	SL01	1100	10	1.1		L2EM1	Pm	1	130
102486	3	SL01	1100	10	1.1		L2EM1	LSu	1	681
102486	3	SL01	1100	10	1.1		L2EM1	Cp	3	4767
102486	4	SC01	1140	10	1		PUB3	LB	1	88
102486	5	SC02	1310	10	1.7		PUB3	LB	1	3
102486	5	SC02	1310	10	1.7		PUB3	BC	1	2
102486	5	SC02	1310	10	1.7		PUB3	Cot	1	3

102486	5	SC02	1310	10	1.7		PUB3	Cp	2	3087
102486	6	BL08	1350	10	1.5		L2UB3*	YP	1	103
102486	6	BL08	1350	10	1.5		L2UB3*	HSf	1	14
102486	6	BL08	1350	10	1.5		L2UB3*	Bg	17	80
102486	6	BL08	1350	10	1.5		L2UB3*	Cp	2	3995
102486	7	BL01	1440	10	1		PSS1	YP	2	156
102486	7	BL01	1440	10	1		PSS1	LB	1	133
102486	7	BL01	1440	10	1		PSS1	Ps	2	62
102486	7	BL01	1440	10	1		PSS1	Bg	14	164
102486	7	BL01	1440	10	1		PSS1	WC	1	8
102486	7	BL01	1440	10	1		PSS1	Cp	4	6401
102486	8	BL02	1530	10	1.4		L2UB3	N/A	N/A	N/A
102486	9	BL06	1600	10	1		PSS/EM1	LB	3	738
102486	9	BL06	1600	10	1		PSS/EM1	WC	2	55
102486	9	BL06	1600	10	1		PSS/EM1	Bg	14	71
102486	9	BL06	1600	10	1		PSS/EM1	Cp	1	1362
102486	10	BL11	1630	10	.6		PEM1	Cp	1	1350
102486	10	BL11	1630	10	.6		PEM1	WC	5	239
102486	10	BL11	1630	10	.6		PEM1	Bg	32	349
102486	10	BL11	1630	10	.6		PEM1	Ps	1	64
102586	1	CS01	930	10	1	15	R1UB3	LSu	2	1952
102586	1	CS01	930	10	1	15	R1UB3	Sq	1	5
102586	1	CS01	930	10	1	15	R1UB3	SF	2	125
102586	2	CS03	1045	10	1.5		R1UB3	6m	9	2
102586	2	CS03	1045	10	1.5		R1UB3	LB	2	16
102586	2	CS03	1045	10	1.5		R1UB3	LSu	1	953
102586	3	CS04	1130	10	1.5		R1UB3	6f	12	3898
102586	3	CS04	1130	10	1.5		R1UB3	YP	3	107
102586	3	CS04	1130	10	1.5		R1UB3	Ps	4	89
102586	3	CS04	1130	10	1.5		R1UB3	Bg	4	55
102586	3	CS04	1130	10	1.5		R1UB3	WC	2	125
102586	3	CS04	1130	10	1.5		R1UB3	LB	1	227
102586	3	CS04	1130	10	1.5		R1UB3	Cp	3	2179
102586	3	CS04	1130	10	1.5		R1UB3	LSu	1	817
102586	4	CS06	1300	10	.6		R1UB3	Sq	2	456
102586	4	CS06	1300	10	.6		R1UB3	Cp	1	1362
102586	5	CS08	1330	10	.6		R1UB3	Cot	1	1
102586	5	CS08	1330	10	.6		R1UB3	Cp	2	3065
102586	5	CS08	1330	10	.6		R1UB3	LSu	1	409

TABLE G-A-2 FISH CATCH DATA: MEANS

FISH CATCH DATA

APRIL 30 - MAY 9, 1986

SPECIES	BYBEE LAKE (7 stations: 69 min.) Mean No.	Mean Wt.	SMITH LAKE (6 stations: 50 min.) Mean No.	Mean Wt.	SMITH CHANNEL (3 stations: 30 min.) Mean No.	Mean Wt.	COLUMBIA SLOUGH (8 stations: 80 min.) Mean No.	Mean Wt.	DAM POOL (1 station: 10 min.) Mean No.	Mean Wt.
BC	0	0	1.5	73.8	0	0	0	0	0	0
Bg	.4	3.1	.8	12.2	1	82.7	.4	1.1	0	0
BrB	.1	61.2	0	0	0	0	0	0	0	0
Ch	1.39	21.69	1.5	27.2	1.7	27.7	5.5	58	13	228
Cot	0	0	0	0	0	0	.4	9.5	0	0
Cp	2.91	4304.3	4.2	5202.6	4	7869.3	2.8	3622.9	16	20430
Gf	0	0	.2	25.4	.7	164.7	.5	104.3	0	0
LB	.13	1.02	0	0	2	1130.7	0	0	4	1415
LSu	.13	.17	.2	.6	0	0	3.5	1676.9	4	2724
Pm	0	0	.2	.41	0	0	.4	16	6	746
Ps	.4	23.7	.2	6.8	0	0	0	0	0	0
Sq	.23	1.14	1	39.2	0	0	.5	5	1	4
WC	2.3	147.5	.6	54.6	3	327.3	2.3	133.3	0	0
Wm	0	0	0	0	0	0	0	0	0	0
YP	2.66	115.08	2.1	123.2	1.3	102	1.8	61	1	42
TOTAL:	10.65	4678.9	12.5	5606.6	13.7	9704.4	18.1	5688	45	25589
No. Spp.:	10		11		7		10		7	

JUNE 26, 1986

SPECIES	(4 stations: 40 min.) Mean No.	Mean Wt.	(3 stations: 40 min.) Mean No.	Mean Wt.	(2 stations: 20 min.) Mean No.	Mean Wt.	(4 stations: 40 min.) Mean No.	Mean Wt.	(1 station: 10 min.) Mean No.	Mean Wt.
BC	0	0	.75	31.5	1.5	39	0	0	0	0
Bg	.25	1.25	0	0	1	184.5	.75	16	6	215
BrB	0	0	.25	87.75	0	0	.25	40.75	0	0
Ch	0	0	0	0	0	0	0	0	0	0
Cot	0	0	0	0	0	0	0	0	0	0
Cp	2	2406.5	2.25	2814.75	6	7014	4.75	5618.25	23	24380
Gf	0	0	0	0	0	0	1.75	241.25	0	0
LB	.25	94.75	.75	96.25	4	881.5	0	0	2	1362
LSu	0	0	0	0	0	0	1.25	905.75	0	0
Pm	0	0	.75	96.5	0	0	0	0	1	136
Ps	0	0	0	0	0	0	0	0	0	0
Sq	0	0	0	0	0	0	1	6	1	37
WC	1.25	51.75	.5	61	.5	16	1.5	115	2	72
Wm	0	0	0	0	0	0	.5	10	0	0
YP	.75	53.5	0	.0	0	0	.5	14	1	76
TOTAL:	4.5	2607.75	5.25	3187.75	13	8135	12.25	6967	36	26278
No. Spp.:	4		6		5		9		7	

Mean No. = mean number per 10 minutes
Mean Wt. = mean weight in grams per 10 minutes

SPECIES:

BC=Black Crappie	LSu= Largescale Sucker
Bg= Bluegill	Pm= Peamouth
BrB= Brown Bullhead	Ps= Pumpkinseed
Ch= Chinook salmon	Sq= Squawfish
Cot= Cottid (sculpin)	WC= White Crappie
Cp=Carp	Wm= Warmouth
Gf= Goldfish	YP= Yellow Perch
LB= Largemouth Bass	

FISH CATCH DATA

OCTOBER 24-25, 1986

SPECIES	BYBEE LAKE (4 stations: 40 min.)		SMITH LAKE (3 stations: 30 min.)		SMITH CHANNEL (2 stations: 20 min.)		COLUMBIA SLOUGH (5 stations: 50 min.)		DAM POOL (1 station: 10 min.)	
	Mean No.	Mean Wt.	Mean No.	Mean Wt.	Mean No.	Mean Wt.	Mean No.	Mean Wt.	Mean No.	Mean Wt.
BC	0	0	1	79.33	.5	1	0	0	0	0
Bg	17.5	146	1.67	45.67	0	0	.8	11	17	80
BrB	0	0	0	0	0	0	0	0	0	0
Ch	0	0	0	0	0	0	0	0	0	0
Cot	0	0	0	0	.5	1.5	.2	.2	0	0
Cp	1.5	2278.25	1.33	2043	1	1543.5	1.2	1324.8	2	3995
Gf	0	0	.33	227	0	0	2.4	779.6	0	0
LB	1	217.75	.33	20.33	1	45.5	.6	48.6	0	0
LSu	0	0	.33	227	0	0	1	826.2	0	0
Pm	0	0	.33	43.33	0	0	0	0	0	0
Ps	.75	31.5	0	0	0	0	.8	17.8	0	0
Sf	0	0	0	0	0	0	0	0	1	14
SF	0	0	0	0	0	0	.4	25	0	0
Sq	0	0	0	0	0	0	.6	92.2	0	0
WC	2	73.5	0	0	0	0	.4	25	0	0
Wm	0	0	0	0	0	0	0	0	0	0
YP	.5	39	.33	17	0	0	.6	21.4	1	103
TOTAL:	22.75	2749	5.32	2685.66	3	1591.5	8.4	3150.4	20	4089
No. Spp.:	6		8		4		11		4	

Mean No. = mean number per 10 minutes
Mean Wt. = mean weight in grams per 10 minutes

SPECIES:
BC=Black Crappie
Bg= Bluegill
BrB= Brown Bullhead
Ch= Chinook salmon
Cot= Cottid (sculpin)
Cp=Carp
Gf= Goldfish
LB= Largemouth Bass
LSu= Largescale Sucker
Pm= Peamouth
Ps= Pumpkinseed
Sq= Squawfish
WC= White Crappie
Wm= Warmouth
YP= Yellow Perch
Sf= Sunfish
SF= Starry Flounder

LENGTH FREQUENCY TABLES FOR FISH SPECIES

SMITH AND BYBEE LAKES STUDY AREA, 1986

TABLE G-A-3 LENGTH FREQUENCY DATA

NUMBER OF FISH WITH LENGTH GREATER THAN:

	55	60	65	70	75	80	85	90	95	100	105	110	115	120	125	130	135	140	145	150	n
JUVENILE SALMON, SPRING	1			2	4	7	13	12	4	8	10	13	6	1	4	4	4		1		
JUVENILE SALMON, LAKES	0	0	0	1	0	0	0	1	0	7	9	13	6	1	4	4	4	0	1	0	51
JUVENILE SALMON, SLOUGH	1	0	0	1	4	7	13	11	5	1	1	0	0	0	0	0	0	0	0	0	44

BLUEGILL LENGTH FREQUENCY

	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	n
SPRING	0	3	3	2	0	1	1	0	0	0	2	0	0	0	0	0	0	1	0	0	0	0	0	13
SUMMER	0	0	1	1	2	0	1	0	0	0	2	1	1	1	0	0	0	0	0	0	0	1	0	11
AUTUMN	8	21	14	2	5	10	13	6	4	1	0	0	0	2	0	0	0	0	0	0	0	0	0	86

CARP LENGTH FREQUENCY

	250	260	270	280	290	300	310	320	330	340	350	360	370	380	390	400	410	420	430	440	450	460	470	480	490	500	510	520	530	540	550	560	570	580	590
SPRING	0	0	0	0	1	0	0	0	1	0	2	4	5	8	14	14	4	7	8	1	3	1	0	2	2	1	3	1	1	0	2	0	0	0	1

SUMMER	0	0	0	0	1	0	1	2	0	2	0	5	6	10	5	12	8	2	2	3	3	2	0	3	0	0	0	1	0	0	0	0	0	0	0	68
AUTUMN	1	0	0	0	0	0	0	0	1	0	0	0	1	0	2	4	1	3	2	1	0	1	1	0	0	0	0	0	1	0	0	0	1	0	0	20

WHITE CRAPPIE LENGTH FREQUENCY

	55	60	65	70	75	80	85	90	95	100	105	110	115	120	125	130	135	140	145	150	155	160	165	170	175	180	185	190	195	200	205	210	215	220	225	230	235	240	245	250	255
SPRING	0	0	1	0	2	3	1	1	1	0	1	0	0	1	2	2	0	1	0	0	0	2	7	11	4	3	0	0	0	0	1	0	0	1	2	0	0	0	0	0	1
SUMMER	0	0	0	0	0	0	0	1	1	0	2	0	0	0	1	0	2	0	0	0	0	1	1	0	2	1	0	1	2	0	0	0	1	0	0	0	0	0	0	0	0
AUTUMN	1	0	2	1	1	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0

YELLOW PERCH LENGTH FREQUENCY

	75	80	85	90	95	100	105	110	115	120	125	130	135	140	145	150	155	160	165	170	175	180	185	190	195	200	205	210	215	220	n
SPRING	1	0	1	2	3	1	3	1	0	2	0	7	7	4	1	3	0	4	4	2	3	4	1	2	0	0	0	0	1	1	58
SUMMER	0	0	0	0	0	0	0	0	0	2	0	0	0	1	0	0	0	0	0	0	1	0	0	1	0	0	0	1	0	0	6
AUTUMN	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	1	1	0	1	0	0	0	0	1	1	0	0	0	0	7

LARGESCALE SUCKER LENGTH FREQUENCY

	60	80	100	120	140	160	180	200	220	240	260	280	300	320	340	360	380	400	420	440	460	480	n
ALL SAMPLES	1	1	0	1	0	0	0	2	5	0	0	1	0	0	4	9	8	11	5	2	1	1	52

LARGEMOUTH BASS

	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210
SPRING	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
SUMMER	1	1	1	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	1	0
AUTUMN	0	0	0	0	2	1	1	0	0	0	0	0	0	1	1	0	1	1	0	1

	220	230	240	250	260	270	280	290	300	310	320	330	340	350	360	370	380	390	400	n
SPRING	0	0	0	2	1	1	2	1	1	1	0	1	1	0	0	0	0	0	1	13
SUMMER	0	0	0	0	0	1	1	1	0	0	1	0	0	2	0	0	1	0	0	14
AUTUMN	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	10

OOD HABITS DATA

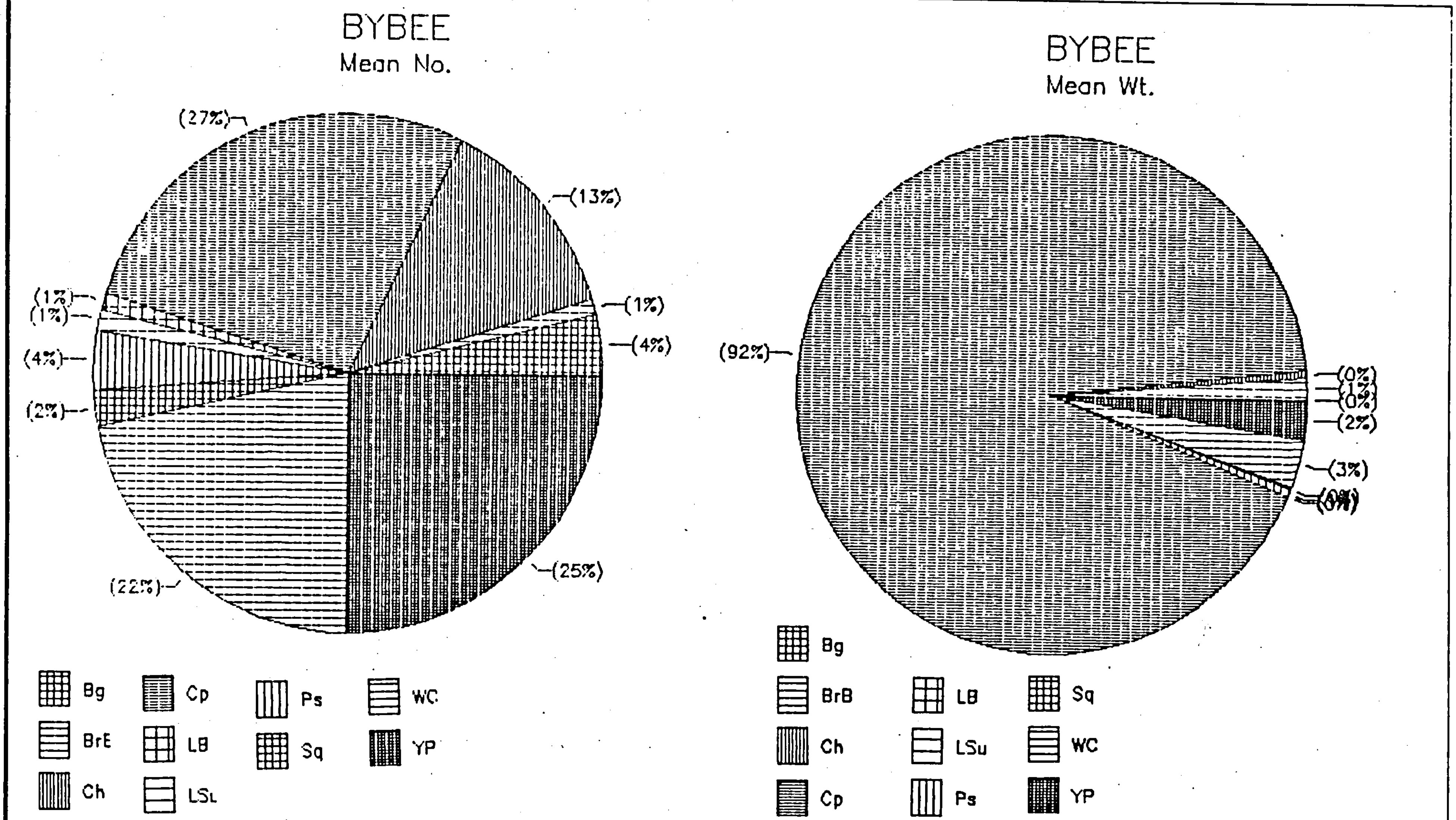
TABLE G-A-4 FOOD HABITS DATA

SPECIES	DATE	HAUL NO.	STATION	FISH NO.	LENGTH (MM)	FULLNESS	NUMBER: Cladocera	Copepod	Ostracod	Insect	Midge Fly larv.	Midge Fly ad.	Stonefly nymph	Caddisfly nymph	Amphipod	Isopod	Crustacea	Nematoda	Segment. Worm	Spider	Mite	Snail	Clam	PERCENT: Fish Tiss	Plant	Unident.
Salmon	30APR86	06	BI.06	1	132		254																			20
Salmon	30APR86	06	BI.06	2	107	3	52	1																		
Salmon	30APR86	06	BI.06	3	113	2	968	46	2																	
Salmon	30APR86	06	BI.06	4	101	3	125																			
Salmon	30APR86	06	BI.06	5	103	2	891	15	3	1																
Salmon	30APR86	04	BI.04	1	102	2	384			100										1						
Salmon	30APR86	05	BI.05	1	98	1	699	15				9														
Salmon	2MAY86	01	SI.01	1	86	1	3			7																
Salmon	2MAY86	01	SI.01	2	92	1	26			8										1	4					
Salmon	2MAY86	04	SI.04	1	128	1	614	7		1																
Salmon	2MAY86	04	SI.04	2	108																					
Salmon	9MAY86	03	C303	1	98	3	112	104	200																	
Salmon	9MAY86	03	C303	2	74	1	130	2	3																	
Salmon	9MAY86	03	C303	3	79	1	365	11	1	1	1															
Salmon	9MAY86	03	C303	4	81	1	226	9	1		4															
Salmon	9MAY86	04	C304	1	54	4	900			1																
Salmon	9MAY86	05	C305	1	84	2				5																
Salmon	9MAY86	07	C307	1	90	3	45	1224			3															
Salmon	9MAY86	07	C307	2	96	2	774	15			8															
Salmon	9MAY86	07	C307	3	90	2	1182			1																
Salmon	9MAY86	07	C307	4	76	2	470	4			1															
TOTAL:							8220	1553	218	122	17	9	0		0	0	0	0		2	4					
OTAL PERCENT:							81	15	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0			
MEAN:							391.43	73.00	10.38	5.81	.81	.43	.00	.00	.00	.00	.00	.00	.00	.10	.19	.00	.00			
Y.Perch	30APR86	01	BI.01	1	172						9	1								3						40
Y.Perch	30APR86	01	BI.01	2	141	1					2						1									90
Y.Perch	30APR86	01	BI.01	3	136	2		1	2		3	2														50
Y.Perch	30APR86	01	BI.01	4	134	2					3	5														30
Y.Perch	30APR86	01	BI.01	5	120	2					2	1														30
Y.Perch	30APR86	01	BI.01	6	95	1						1														0
Y.Perch	30APR86	02	BI.02	1	133	1		4	3		40	1														10
Y.Perch	30APR86	02	BI.02	2	133	1			2			1														10
Y.Perch	30APR86	02	BI.02	3	126	1			1		33	1								10						0
Y.Perch	30APR86	02	BI.02	4	94	2	4	66	17		13									1						40
Y.Perch	30APR86	04	BI.04	1	160	1					41	4								4						
Y.Perch	30APR86	04	BI.04	2	139	3	1		1	1	22				1	1										
Y.Perch	30APR86	04	BI.04	3	79	2		1	5		61	1														
Y.Perch	30APR86	06	BI.06	1	183	1	1			3	1				3											90
Y.Perch	30APR86	06	BI.06	2	178	3		1	5	1	1											2				97
Y.Perch	30APR86	06	BI.06	3	134	1																				0
Y.Perch	30APR86	06	BI.06	4	134	1																				100
Y.Perch	30APR86	06	BI.06	5	132	2	5				2		3									5				
Y.Perch	2MAY86	02	SI.02	1	143	1			1		1															99
Y.Perch	2MAY86	02	SI.02	2	166	1			2	1	9															25
Y.Perch	2MAY86	02	SI.02	3	219	1			1	4	6									9						60
Y.Perch	9MAY86	07	C307	1	105	2	15	810				1														
Y.Perch	9MAY86	07	C307	2	105	1		292				3														
Y.Perch	9MAY86	04	C304	1	129	1																				100
Y.Perch	9MAY86	04	C304	2	111	2	2	44	3		1					3				2						50
Y.Perch	9MAY86	04	C304	3	99	1	7	311	4											2						
Y.Perch	26JUN86	04	BI.10	1	172	5																				100
Y.Perch	26JUN86	04	BI.10	2	200	3							1		2											90
TOTAL:							35	1530	47	10	250	22	4		6	4	1	0		31	0	7				
ERCENT TOTAL:							2	79	2	1	13	1	0		0	0	0	0		2	0	0				
MEAN:							1.25	54.64	1.68	.36	8.93	.79	.14	.00	.21	.14	.04	.00	.00	1.11	.00	.25	.00			
Bluegill	30APR86	01	BI.01	1	120	4	3136	272	8																	0
Bluegill	30APR86	01	BI.01	2	81	4	165	1575	3			1														0
Bluegill	30APR86	01	BI.01	3	76	2	28	361				1														0
Bluegill	30APR86	01	BI.01	4	80	3	525	480				1														0
Bluegill	9MAY86	04	C304	1	70	1		47	12		7					3										15
Bluegill	9MAY86	04	C304	2	46		145	162	51		2					1				2						
Bluegill	9MAY86	04	C304	3	36	2	18	53	115											2						

Bluegill	24OCT86	01	SL04	1	81	3	3	138	7				1			3							4	0
Bluegill	24OCT86	01	SL04	2	91	2		21			2													70
Bluegill	24OCT86	01	SL04	3	81	1		139			1													0
Bluegill	24OCT86	06	BL08	1	83	2		6			20									2				0
Bluegill	24OCT86	06	BL08	2	78	3		325	4		3									2				0
Bluegill	24OCT86	06	BL08	3	79	2		276	1		16									1				0
Bluegill	24OCT86	06	BL08	4	78	4		9			23													0
Bluegill	24OCT86	06	BL08	5	71	1		25			6													70
Bluegill	24OCT86	06	BL08	6	38	3	1	92			1													0
Bluegill	24OCT86	06	BL08	7	43	3		1086			3													0
Bluegill	24OCT86	06	BL08	8	38	1		73							1									0
Bluegill	24OCT86	06	BL08	9	38	3		23			3	1												0
Bluegill	24OCT86	06	BL08	10	34	2																		0
Bluegill	24OCT86	10	BL11	1	103	3		9	11		23		5		96	1				1				5
Bluegill	24OCT86	10	BL11	2	94	3		4	267		96				1									10
Bluegill	24OCT86	10	BL11	3	101	3		1	71	3	104		4		20									0
Bluegill	24OCT86	10	BL11	4	71	3		630	13		7													0
Bluegill	24OCT86	10	BL11	5	61	3		123	25		34				4									0
TOTAL:							4021	5930	588	3	351	4	10		122	8	0	0		10	0	0	4	
ERCENT TOTAL:							36	54	5	0	3	0	0		1	0	0	0		0	0	0	0	
MEAN:							160.84	237.20	23.52	.12	14.04	.16	.40	.00	4.88	.32	.00	.00	.00	.40	.00	.00	.16	
Crappie	30APR86	02	BL02	1	218	1						1												0
Crappie	30APR86	02	BL02	2	171	1	800	10				1												0
Crappie	30APR86	02	BL02	3	184	1	500	5	15															0
Crappie	30APR86	02	BL02	4	177	2	1000	50	100			4												0
Crappie	2MAY86	08	SC02	1	235	1			1		3				1	1								0
Crappie	9MAY86	07	CS07	1	105	2	420	1725	5		5													0
Crappie	9MAY86	07	CS07	2	87	2	1712	900																0
Crappie	9MAY86	07	CS07	3	93	2	1200	1554	12		6													0
Crappie	26JUN86	06	SL04	1	166	1	350	10																30
Crappie	24OCT86	05	SC02	1	55	3	6	1										2						0
Crappie	24OCT86	10	BL11	1	66	4	62	346	4															0
Crappie	24OCT86	10	BL11	2	67	3	22	510	4			1			4									0
Crappie	24OCT86	10	BL11	3	53	3	20	396	24															0
Crappie	24OCT86	10	BL11	4	32	3		85	1															0
Crappie	24OCT86	10	BL11	5	25	3		69	2															0
Crappie	24OCT86	10	BL11	6	29	4		64	19						1									0
Crappie	24OCT86	10	BL11	7	29	4		110	12															0
Crappie	24OCT86	10	BL11	8	30		3	59	18															0
TOTAL:							6095	5894	217	0	14	7	0		6	1	0	2		0	0	0	0	
ERCENT TOTAL:							50	48	2	0	0	0	0		0	0	0	0		0	0	0	0	
MEAN:							338.61	327.44	12.06	.00	.78	.39	.00	.00	.33	.06	.00	.11	.00	.00	.00	.00	.00	
Crappie	2MAY86	01	SL01	1	168	3	4440	120	84		12	12			99									0
Crappie	2MAY86	01	SL01	2	153	3	1338	144	1008															0
Crappie	2MAY86	01	SL01	3	167	3	2244	948	168						30									0
Crappie	26JUN86	06	SL04	1	171	2	850	10			3	5			25									0
TOTAL:							8872	1222	1260	0	15	17	0		154	0	0	0		0	0	0	0	
ERCENT TOTAL:							77	11	11	0	0	0	0		1	0	0	0		0	0	0	0	
MEAN:							2218.00	305.50	315.00	.00	3.75	4.25	.00	.00	38.50	.00	.00	.00	.00	.00	.00	.00	.00	
LM Bass	30APR86	08	BL08	1	280	1																		0
LM Bass	30APR86	08	BL08	2	285	1																		0
LM Bass	30APR86	08	BL08	3	205	1																		0
LM Bass	30APR86	08	BL08	4	259	1																		0
LM Bass	30APR86	08	BL08	5	305	1																		0
LM Bass	24OCT86	05	SC02	1	62	3	188	31																
LM Bass	25OCT86	02	CS03	1	83	1																		0
LM Bass	25OCT86	02	CS03	2	77	1																		0
TOTAL:							188	31	0	0	0	0	0		0	0	0	0		0	0	0	0	
ERCENT TOTAL:							86	14	0	0	0	0	0		0	0	0	0		0	0	0	0	
MEAN:							23.50	3.88	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	
* Mouth	30APR86	08	BL08	1	213																			100
* Mouth	30APR86	08	BL08	2	225						4	1												99
* Mouth	30APR86	08	BL08	3	245																			99
* Mouth	30APR86	08	BL08	4	245						8													99
* Mouth	30APR86	08	BL08	5	240														34					0
* Mouth	2MAY86	02	SL02	1	179																			0

P Mouth	2MAY86	02	SL02	2	132		674																			90
P Mouth	2MAY86	06	SL06	1	137	3																				100
P Mouth	2MAY86	06	SL06	2	129	2						5														100
P Mouth	2MAY86	06	SL06	3	127	2																				
TOTAL:							674	0	0	0	12	6	0		0	0	0	0	34	0	0	0	0			
ERCENT TOTAL:							93	0	0	0	2	1	0		0	0	0	0	5	0	0	0	0			
MEAN:							67.40	.00	.00	.00	1.20	.60	.00	.00	.00	.00	.00	.00	3.40	.00	.00	.00	.00			
L Sucker	9MAY86	03	CS03	1	536			5	708		3													1.	75	2[illegible]
L Sucker	9MAY86	03	CS03	2	568																					10[illegible]
L Sucker	9MAY86	03	CS03	3	508																					10[illegible]
Sculpin	9MAY86	05	CS05	1	140					1					1											9[illegible]
Sculpin	9MAY86	05	SC02	2	103	2													1							[illegible]
Sculpin	9MAY86	05	SC02	3	94	1																				[illegible]
Sculpin	24OCT86	05	SC02	1	63	2		1			1			1	1											9[illegible]
TOTAL:							0	1	0	1	1	0	0	1	2	0	0	0	1	0	0	0	0			

* Stomach Fullness scale: 1 = empty; 5 = gorged



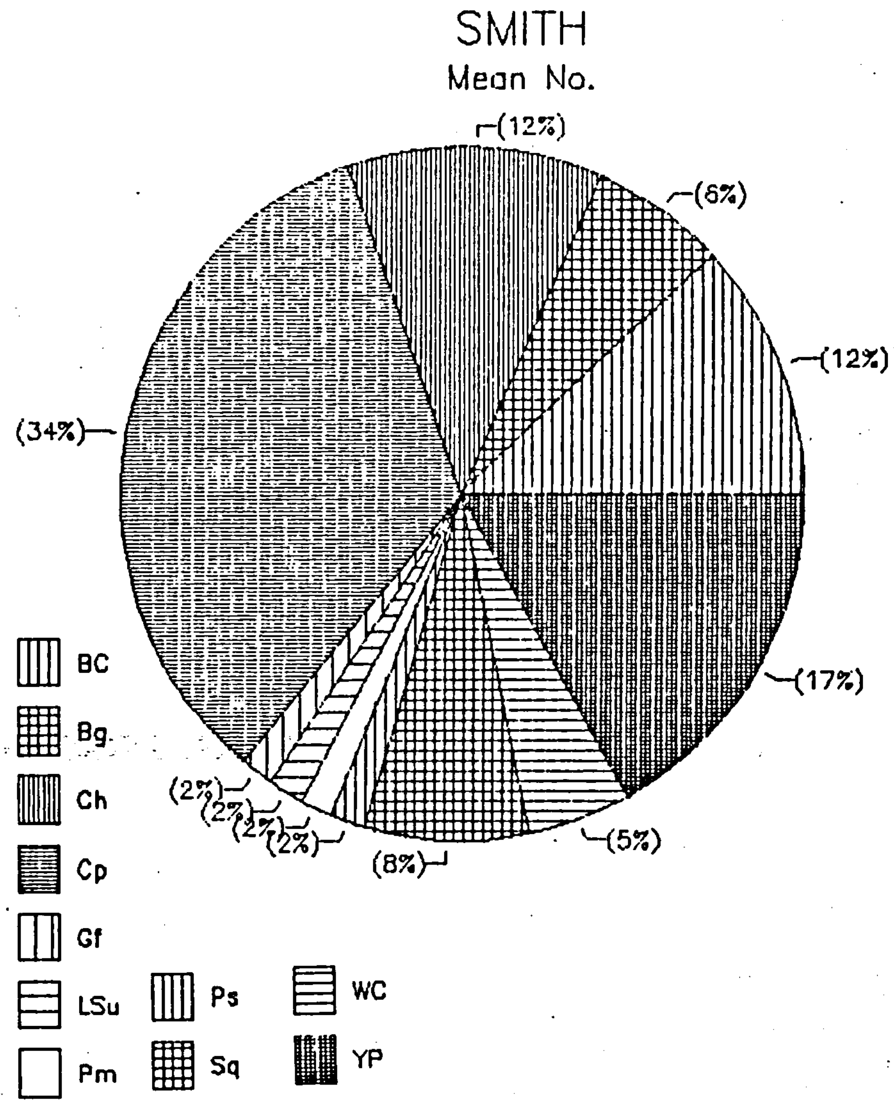
SMITH AND BYBEE LAKES
ENVIRONMENTAL STUDIES

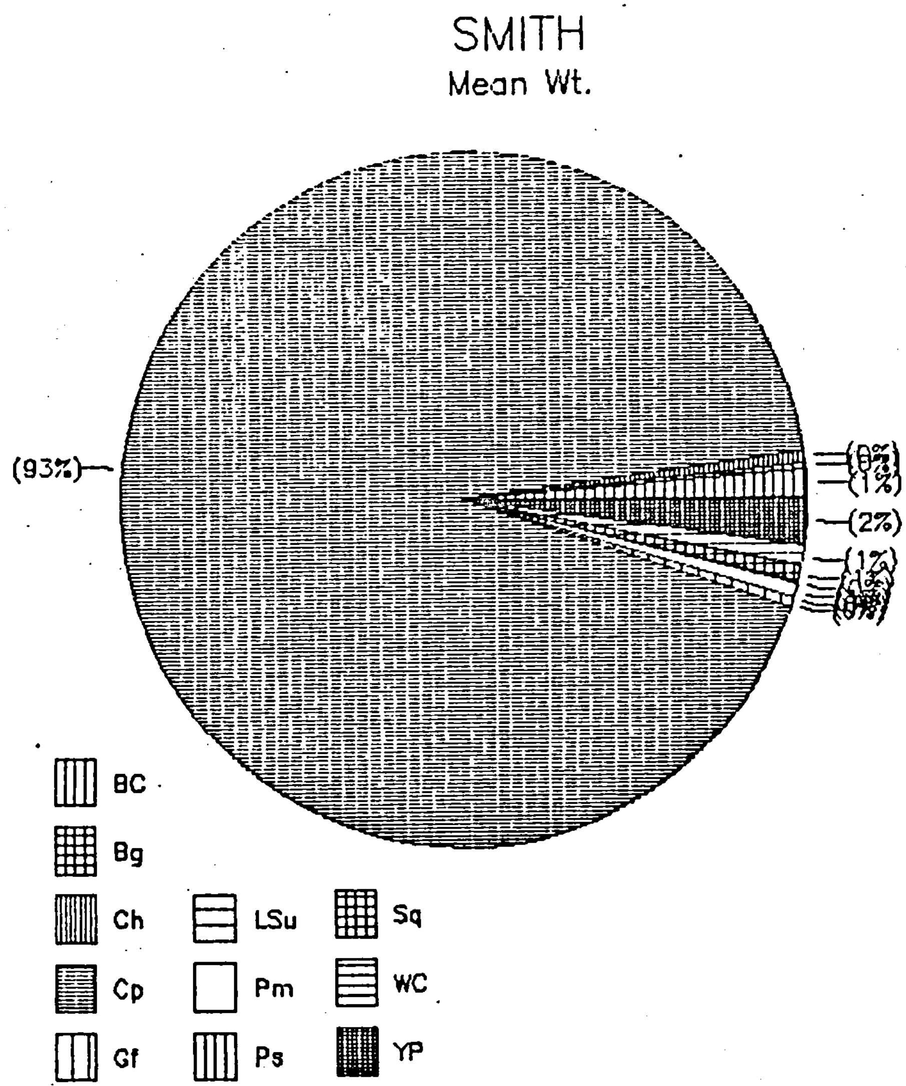
SMITH LAKE FISH CATCH DATA
MAY, 1986

FISHMAN ENVIRONMENTAL SERVICES

DECEMBER, 1986

FIGURE 6-A-1





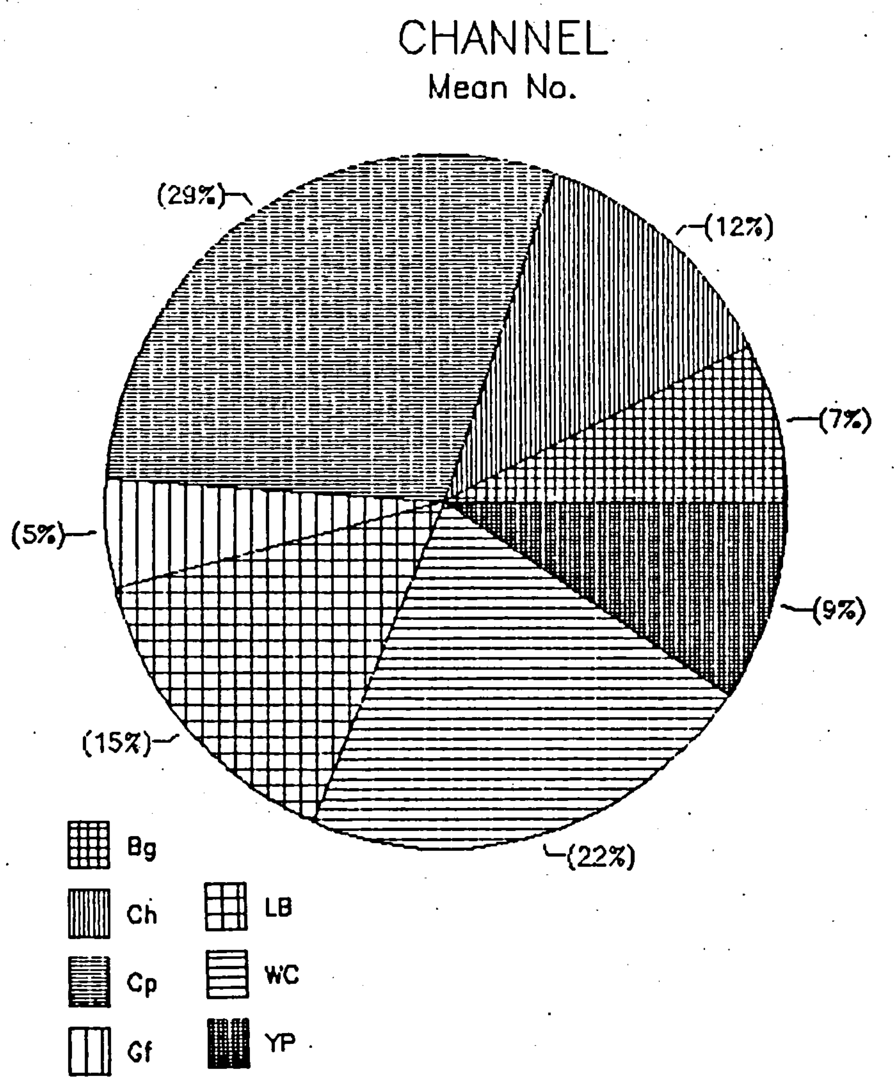
SMITH AND BYBEE LAKES
ENVIRONMENTAL STUDIES

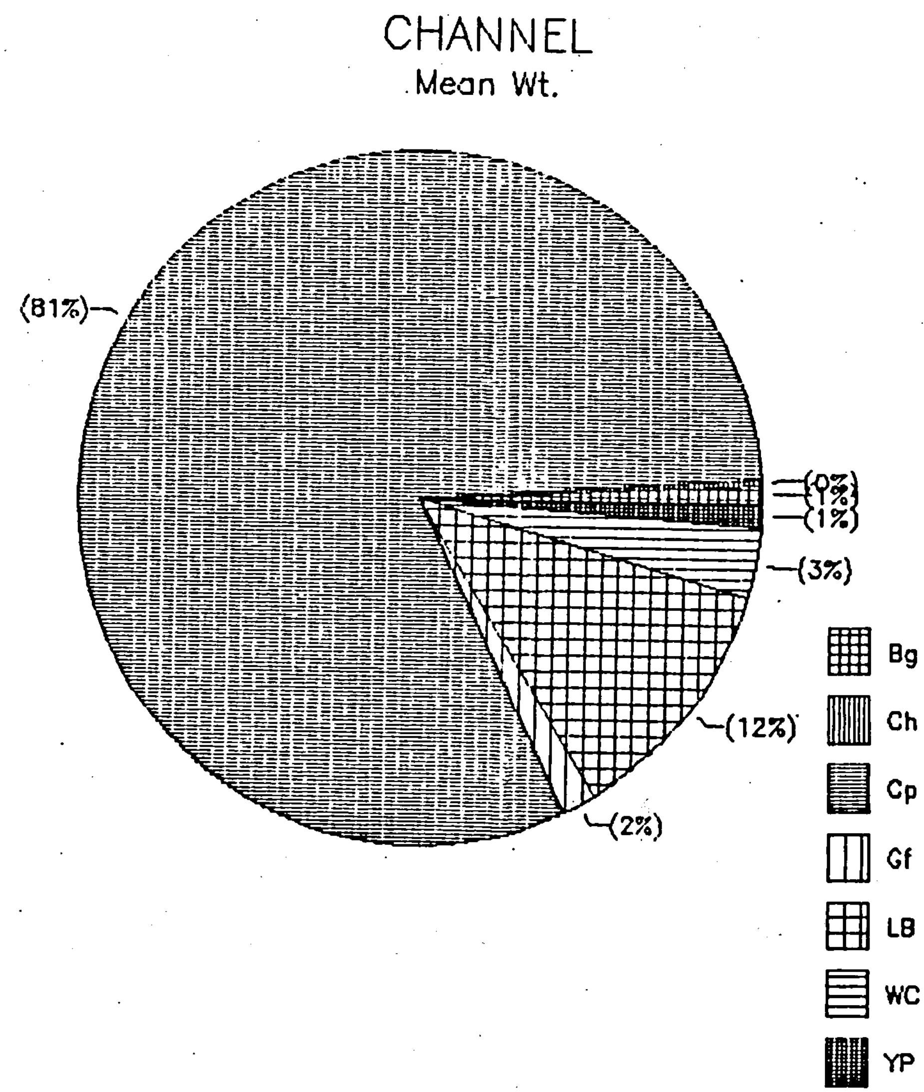
BYBEE LAKE FISH CATCH DATA
MAY, 1986

FISHMAN ENVIRONMENTAL SERVICES

DECEMBER, 1986

FIGURE 6-A-2





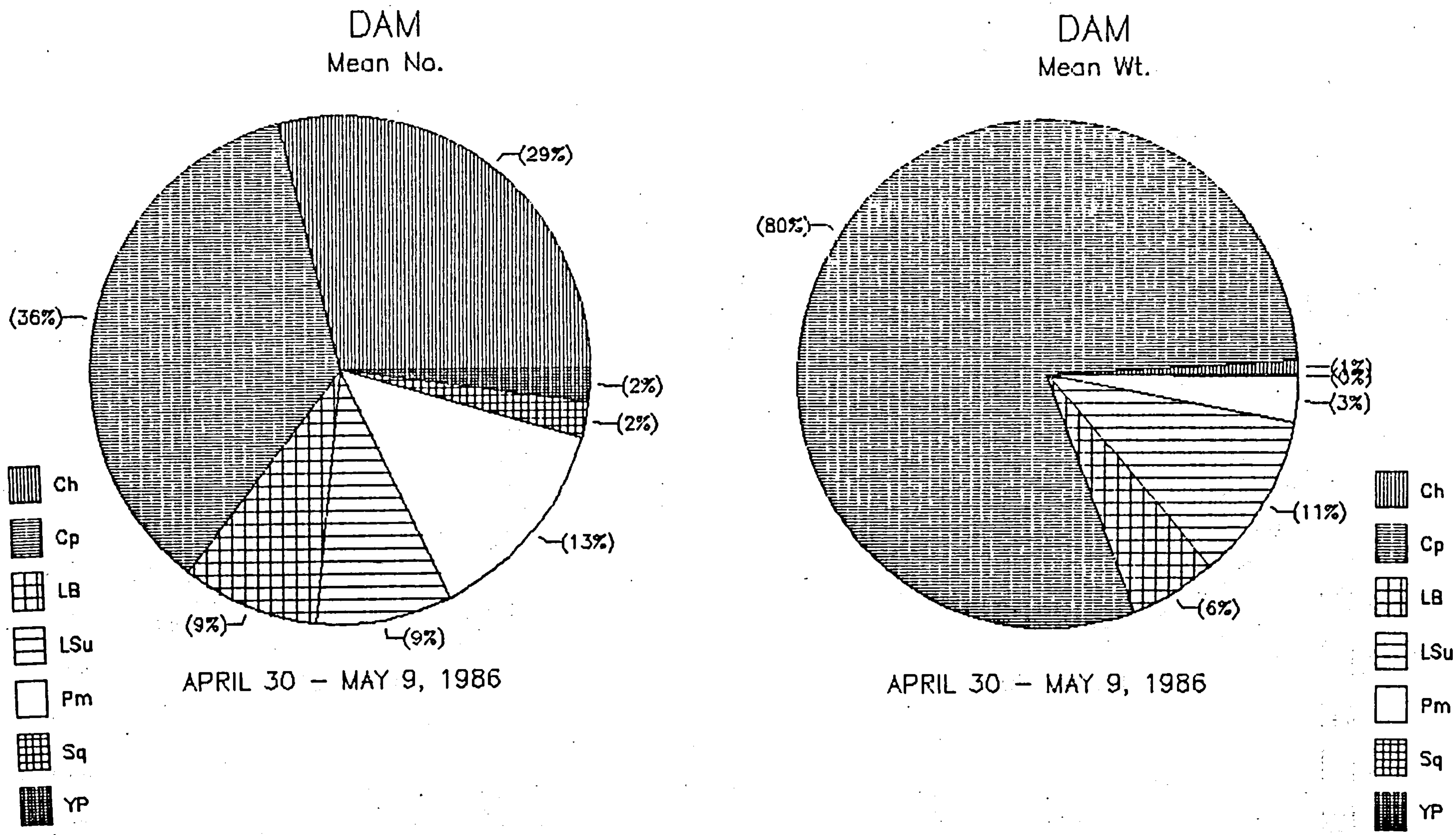
SMITH AND BYBEE LAKES
ENVIRONMENTAL STUDIES

SMITH CHANNEL FISH CATCH DATA
MAY, 1986

FISHMAN ENVIRONMENTAL SERVICES

DECEMBER, 1986

FIGURE G-A-3



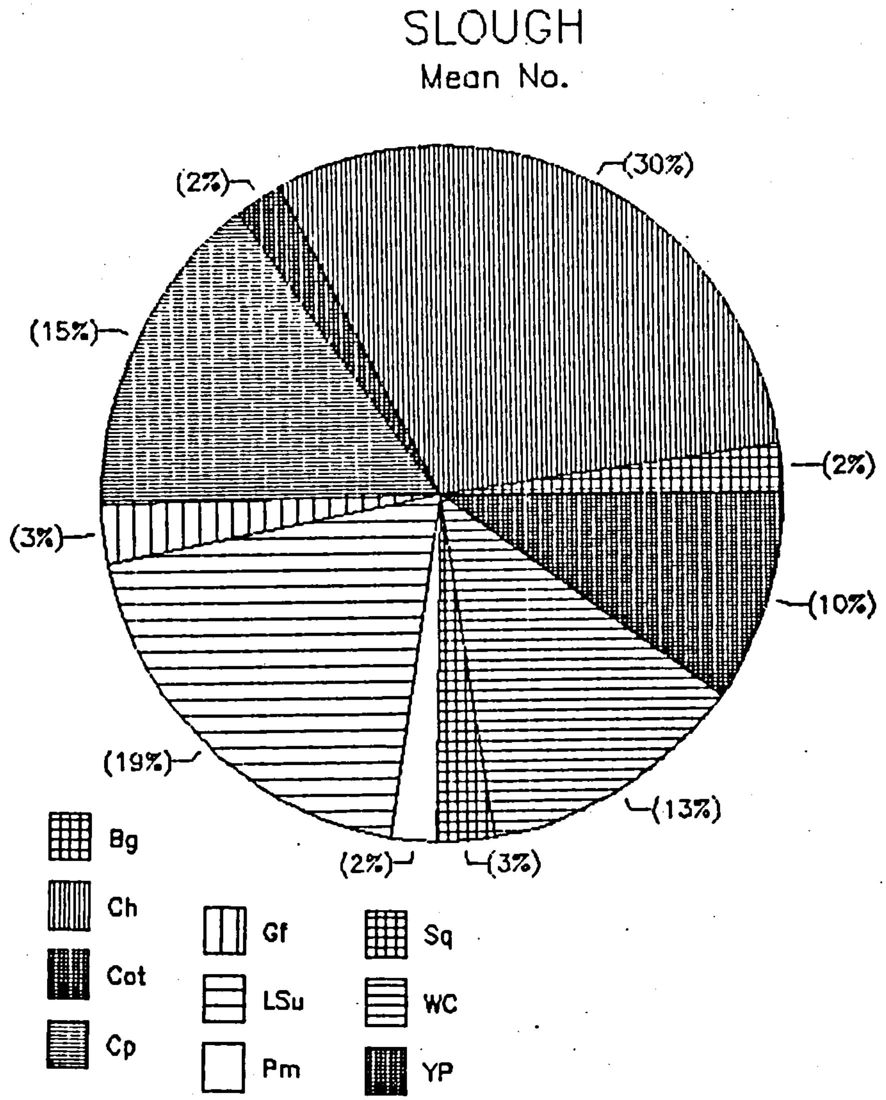
SMITH AND BYBEE LAKES
ENVIRONMENTAL STUDIES

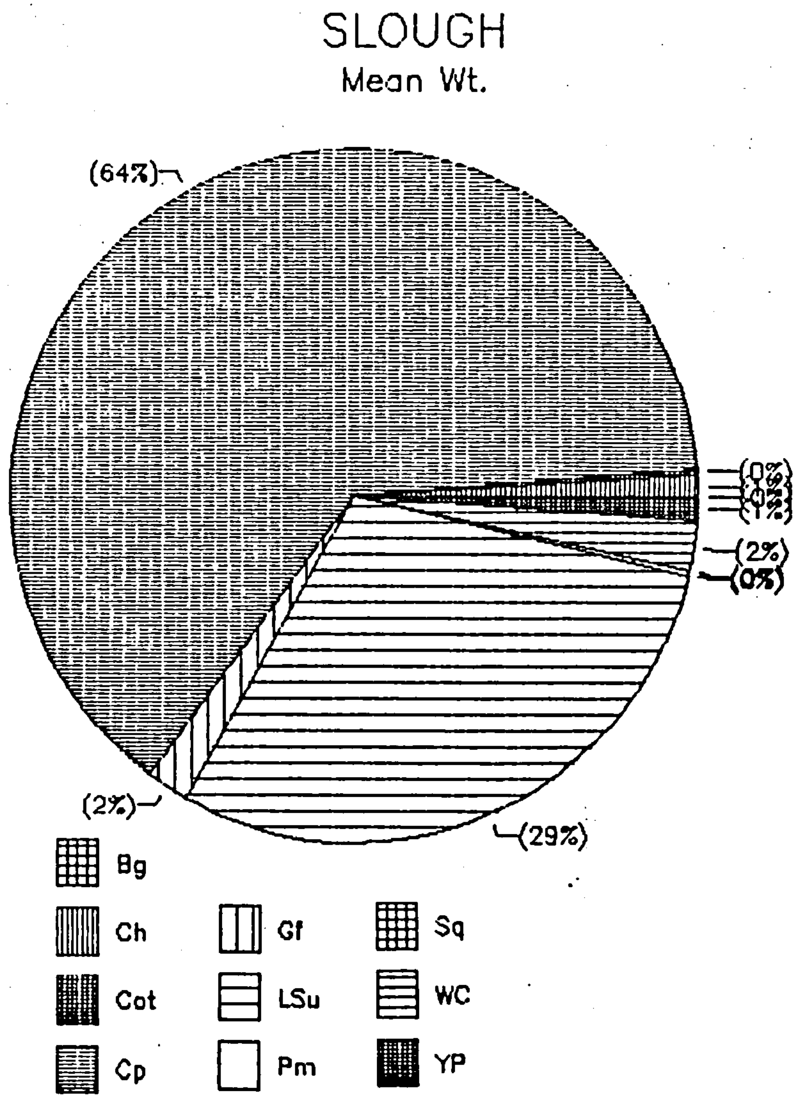
DAM POOL FISH CATCH DATA
MAY, 1986

FISHMAN ENVIRONMENTAL SERVICES

DECEMBER, 1986

FIGURE G-A-4



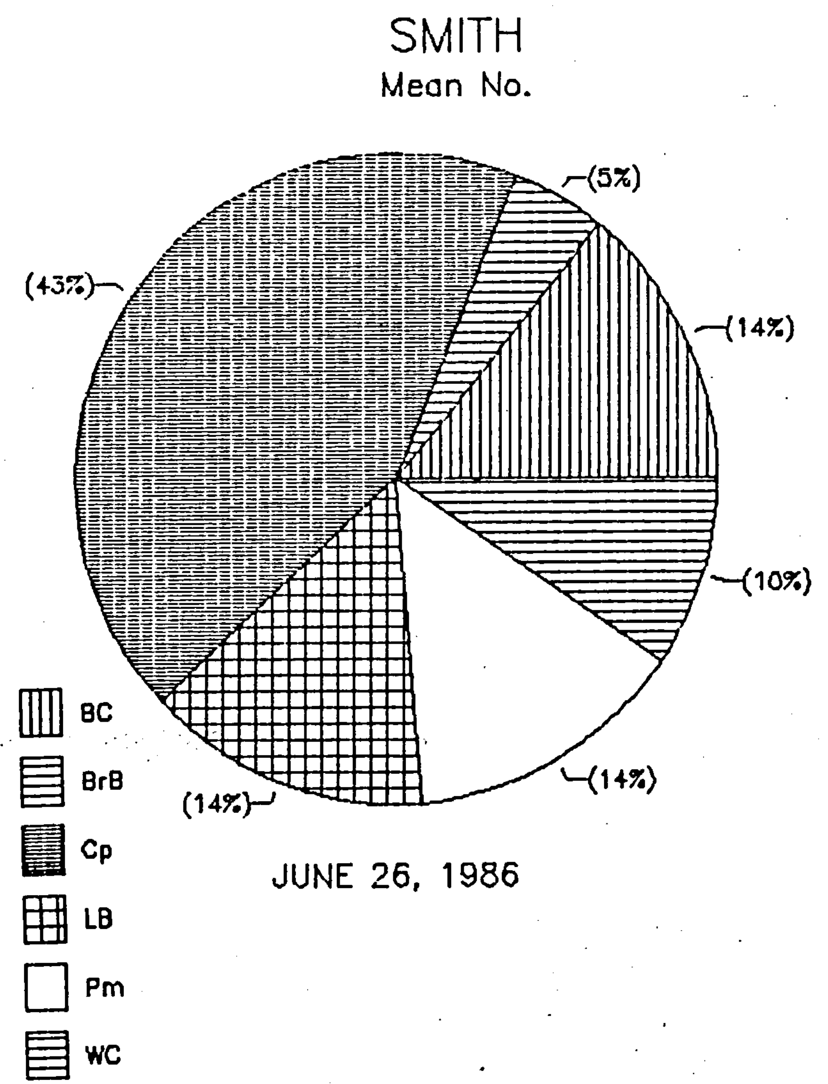


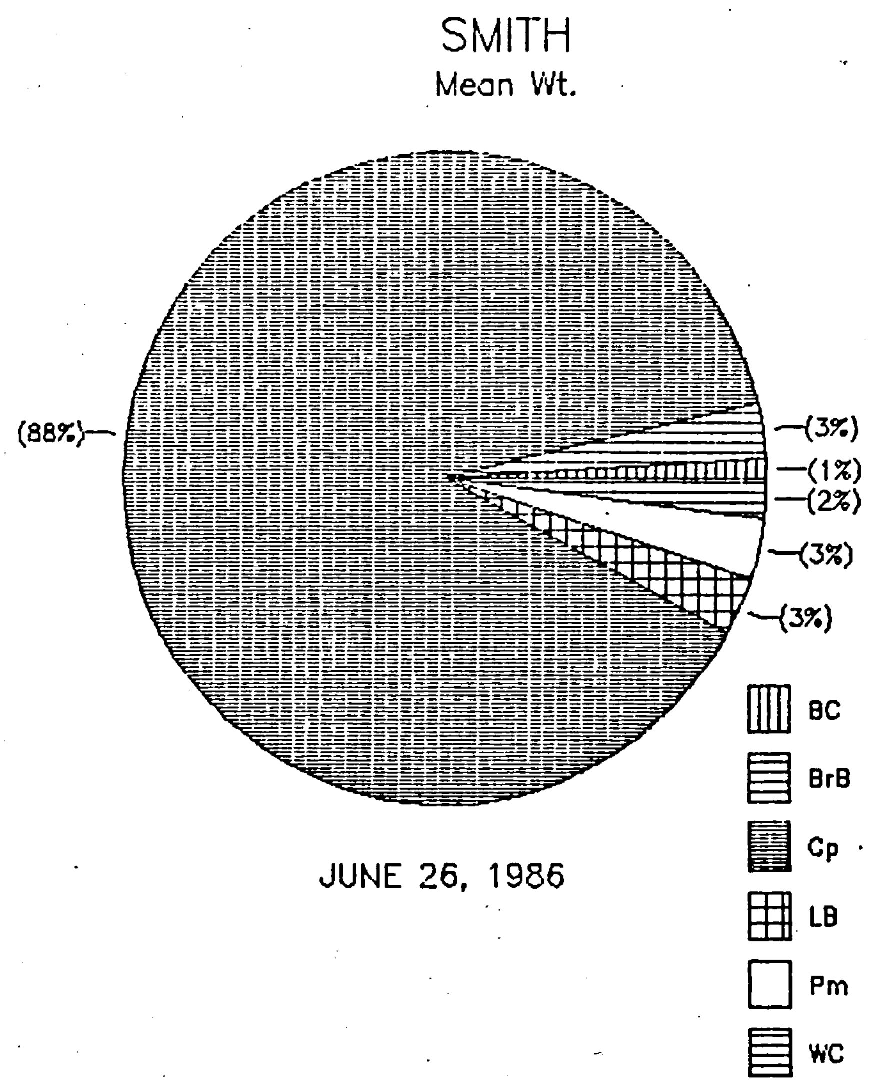
SMITH AND BYBEE LAKES
ENVIRONMENTAL STUDIES

COLUMBIA SLOUGH FISH CATCH DATA
MAY, 1986

FISHMAN ENVIRONMENTAL SERVICES

DECEMBER, 1986 | FIGURE 6-A-5





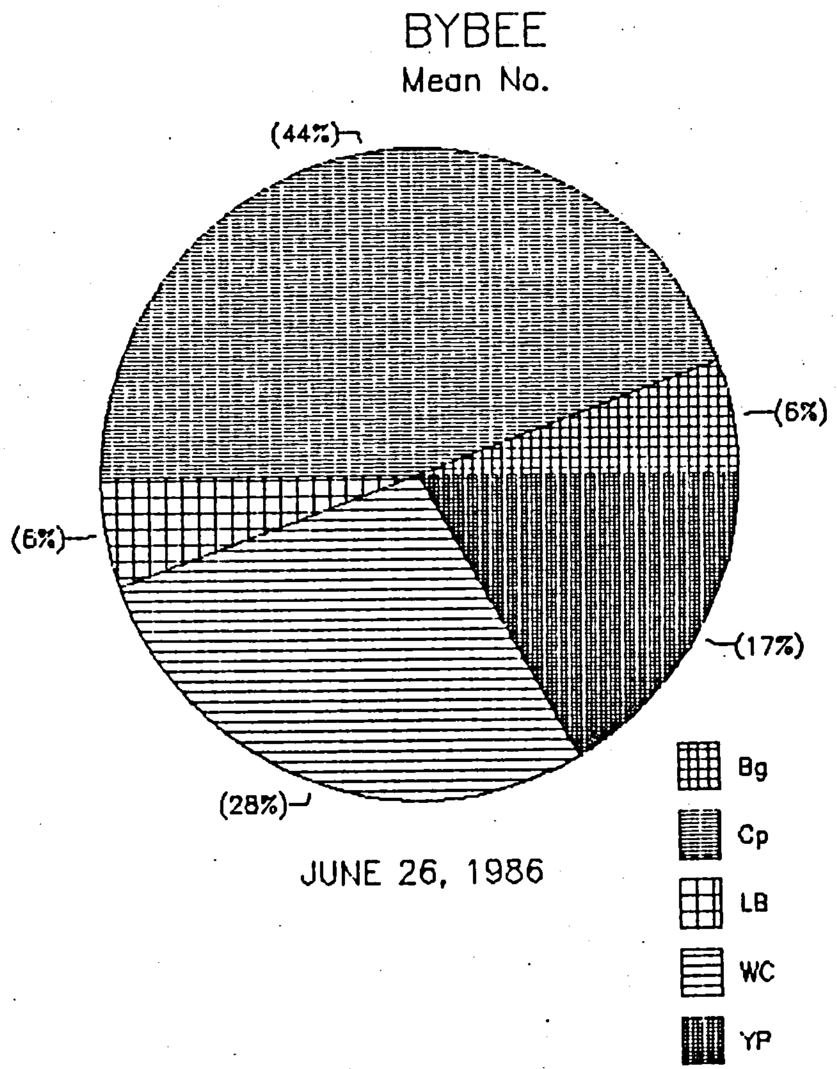
SMITH AND BYBEE LAKES ENVIRONMENTAL STUDIES

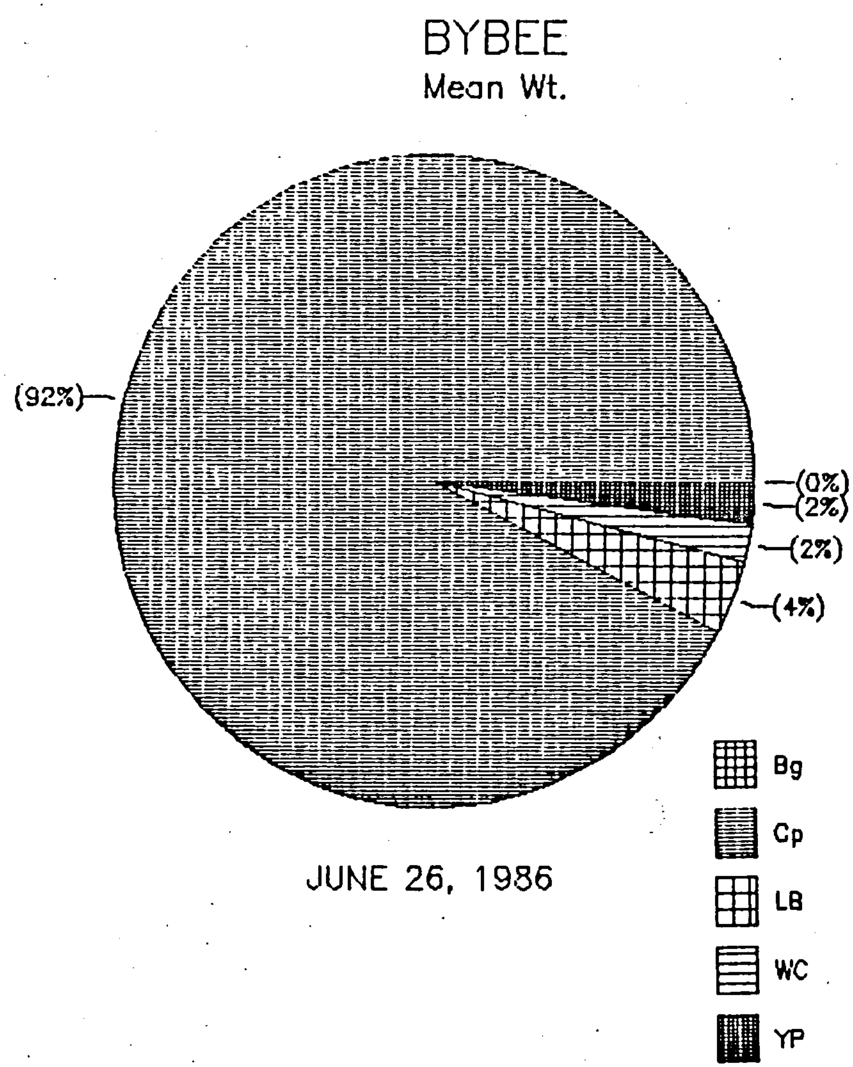
SMITH LAKE FISH CATCH DATA JUNE, 1986

FISHMAN ENVIRONMENTAL SERVICES

DECEMBER, 1986

FIGURE 6-A-6





SMITH AND BYBEE LAKES
ENVIRONMENTAL STUDIES

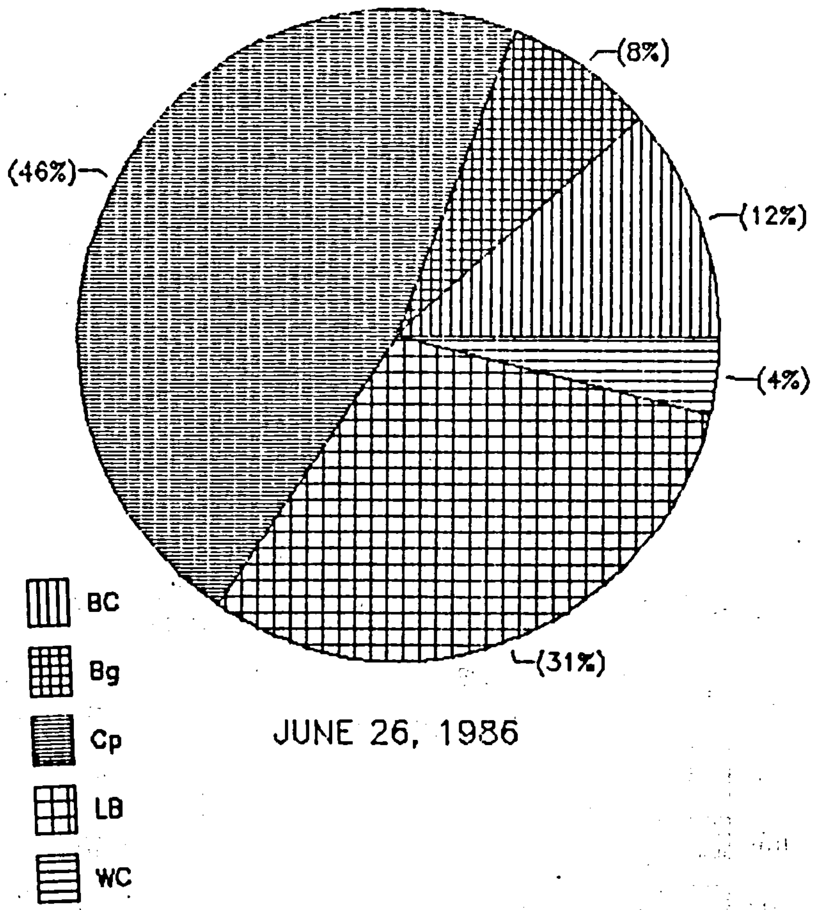
BYBEE LAKE FISH CATCH DATA
JUNE, 1986

FISHMAN ENVIRONMENTAL SERVICES

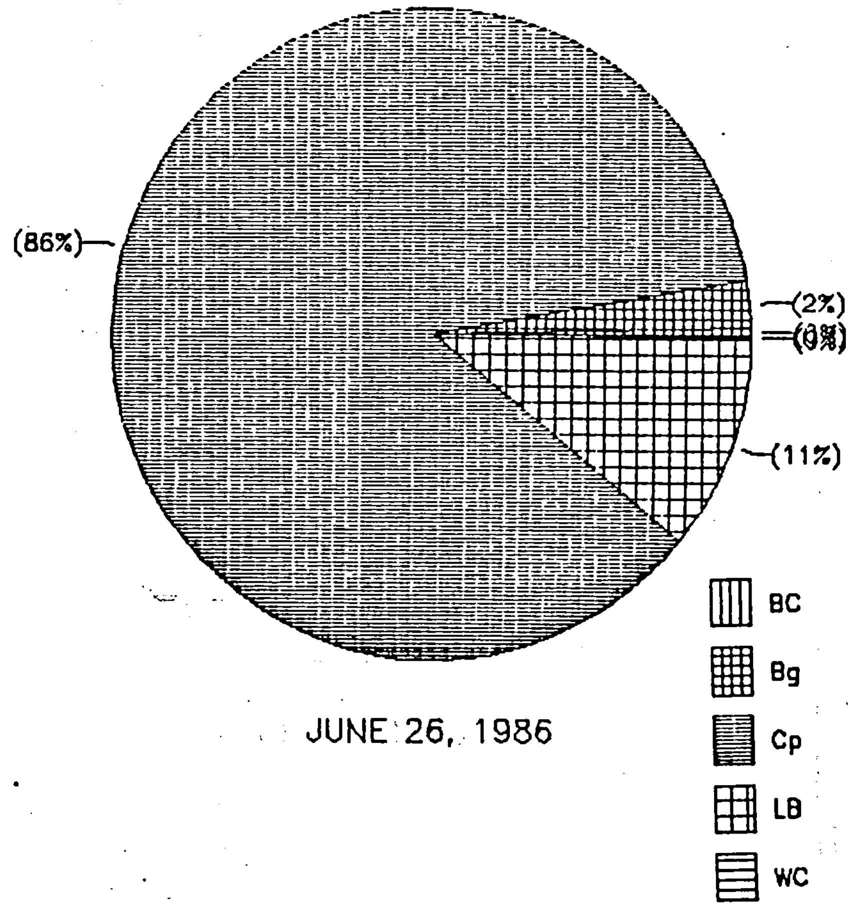
DECEMBER, 1986

FIGURE 6-A-7

CHANNEL
Mean No.



CHANNEL
Mean Wt.



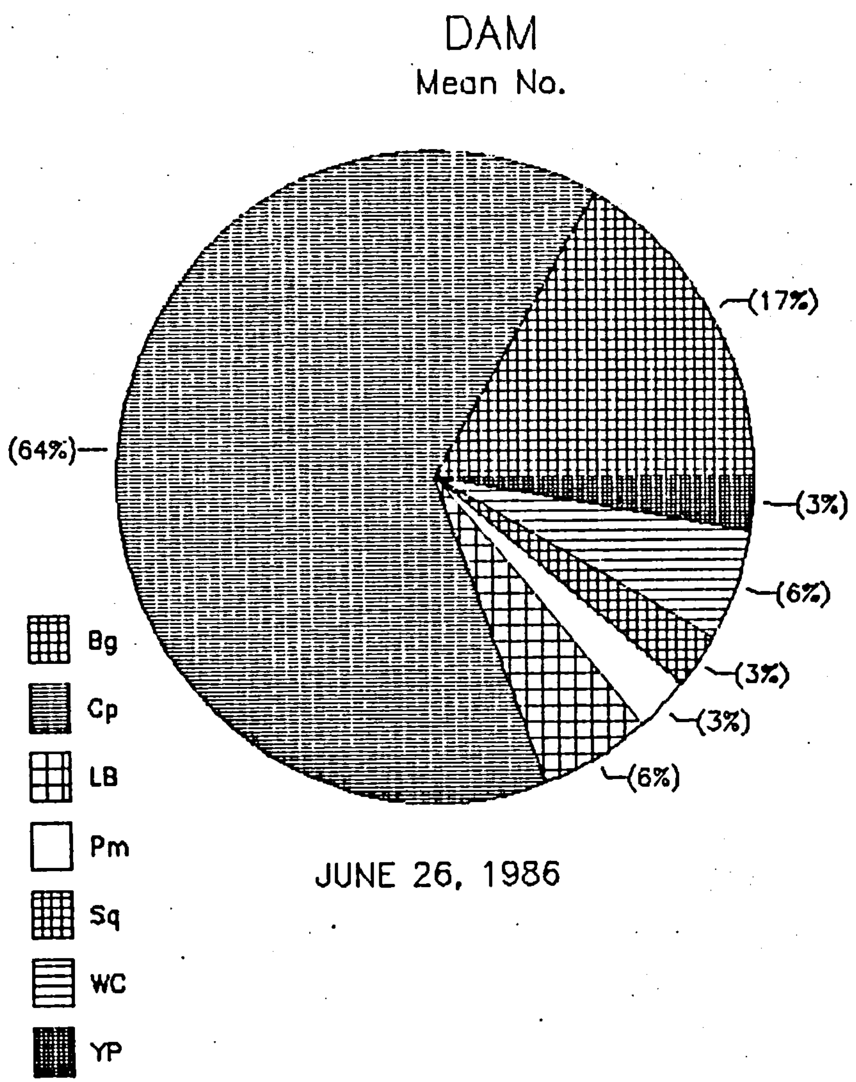
SMITH AND BYBEE LAKES
ENVIRONMENTAL STUDIES

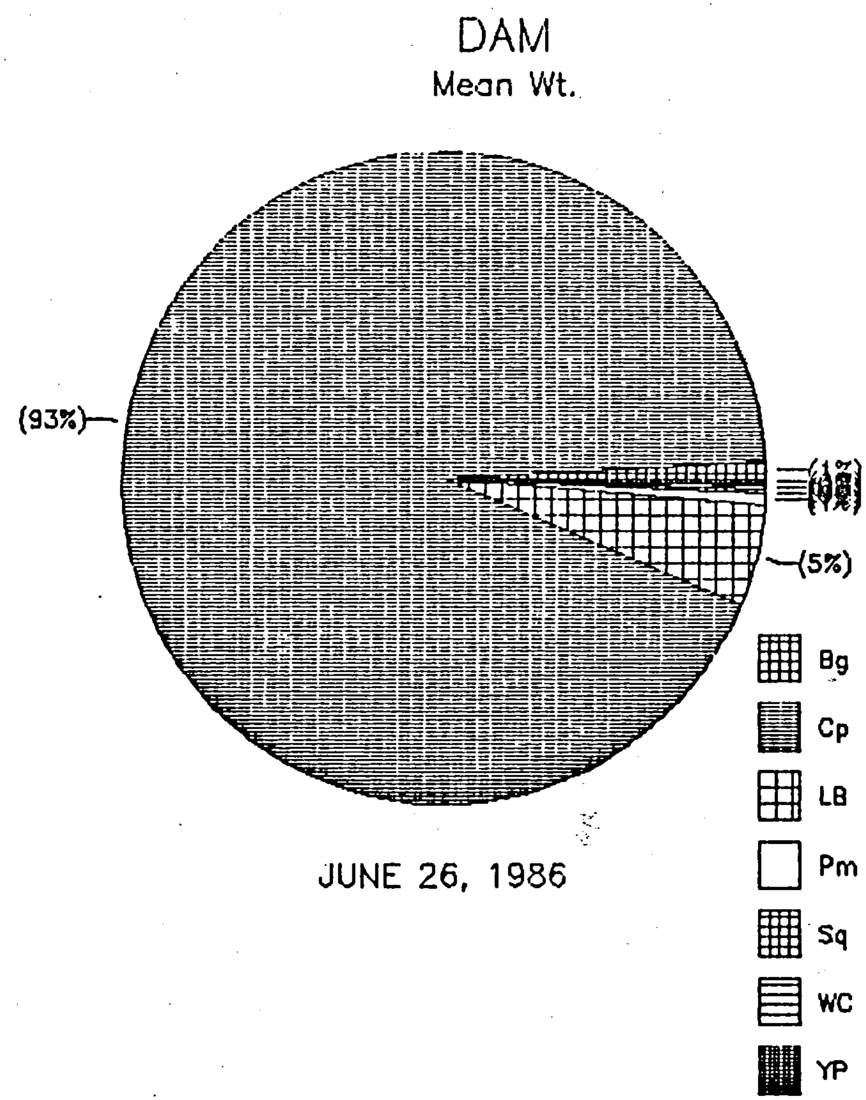
SMITH CHANNEL FISH CATCH DATA
JUNE, 1986

FISHMAN ENVIRONMENTAL SERVICES

DECEMBER, 1986

FIGURE G-A-8





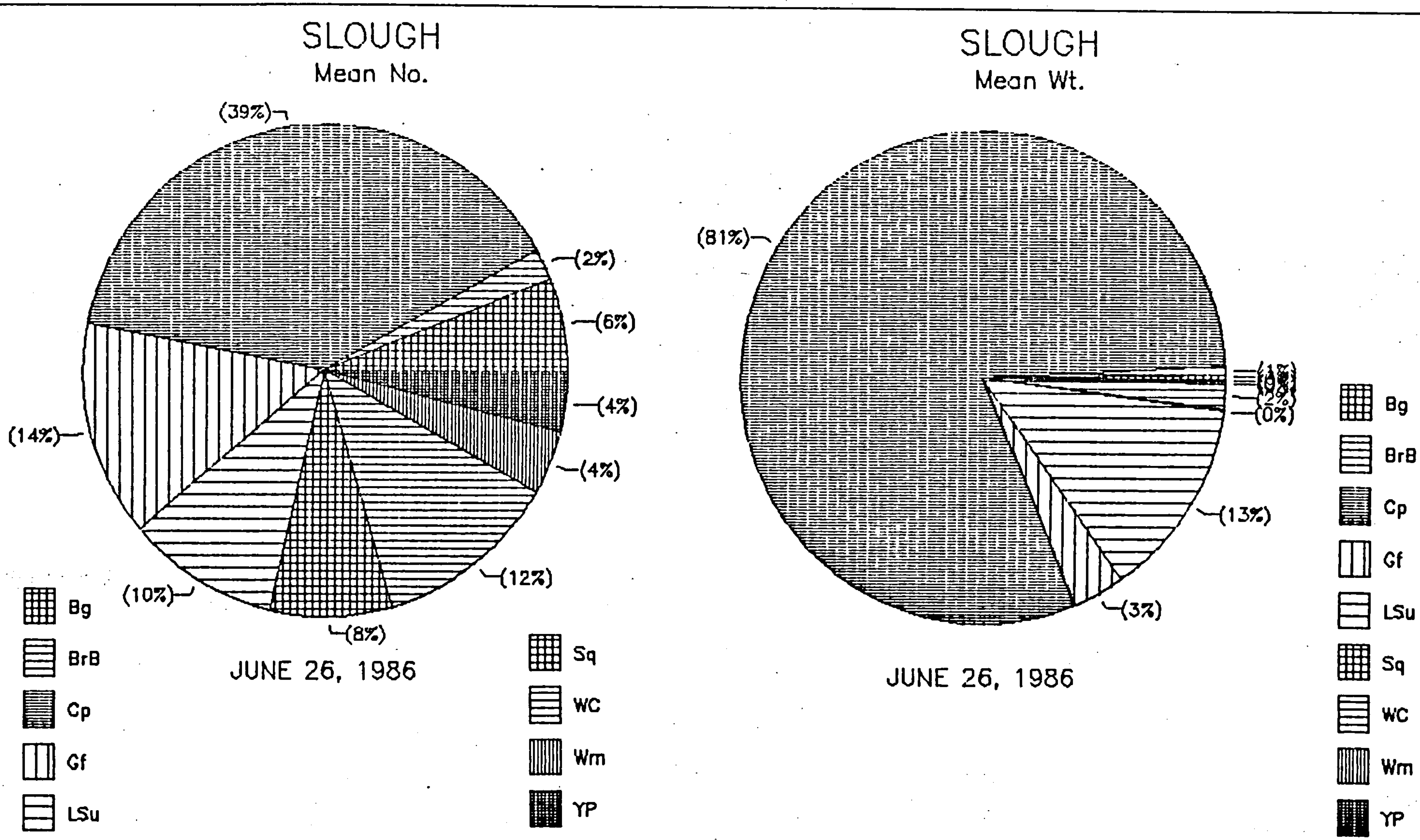
SMITH AND BYBEE LAKES
ENVIRONMENTAL STUDIES

DAM POOL FISH CATCH DATA
JUNE, 1986

FISHMAN ENVIRONMENTAL SERVICES

DECEMBER, 1986

FIGURE G-A-9



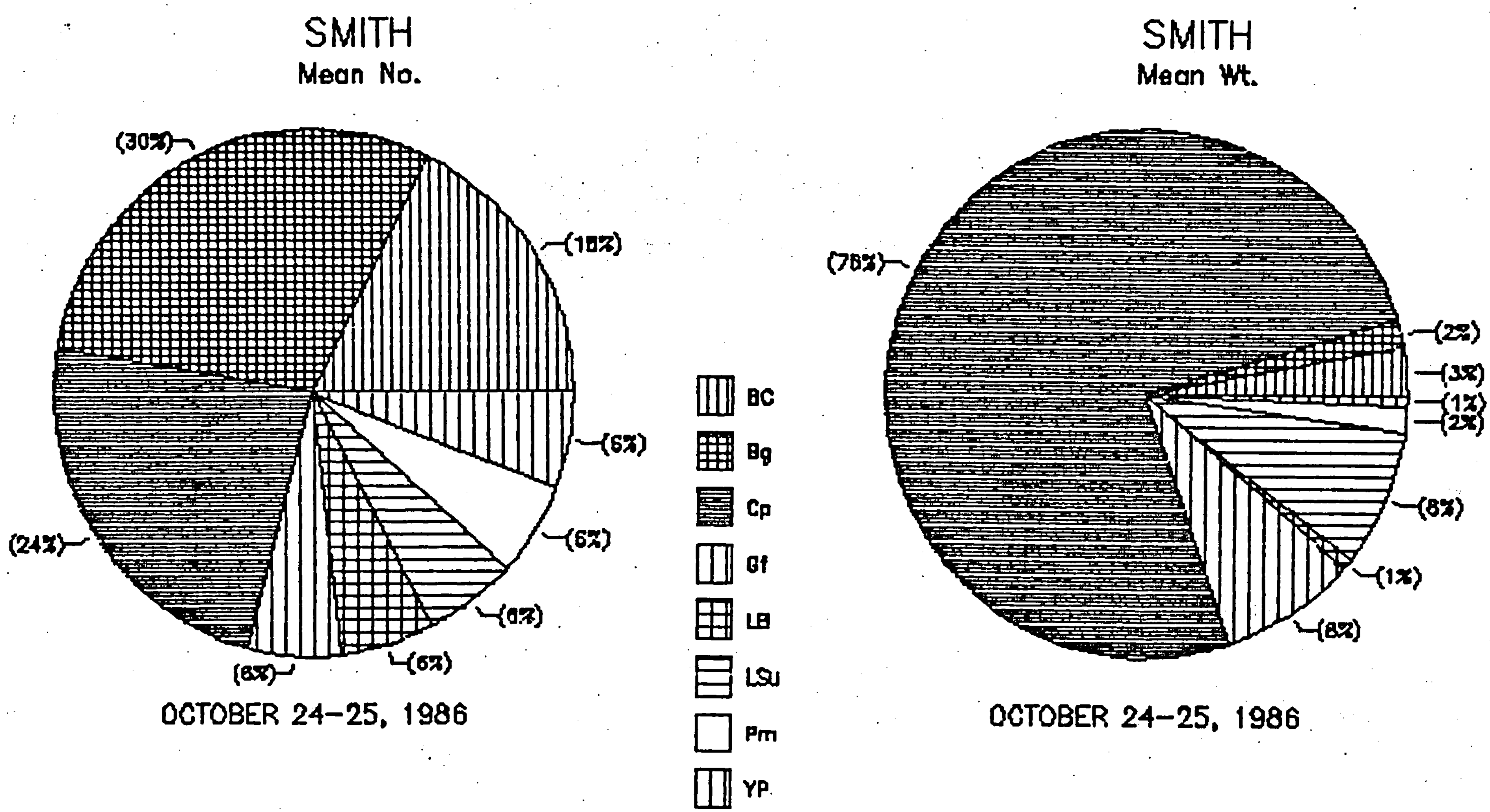
SMITH AND BYBEE LAKES
ENVIRONMENTAL STUDIES

COLUMBIA SLOUGH FISH CATCH DATA
JUNE, 1986

FISHMAN ENVIRONMENTAL SERVICES

DECEMBER, 1986

FIGURE G-A-10

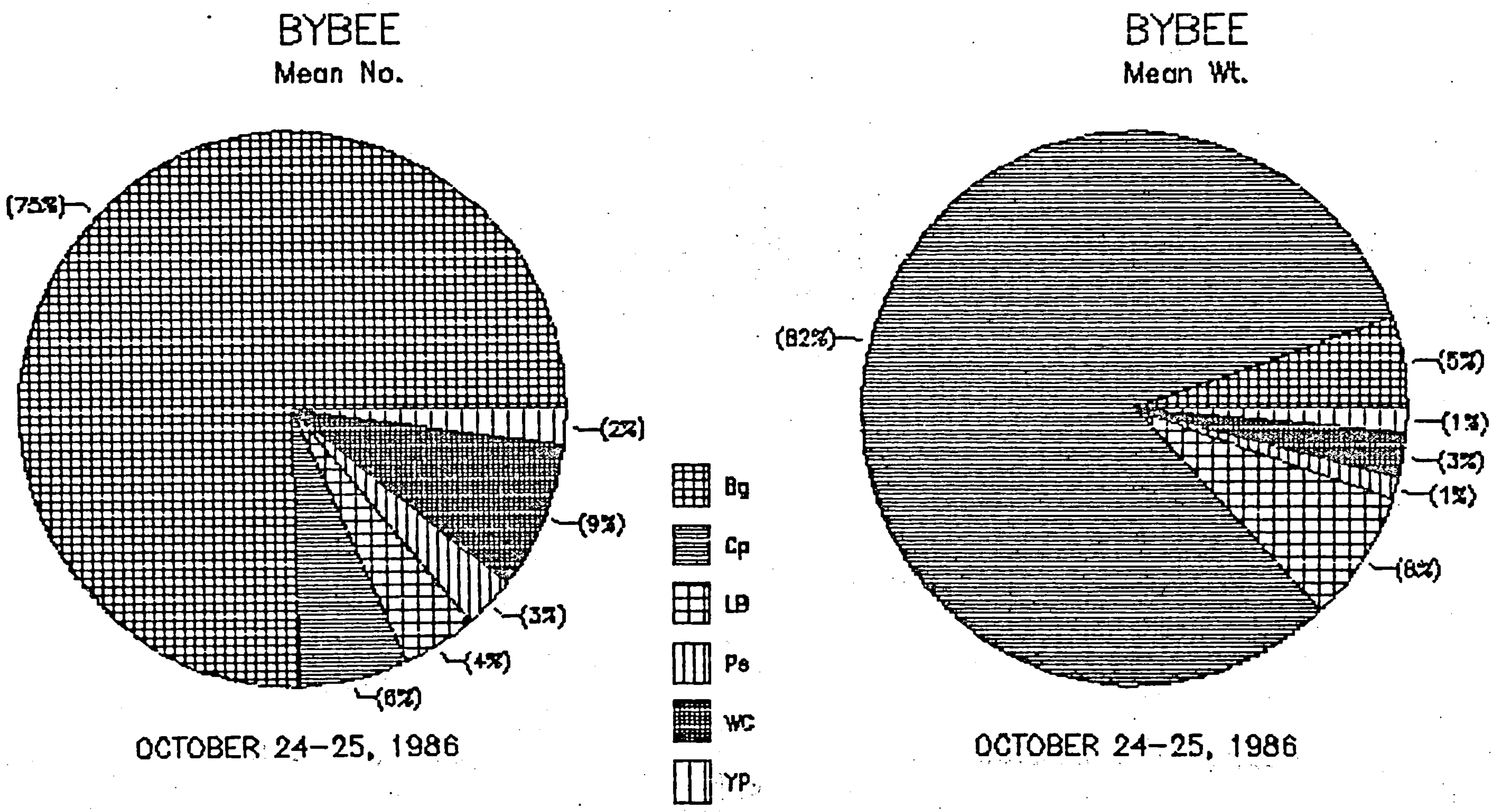


SMITH AND BYBEE LAKES
ENVIRONMENTAL STUDIES

SMITH LAKE FISH CATCH DATA
OCTOBER, 1986

FISHMAN ENVIRONMENTAL SERVICES

DECEMBER, 1986 | FIGURE G-A-11

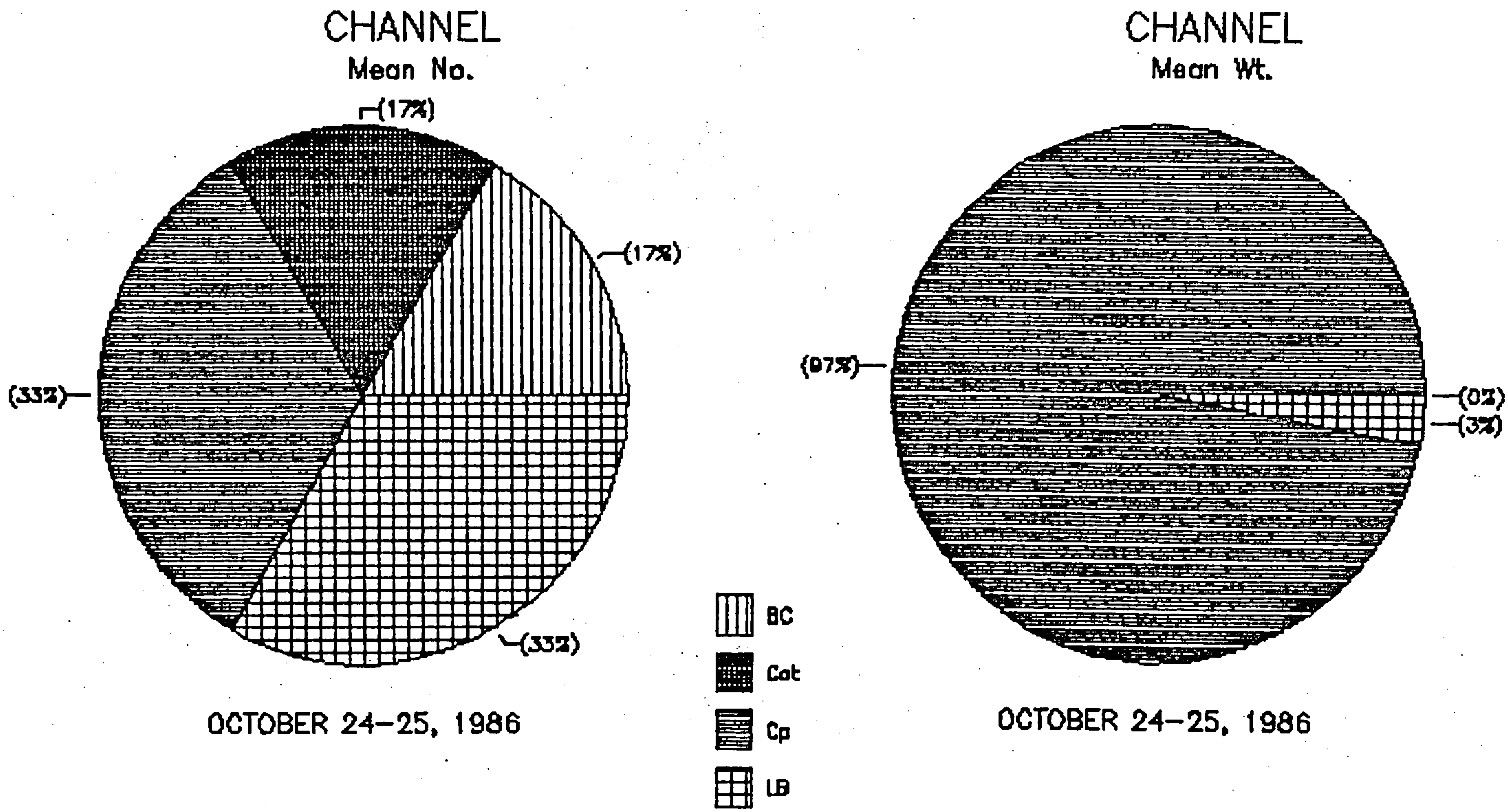


FISHMAN ENVIRONMENTAL SERVICES

SMITH AND BYBEE LAKES
ENVIRONMENTAL STUDIES

BYBEE LAKE FISH CATCH DATA
OCTOBER, 1986

DECEMBER, 1986 | FIGURE G-A-12



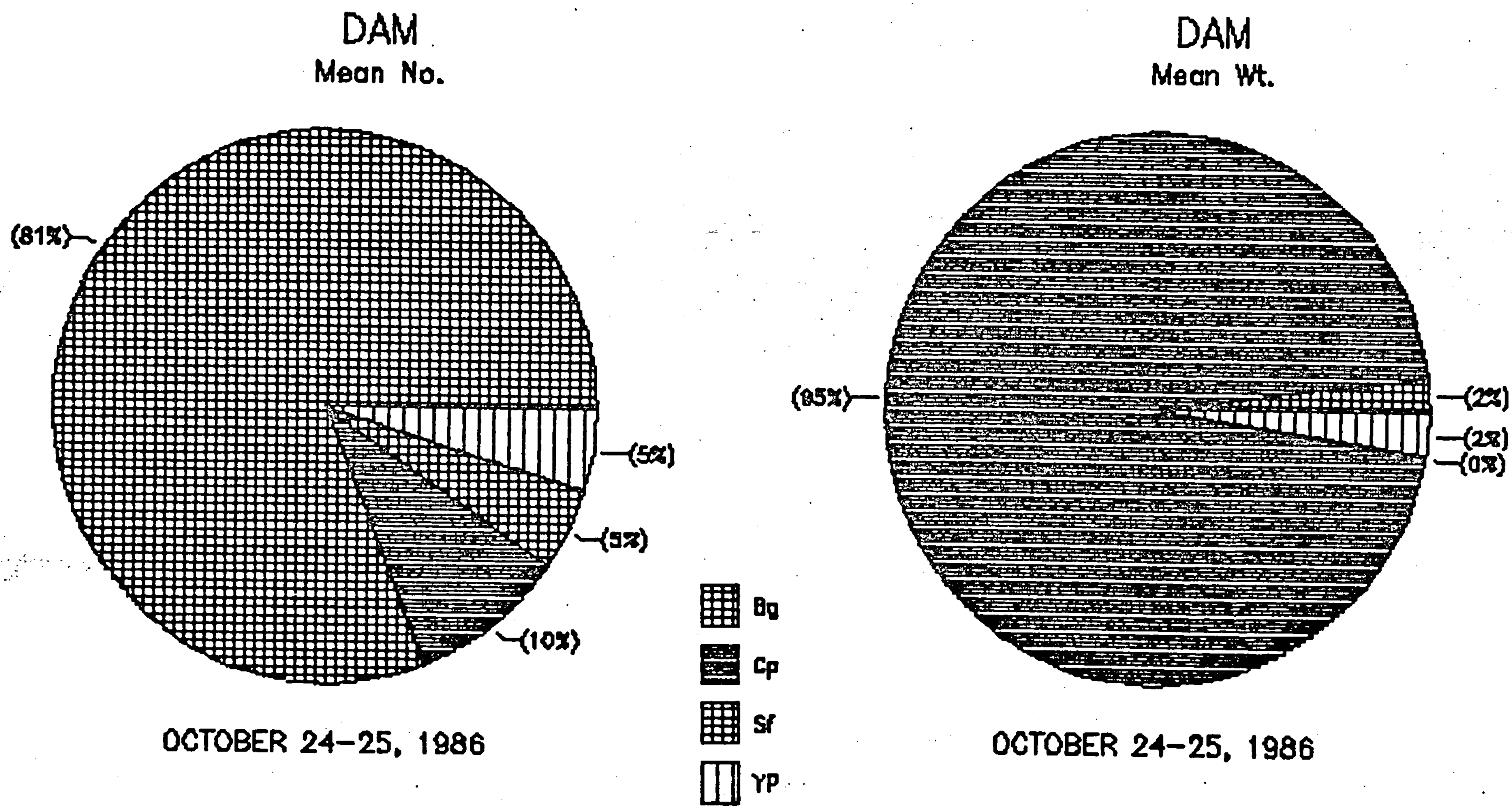
FISHMAN ENVIRONMENTAL SERVICES

SMITH AND BYBEE LAKES
ENVIRONMENTAL STUDIES

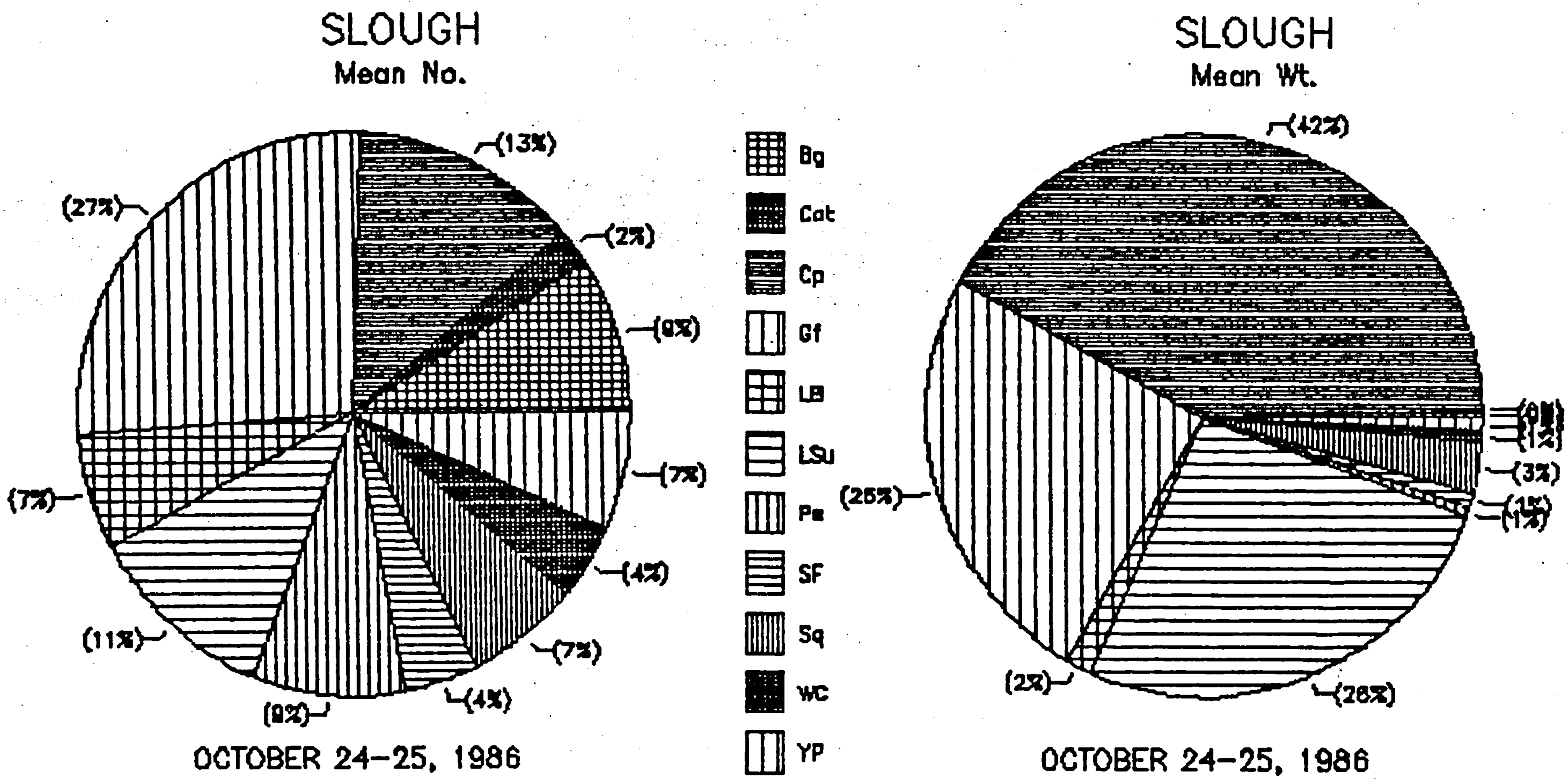
SMITH CHANNEL FISH CATCH DATA
OCTOBER, 1986

DECEMBER, 1986

FIGURE G-A-13



	SMITH AND BYBEE LAKES ENVIRONMENTAL STUDIES
	DAM POOL FISH CATCH DATA OCTOBER, 1986
FISHMAN ENVIRONMENTAL SERVICES	DECEMBER, 1986 FIGURE G-A-14



FISHMAN ENVIRONMENTAL SERVICES

SMITH AND BYBEE LAKES
ENVIRONMENTAL STUDIES

COLUMBIA SLOUGH FISH CATCH DATA
OCTOBER, 1986

DECEMBER, 1986 | FIGURE G-A-15

APPENDIX G-B

FISH TISSUE ANALYSES DATA

SOURCE: Oregon DEQ. 1984. DRAFT REPORT. Oregon Ambient Water Quality Toxics Data Summary - 1979 to 1983.

A copy of this draft report was obtained from DEQ for review related to the Smith and Bybee Lakes Environmental Studies project. The accumulation of toxic compounds in aquatic environments is presently under study by DEQ and the U.S. Environmental Protection Agency. Bioaccumulation pathways, and the relationship between compound concentrations and the health of organisms, including human consumers, are topics receiving wide attention; however, interpretation of survey results is very difficult. Interpretation of the data presented here is left to the investigating agencies.

Table C.1 Metals in Fish Tissue (cont.)

Station	Date	Time	Species	Arsenic (mg/kg)	Cadmium (mg/kg)	Chromium (mg/kg)	Copper (mg/kg)	Mercury (mg/kg)	Lead (mg/kg)
Station: 402822 Fern Ridge Reservoir	10/13/82	1:27	SUK	-	-	0.22	0.18	0.150	-
	10/13/82	1:27	LMB	-	-	-	0.15	0.180	-
Station: 402017 Conser Slough	9/23/8:	1:27	SUK	-	0.050	-	0.21	0.240	-
	9/23/82	1:27	NSO	-	-	0.15	-	0.330	-
Station: 402451 Santiam River at mouth	9/27/79	1:28	SUK	0.28	0.070			0.170	
	9/27/79	1:28	NSO	0.20	-			0.070	
	11/04/80	1:27	SUK	0.23	-	0.17	0.28	0.160	0.290
	11/04/80	1:27	MWH	0.26	-	0.24	0.31	0.060	0.220
	10/01/81	1:27	SUK	-	-	0.16	0.23	0.170	-
	10/01/81	1:27	NSO	-	-	-	0.22	0.360	-
	10/01/81	1:27	CM	-	-	-	0.29	0.060	-
	9/23/82	1:27	SUK	-	-	0.16	0.26	0.210	-
	9/23/82	1:27	NSO	-	-	0.70	0.25	0.780	-
Station: 402012 Willamette River at Wheatland Ferry	9/26/79	1:28	NSO	-	-			0.120	
	9/26/79	1:28	CM	0.28	-			0.050	
	11/04/80	1:27	SUK	0.16	-	0.58	0.25	0.080	0.210
	11/04/80	1:27	NSO	0.21	-	0.15	0.31	0.120	0.360
	11/04/80	1:27	CM	0.21	-	0.36	0.30	-	0.360
	10/15/81	1:27	SUK	-	-	-	0.79	0.320	-
	10/15/81	1:27	LMB	-	-	0.54	0.41	0.130	0.190
	10/15/81	1:27	CM	-	-	-	0.51	0.040	0.180
Station: 402031 Yamhill River at Dayton	10/21/82	1:27	SUK	-	-	-	0.15	0.170	-
	10/21/82	1:27	LMB	-	-	0.20	0.15	0.200	-
Station: 412380 North Fork Reservoir	11/25/80	1:27	SUK	-	-	0.32	0.13	0.210	0.240
	11/25/80	1:27	RBT	0.60	0.140	0.17	0.99	0.170	0.150
Station: 412381 Hagg Lake #1 S.E. Basin 1/2 Mile above Da	11/21/79	1:28	SUK	-	-			0.040	
	11/21/79	1:28	RBT	0.19	-			0.080	
	11/26/80	1:27	SUK	-	0.060	0.24	0.17	0.060	-
	10/08/81	1:27	SUK	-	-	-	-	0.100	-
	10/08/81	1:27	RBT	-	-	-	0.24	0.120	-
Station: 402000 Willamette River at SP&S RR Bridge	1/27/81	1:27	PEA	0.23	-	0.97	0.26	0.050	0.290
	10/06/81	1:27	SUK	-	-	-	0.28	0.350	-
	10/06/81	1:27	CM	-	-	-	0.72	0.040	-
	10/06/81	1:27	PEA	-	-	-	0.31	0.170	-
Station: 402881 Columbia Slough at Dump Rd. Bridge	10/29/80	1:27	SUK	-	-	1.23	0.61	0.210	0.180
	10/29/80	1:27	C	0.16	-	0.54	0.39	-	0.150
	10/29/80	1:27	SUK	-	-	-	0.41	0.530	0.220
	10/06/81	1:27	C	-	-	-	0.62	0.200	0.150
	10/06/81	1:27	LMB	-	-	0.26	0.43	0.760	0.220
Station: 402293 North Portland Harbor	9/08/82	1:27	C	-	0.050	-	0.60	0.180	-
	9/08/82	1:27	NSO	-	-	1.00	0.26	0.830	-
Station: 402081 Deschutes River at mouth	3/19/80	1:28	RBT	0.21	-			0.040	
	10/30/80	1:27	SUK	-	0.060	-	0.20	0.190	-
	9/25/81	1:27	SUK	-	-	0.83	0.24	0.140	0.210
	9/25/81	1:27	MWH	-	-	0.24	0.21	0.080	-
	9/15/82	1:27	SUK	-	-	0.34	0.26	0.290	-
Station: 402442 Klamath River at Keno Bridge	10/05/79	1:28	LMB	-	-			0.110	
	10/05/79	1:28	CFH	-	-			0.100	
	11/26/80	1:27	RBT	-	0.050	-	0.24	0.200	-
	10/14/81	1:27	CCB	-	-	-	0.50	0.360	0.180
	10/14/81	1:27	YP	-	-	-	0.44	0.440	0.200
	9/29/82	1:27	SUK	-	-	-	0.68	0.360	-
	9/29/82	1:27	CCB	-	-	-	0.25	0.330	-

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Table C.2 DDT's in Fish Tissue (cont.)

Station	Date	Time	Species	DDD, O,P'- (mg/kg)	DDD, P,P'- (mg/kg)	DDE, O,P'- (mg/kg)	DDE, P,P'- (mg/kg)	DDT, O,P'- (mg/kg)	DDT, P,P'- (mg/kg)
Station: 402981 Columbia Slough at Dump Rd. Bridge	10/29/80	0:06	SUK	-	-	-	0.1500	-	-
	10/29/80	0:06	C	0.051	-	0.049	0.1100	-	-
	10/29/80	1:27	SUK						
	10/06/81	0:06	SUK	-	0.1600	-	0.2900	-	-
	10/06/81	0:06	LMB	-	0.0500	0.020	0.1600	-	-
	10/06/81	1:27	SUK	-	0.1600	0.063	0.2900	-	-
	10/06/81	1:27	C	-	0.0800	0.055	0.2400	-	-
	10/06/81	1:27	LMB	0.004	0.0800	0.048	0.2300	-	-
	8/31/82	0:06	C		0.5400		0.7650		0.29
Station: 402293 North Portland Harbor	9/08/82	1:27	C	-	0.0300	0.040	0.1100	-	-
	9/08/82	1:27	NSO	-	0.0200	0.024	0.1400	-	-
Station: 402081 Deschutes River at mouth	3/19/80	1:28	RBT	-	-	-	-	-	-
	10/30/80	0:06	SUK	0.009	-	0.007	0.1700	-	0.02
	9/25/81	1:27	SUK	0.002	0.0400	-	0.1600	-	-
	9/25/81	1:27	MWH	-	0.0100	-	0.0600	-	-
	9/15/82	1:27	SUK	0.006	0.0600	0.004	0.3100	0.02	0.06
Station: 402442 Klamath River at Keno Bridge	10/05/79	1:28	LMB	-	-	-	-	-	-
	10/05/79	1:28	CFH	-	-	-	-	-	-
	11/26/80	0:06	RBT	-	-	-	-	-	-
	10/14/81	1:27	CCB	-	-	-	0.0200	-	-
	10/14/81	1:27	YP	-	-	-	0.0100	-	-
	9/29/82	1:27	SUK	-	-	0.025	0.0200	-	-
	9/29/82	1:27	CCB	-	-	0.008	0.0100	-	-

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Table C.3 Pesticides in Fish Tissue (cont.)

Station	Date	Time	Species	Aldrin (mg/kg)	Dieldrin (mg/kg)	Endrin (mg/kg)	BHC, Alpha (mg/kg)	BHC, Beta (mg/kg)	BHC, Gamma (mg/kg)
Station: 412381 Hagg Lake #1 S.E. Basin 1/2 Mile above Da	11/21/79	1:28	SUK	-	-	-	-		-
	11/21/79	1:28	RBT	-	-	-	0.0030		-
	11/26/80	0:06	SUK	-	0.008	-	0.0380		-
	10/08/81	1:27	SUK	-	-	-	0.0020		
	10/08/81	1:27	RBT	-	-	-	0.0030		
Station: 402126 Tualatin River at Tualatin	9/01/82	0:06	SUK	-	-	-	-	-	-
Station: 402000 Willamette River at SP&S RR Bridge	1/27/81	0:06	PEA	0.0160	0.015	-	-		-
	1/27/81	1:27	PEA						
	10/06/81	1:27	SUK	0.0020	-	-	-		-
	10/06/81	1:27	CM	-	-	-	0.0020		-
	10/06/81	1:27	PEA	-	-	-	0.0180		-
	8/31/82	0:06	C	-	-	-	-	-	-
Station: 402881 Columbia Slough at Dump Rd. Bridge	10/29/80	0:06	SUK	0.0050	0.024	-	-		-
	10/29/80	0:06	C	0.0030	0.014	0.003	-		-
	10/06/81	0:06	SUK	-	-	-	-		-
	10/06/81	0:06	LMB	-	0.002	0.004	-		-
	10/06/81	1:27	SUK	0.0020	-	-	0.0010		-
	10/06/81	1:27	C	0.0040	-	-	0.0010		-
	10/06/81	1:27	LMB	-	-	-	0.0030		-
	8/31/82	0:06	C	-	-	-	-	-	-
Station: 402293 North Portland Harbor	9/08/82	1:27	C	-	-	-	0.0060	-	-
	9/08/82	1:27	NSO	-	0.006	-	0.0040	-	-
Station: 402081 Deschutes River at mouth	3/19/80	1:28	RBT	-	-	-	-		-
	10/30/80	0:06	SUK	-	-	-	0.0050		-
	9/25/81	1:27	SUK	-	-	-	0.0020		-
	9/25/81	1:27	MWH	-	-	-	0.0010		-
	9/15/82	1:27	SUK	-	0.006	-	0.0030	-	-
Station: 402442 Klamath River at Keno Bridge	10/05/79	1:28	LMB	-	-	-	-		-
	10/05/79	1:28	CFH	-	-	-	-		-
	11/26/80	0:06	RBT	-	-	-	0.0150		-
	10/14/81	1:27	CCB	-	-	-	0.0060		-
	10/14/81	1:27	YP	-	-	-	0.0030		-
	9/29/82	1:27	SUK	-	-	-	0.0080	0.002	-
	9/29/82	1:27	CCB	-	-	-	0.0020	-	-

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Table C.4 Pesticides and PCB's in Fish Tissue (cont.)

Station	Date	Time	Species	Heptachlr (mg/kg)	Benzene, Hexachlr- (mg/kg)	Chlordane (mg/kg)	PCB's, Total (mg/kg)
Station: 412381 Hagg Lake #1 S.E. Basin 1/2 Mile above Da	11/21/79	1:28	SUK		-	-	-
	11/21/79	1:28	RBT		-	-	-
	11/26/80	0:06	SUK	-	0.006	-	-
	10/08/81	1:27	SUK	-	-	-	0.120
	10/08/81	1:27	RBT	-	-	-	0.050
Station: 402126 Tualatin River at Tualatin	9/01/82	0:06	SUK		-	-	-
Station: 402000 Willamette River at SP&S RR Bridge	1/27/81	0:06	PEA	-	0.020	-	2.300
	10/06/81	1:27	SUK	-	-	0.040	0.170
	10/06/81	1:27	CH	-	-	0.070	0.440
	10/06/81	1:27	PEA	-	-	0.040	0.150
	8/31/82	0:06	C		-	-	-
Station: 402881 Columbia Slough at Dump Rd. Bridge	10/29/80	0:06	SUK	-	0.002	-	2.200
	10/29/80	0:06	C	-	0.002	-	1.200
	10/06/81	0:06	SUK	-	-	-	0.790
	10/06/81	0:06	LMB	-	0.001	-	0.830
	10/06/81	1:27	SUK	-	-	-	0.230
	10/06/81	1:27	C	-	-	0.080	0.350
	10/06/81	1:27	LMB	-	0.002	-	0.150
	8/31/82	0:06	C		-	-	-
Station: 402293 North Portland Harbor	9/08/82	1:27	C	-	0.008	-	0.230
	9/08/82	1:27	NSO	-	0.004	-	0.420
Station: 402081 Deschutes River at mouth	3/19/80	1:28	RBT		-	-	-
	10/30/80	0:06	SUK	-	-	-	0.100
	9/25/81	1:27	SUK	-	0.003	0.060	0.090
	9/25/81	1:27	MWH	-	0.002	0.060	0.080
	9/15/82	1:27	SUK	-	0.006	-	0.190
Station: 402442 Klamath River at Keno Bridge	10/05/79	1:28	LMB		-	-	-
	10/05/79	1:28	CFH		-	-	-
	11/26/80	0:06	RBT	-	-	-	0.040
	10/14/81	1:27	CCB	-	0.002	-	-
	10/14/81	1:27	YP	-	-	-	0.090
	9/29/82	1:27	SUK	-	0.002	-	0.380
	9/29/82	1:27	CCB	-	-	-	0.050

H WILDLIFE

SMITH AND BYBEE LAKES ENVIRONMENTAL STUDIES

TECHNICAL APPENDIX H: WILDLIFE

Project Sponsored By:

Port of Portland

and

City of Portland, Bureau of Environmental Services

Project Managed By:

Fishman Environmental Services

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December, 1986

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1 BACKGROUND AND OBJECTIVES

The Smith and Bybee Lakes area contains a diversity of habitats, which, in the nearby areas of Sauvie Island, the Vancouver lowlands and Ridgefield National Wildlife Refuge, are extraordinarily rich in wildlife, especially waterfowl (U. S. Fish and Wildlife waterfowl censuses, 1979-1986). It is likely that the Smith and Bybee Lakes area was also once similarly rich in both species and numbers of wildlife, but the combined effects of several urban-related disturbances have apparently been associated with decreased abundances of this wildlife in recent years. The area of the wetland habitats suitable for wildlife usage has been greatly reduced by filling for urban and industrial development.

The adjacent St. Johns landfill, in addition to replacing about 250 acres of wetland habitat, is a source of considerable noise and attracts enormous numbers of scavenging species such as gulls and starlings, which dominate the surrounding area. The nearby Portland International Airport is a source of additional noise disturbance. In addition to these disturbances, the recent construction of a dam on North Slough, with the resulting impoundment of the lakes, has resulted in major changes to the vegetation and thus the overall structure of the remaining habitats.

Although no detailed censuses of the wildlife of the Smith and Bybee Lakes area had been conducted previous to this investigation, the area had been included in casual censuses conducted by amateur birdwatchers in previous years (Audubon Society Christmas Bird Counts, etc.), and the area had been included in aerial waterfowl surveys conducted by the U.S. Fish and Wildlife Service on an irregular basis over the last few years. In order to evaluate the current usage of the Smith and Bybee Lakes area by birds and other wildlife species, this report combines information from these sources with a more thorough survey of the area's avifauna conducted in late spring 1986.

2 METHODS

A total of 7 field surveys were conducted, 6 between 20 May and 19 June 1986 in order to census the breeding community, the 7th on 29 October to evaluate the wintering waterfowl community. Although different routes were followed on each of the surveys, each began at the Blind Slough remnant in the landfill, where waterfowl tended to be concentrated. An attempt was made to visit all significant habitat types and all important subregions of the study area at least once. Four of the surveys were conducted by canoe, three by foot.

The general numbers and associated habitats of each observed species were recorded. The habitat classification used was that devised for the study area by Stan Geiger, Scientific Resources, Inc. (SRI 1986). These habitat designations, however, were not completely applicable for all species. Two additional designations were therefore added to those specified by Geiger (SRI 1986): Shore Line was used for those species which forage at the edges of water and wetland habitats regardless of the specific type of wetland habitat; Overhead was used for those species sighted flying over the study area but without any specific habitat association. Although the primary objective of the surveys was to census the avian community, incidental observations of species from other groups of wildlife were also recorded.

Consultations were made with representatives of the U. S. Fish and Wildlife Service, the Oregon Department of Fish and Wildlife, and the Portland Audubon Society in order to obtain records useful in evaluating historical changes in the wildlife of the study area. The U. S. Fish and Wildlife Service provided information gained from four aerial surveys made in January 1985, January, February, and March 1986. The Audubon Society provided a list of 80 species of birds observed in the study area. All of these records were combined into one master list of bird species known to occur in the study area.

Lists were prepared for potentially occurring species of amphibians, reptiles, and mammals. These lists were compiled from the literature of the known vertebrate faunas of the region in addition to observations of the species and their signs. References used were Nussbaum, R. A., et al. (1983), Marshall, D. (1985), Maser, C., et al. (1981), and

Ingles, L. G. (1965).

3 RESULTS

The wildlife species observed in the study area along with those recorded by others are listed in Tables H-1 through H-3. Since systematic surveys were conducted primarily during the late spring and early summer, this list may be incomplete with regard to wintering species.[1] Judging by the wildlife usage patterns of surrounding areas, it can be expected that it is in the winter that the largest numbers of wildlife occur in the area, and that these numbers are comprised primarily of waterfowl. The survey of 29 October, however, revealed only one additional species of waterfowl, the Ring-necked Duck. Furthermore, fewer waterfowl were observed on this survey than on the earlier, breeding season surveys. Several species of waterfowl which had been expected, based on observations in previous years, were not present. These species included, Ruddy Duck, Scaup, Bufflehead, Wigeon, and Canvasback.

A total of 97 species of birds have been reported to be present in recent years or can be expected to occur in the study area, with 49 species presumed to breed there. However, only 72 species were actually confirmed in the study area in the present study. Six amphibian, 6 reptile, and 31 mammal species can also be expected to occur in the study area.

Waterfowl were found in very low densities in all habitats and subregions of the study area with the exception of the Blind Slough in the landfill, where they were consistently found in impressive abundance and diversity. However, since this area will soon be eliminated by the landfill, and since several species were found only there, the overall diversity of the study area will soon be reduced. Green-winged Teal, Gadwall, Shoveller, Ring-necked Duck, and Pied- billed Grebe were observed only in this location. This also appeared to be the primary breeding area for waterfowl. The great

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1. Project Manager's note: Subsequent to the completion of this report, a bird survey was conducted, from canoes, on March 17, 1987. In addition to the contractors, biologists from ODFW and PGE participated in the survey. A species list from this effort is included in this report as Table H-4.

majority of observations of broods of Mallard and Cinnamon Teal were at this location.

Scavenging species were present in enormous numbers, especially in the landfill and immediately adjacent areas. Starlings and Common Crows were observed over the active landfill area and making flights in large flocks to roost areas in adjacent willow and swamp forests. House Sparrows were also abundant in the vicinity of the active landfill. House Sparrow nests were observed in the willow and ash forests adjacent to the landfill. Since the House Sparrows as well as the Starlings nest in natural tree cavities, a resource which is in short supply and critical to the survival of many species of naturally occurring bird species, the well known ability of these scavenging species to outcompete the naturally occurring species for nest cavities is a serious adverse impact. Tree Swallows, Bewick Wrens, House Wrens, Black-capped Chickadees, Flickers, Downy Woodpeckers, Hairy Woodpeckers, Screech Owls, and Wood Ducks are potentially impacted.

Large numbers of gulls of several species were also observed in the active landfill. These species do not breed in the study area, but they frequently roost on open water after foraging and are doubtless responsible for the transport of large quantities of nutrient from the landfill to the lakes.

An immature Bald Eagle was sighted over the study area by the U. S. Fish and Wildlife Service's aerial waterfowl survey in March 1986. An active winter eagle roost is known to be located in the hills to the west of Scappoose. The individual sighted in March 1986 was probably from this roost. This species was not observed in the study area during the breeding season. [2]

Although smartweed (*Polygonum coccineum*) is generally considered a desirable species for waterfowl habitat, and the seeds are a good food source, the large expanse covered by this species in Smith Lake was almost entirely devoid of waterfowl during the breeding season, nor was it being used by waterfowl during the 29 October survey. The paucity of waterfowl in Smith Lake could possibly be explained by the fact that invasion of smartweed in Smith Lake is a recent phenomenon (since the impoundment of Smith Lake in 1982) and either it may not have been there long enough for the

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2. Project Manager's Note: A bald eagle was observed soaring above NE Bybee Lake and the Columbia River area during the March 17, 1987 survey.

waterfowl to learn of its existence or perhaps it has not yet built up to sufficient densities to be a significant resource. [3]

The willow swamps of the study area have undergone considerable die-back since the impoundment of water in 1982. With the exception of Downy Woodpeckers and Marsh Wrens, very few other species of birds were seen in the willow swamps. The stem size of the willows (less than 3 inches) where the Downy Woodpeckers were repeatedly observed was not sufficient to provide nesting habitat and it was unclear what had attracted them there. The Marsh Wrens, however, were clearly nesting in the willow swamps at the north end of Bybee Lake and perhaps elsewhere. The Yellow Warbler had been seen in the study area in recent years, but was not observed during the 1986 breeding season although considerable effort was expended to find it. This species normally breeds in willow swamps and has been used as an indicator of the overall health of this habitat by the U. S. Fish and Wildlife Service (Schroeder, 1982).

Several threatened and endangered species, or species of special concern have been noted as possible residents or visitors for the area that includes Smith and Bybee Lakes. The peregrine falcon is designated as endangered by the U.S. Fish and Wildlife Service (USFWS); the bald eagle is listed as threatened by the USFWS. The peregrine is a potential visitor to the study area; eagles have been observed in the area.

The Oregon Natural Heritage Data Base lists the western pond turtle on its review list due to recent decline in numbers and apparent elimination from the Portland metropolitan area. This species was not observed in the study area. Tricolor blackbird is a Candidate for Endangered Species Status by the USFWS. A breeding colony of this species was located within the Blind Slough area of the St. Johns landfill, but has been displaced by landfill expansion; its fate is unknown.

The willow flycatcher is designated as sensitive by the USFWS. This species was observed in the study area during project surveys.

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3. Project Manager's note: The density of waterfowl observed during the March 17, 1987 survey was "typical" for similar wetland areas, according to J. Pesek, ODFW. This bird density appeared higher than previous surveys conducted for this study.

It should be noted that the Smith and Bybee Lakes complex was the site of a severe avian botulism outbreak during the late 1970's. This problem was the driving factor behind the construction of the water control structure in 1983 that resulted in impoundment of water in the lakes.

4 CONCLUSIONS

1. Although a relatively large number of species (91) has been known to use the study area in recent years, the actual number of species confirmed by this study to be using the area (72) is considerably lower.

2. Overall numbers of waterfowl were considerably lower than expected, based on wildlife usage patterns in comparable habitats in the nearby Sauvie Island and Ridgefield National Wildlife Sanctuary.

3. Species diversity and overall numbers of waterfowl can be expected to decline in the near future with the loss of the Blind Slough remnant in the landfill.

5 LITERATURE CITED

Ingles, L. G. 1965. Mammals of the Pacific States. Stanford Univ. Press. Stanford, California.

Maser, C., B. R. Mate, F. F. Franklin, C. T. Dyrness. 1981. Natural History of Oregoan Coast Mammals. USDA General Tech. Rept. PNW-133.

Marshall, D. B. 1986. Oregon Nongame Management Plan. Oregon Department of Fish and Wildlife.

Schroeder, R. L. 1982. Habitat Suitability Models: Yellow Warbler. U. S. Fish and Wildlife Service OBS-82/10.27

Scientific Resources, Inc. 1986. Smith and Bybee Lakes Environmental Studies. Technical Appendix E: Vegetation. Report to: Port of Portland and City of Portland, Bureau of Environmental Services.

TABLE H-1

OBSERVED AND POTENTIALLY OCCURRING SPECIES
OF AMPHIBIANS AND REPTILES

COMMON NAME SCIENTIFIC NAME	OW	SL	SmS	SWS	F	UG	RCG	SM	LF	S
Northwestern Salamander Ambystoma gracile				x	x					e
Long-toed Salamander Ambystoma macrodactylum				x	x		o			o
Rough-skinned Newt Taricha granulosa	x			x	x					e
Ensatina Ensatina eschscholtzi				x	x					e
Pacific Treefrog Hyla regilla				x	x					e
Bullfrog Rana catesbeiana		x	x	x						e
Western Pond Turtle Clemys marmorata	x	x								e
Painted Turtle Chrysemys picta	o	x								o
Northern Alligator Lizard Elgaria coerulea					x					e
Western Terrestrial Garter Snake Thamnophis elegans vagrans					x					e
Northwestern Garter Snake Thamnophis ordinoides					x					e
Red-spotted Garter Snake Thamnophis sirtalis concinnus					x					e

Codes:

OW = Open Water
SL = Shore Line
SmS = Smartweed Swamp
SWS = Smartweed/Willow Swamp
F = Forest
UG = Upland Grassland (old parts of landfill)
RCG = Reed Canarygrass Grassland
SM = Sedge Meadows
LF = Landfill (active)
OH = Overhead (birds seen flying over, no specific habitat association)
S =. Status
o = observed; e = expected; X = expected

TABLE H-2

HABITAT ASSOCIATIONS, ABUNDANCE, AND SEASONAL OCCURRENCE OF OBSERVED AND POTENTIALLY OCCURRING BIRD SPECIES

COMMON NAME SCIENTIFIC NAME	HABITAT										
	OW	SL	SmS	SWS	F	UG	RCG	SM	LF	OH	S
Pied-billed Grebe *Podilymbus podiceps*	u										o,y
Double-crested Cormorant *Phalacrocorax auritus*	u										o,y
Tundra Swan *Cygnus columbianus*		o									e,w
Canada Goose *Branta canadensis*	u	ub									o,y
Mallard *Anas platyrynchos*	u	ab	u	u							o,y
Northern Pintail *Anas acuta*	a	a									e,w
Gadwall *Anas strepera*	o	cb									o,y
American Wigeon *Anas americana*	u	u									e,w
Northern Shoveler *Anas clypeata*		c									o,y
Blue-winged Teal *Anas discors*	o	cb	o								o,y
Cinnamon Teal *Anas cyanoptera*		ab									o,y
Green-winged Teal *Anas crecca*		o									o,w
Ring-necked Duck *Aythya collaris*	o	o									o,w
Wood Duck *Aix sponsa*		o		u							o,y
Lesser Scaup *Aythya affinis*	c	c									o,w
Ruddy Duck *Oxyura jamaicensis*	u										e,w

TABLE H-2 (cont.)

COMMON NAME SCIENTIFIC NAME	OW	SL	SmS	SWS	F	UG	RCG	SM	LF	OH	S
	HABITAT										
Hooded Merganser Lophodytes cucullatus	u										o,w
Common Merganser Mergus merganser	u										e,w
Turkey Vulture Cathartes aura										c	e,s
Northern Harrier Circus cyaneus						u	u	u			o,w
Cooper's Hawk Accipiter cooperii		o				u	u	u			o,w
Sharp-shinned Hawk Accipiter striatus					o						e,w
Red-tailed Hawk Buteo jamaicensis					ub					c	o,y
American Kestrel Falco sparverius						ob	ob	o	o		o,y
Bald Eagle Haliaeetus leucocephalus										o	o,y
Ring-necked Pheasant Phasianus colchicus						ub	ub				o,y
Great Blue Heron Ardea herodias		c		c							o,y
Green-backed Heron Butorides striatus		u									o,y
Sandhill Crane Grus canadensis	u										e,w
American Coot Fulica americana			o								o,y
Killdeer Charadrius vociferus		cb				c					o,y
Greater Yellowlegs Tringa melanoleucus		u									e,w
Lesser Yellowlegs Tringa flavipes		u									e,w
Spotted Sandpiper Actitis macularia		ub									o,y

TABLE H-2 (cont.)

COMMON NAME SCIENTIFIC NAME	OW	SL	SmS	SWS	F	UG	RCG	SM	LF	OH	S
Western Sandpiper Calidris mauri		u									e,w
Least Sandpiper Calidris minutilla		u									e,w
Common Snipe Gallinago gallinago		u						u			e,y
Glaucous-winged Gull Larus glaucescens									a		o,y
Herring Gull Larus argentatus									a		o,y
Ring-billed Gull Larus delawarensis									a		o,y
Rock Dove Columba livia									ab		o,y
Band-tailed Pigeon Columba fasciata					o						e,y
Mourning Dove Zenaida macroura						cb			c		o,y
Barn Owl Tyto alba					o				o		e,y
Western Screech Owl Otus kennicottii					u						e,y
Great Horned Owl Bubo virginianus					ub						o,y
Vaux's Swift Chaetura vauxii	u	u	u	u	u	u	u	u	u		o,s
Belted Kingfisher Ceryle alcyon		ub									o,y
Common Flicker Colaptes auratus					cb	o					o,y
Hairy Woodpecker Picoides villosus					ub						o,y
Downy Woodpecker Picoides pubescens				c	cb						o,y
Willow Flycatcher Empidonax traillii				u	cb						o,s

TABLE H-2 (cont.)

COMMON NAME SCIENTIFIC NAME	HABITAT									
	OW	SL	SmS	SWS	F	UG	RCG	SM	LF	OH	S
Western Wood Pewee Contopus sordidulus					cb						o,s
Barn Swallow Hirundo rustica	c	c	c	c	c	c	c	c	c		o,s
Cliff Swallow Hirundo pyrrhonota	c	c	c	c	c	c	c	c	c		o,s
Tree Swallow Tachycineta bicolor	a	a	a	a	ab	a	a	a	a		o,s
Violet-green Swallow Tachycineta thalissina	u	u	u	u	u	u	u	u	u		o,s
Scrub Jay Aphelocoma ultramarina		u			ub				u		o,y
American Crow Corvus brachyrhynchos		u			cb				a		o,y
Black-capped Chickadee Parus atricapillus					cb						o,y
Common Bushtit Psaltriparus minimus					ub						e,y
House Wren Troglodytes aedon					cb						o,s
Winter Wren Troglodytes troglodytes					ob						e,y
Bewick Wren Thryomanes bewickii					cb						o,y
Marsh Wren Cistothorus palustris				cb			cb	cb			o,s
American Robin Turdus migratorius					ab						o,y
Hermit Thrush Catharus guttatus					c						e,w
Swainson's Thrush Catharus ustulatus					cb						o,s
Ruby-crowned Kinglet Regulus calendula					c						e,w
Golden-crowned Kinglet Regulus satrapa					u						e,w

TABLE H-2 (cont.)

COMMON NAME SCIENTIFIC NAME	HABITAT										
	OW	SL	SmS	SWS	F	UG	RCG	SM	LF	OH	S
Cedar Waxwing Bombycilla cedrorum				u	cb						o,y
European Starling Sturnus vulgaris		ab			ab				a		o,y
Warbling Vireo Vireo gilvus					u						e,s
Hutton's Vireo Vireo huttoni					ob						e,y
Orange-crowned Warbler Vermivora celata				u	cb						o,s
Yellow Warbler Dendroica petechia				o							e,s
Yellow-rumped Warbler Dendroica coronata					c						o,w
Black-throated Gray Warbler Dendroica nigrescens					cb						o,s
Common Yellowthroat Geothlypis trichas		ab					ab				o,s
Wilson's Warbler Wilsonia pusilla					u						e,s
House Sparrow Passer domesticus					cb				a		o,y
Red-winged Blackbird Agelaius phoeniceus		ab	u	u		c			a		o,y
Tricolored Blackbird Agelaius tricolor		u	u	u		u			u		e,y
Brewer's Blackbird Euphagus cyanocephalus		u							u		o,y
Brown-headed Cowbird Molothrus ater		c			cb				a		o,y
Northern (Bullock's) Oriole Icterus galbula					cb						o,s
Black-headed Grosbeak Pheucticus melanocephalus					cb						o,s
Purple Finch Carpodacus purpureus					u						e,s

TABLE H-2 (cont.)

COMMON NAME SCIENTIFIC NAME	OW	SL	SmS	SWS	F	UG	RCG	SM	LF	OH	S
House Finch Carpodacus mexicanus					cb						o,y
American Goldfinch Carduelis tristis							cb				o,y
Rufous-sided Towhee Pipilo erythrophthalmus					u						e,y
Dark-eyed Junco Junco hyemalis					c	c					o,w
Savannah Sparrow Passerculus sandwichensis						cb					o,y
White-crowned Sparrow Zonotrichia leucophrys						c					e,w
Golden-crowned Sparrow Zonotrichia atricapilla						c					e,w
Fox Sparrow Passerella iliaca					u						e,w
Song Sparrow Melospiza melodia		u			ab						o,y

Codes, Habitats:
OW = Open Water
SL = Shore Line
SmS = Smartweed Swamp
F = Forest
UG = Upland Grassland (old parts of landfill)
RCG = Reed Canarygrass Grassland
SM = Sedge Meadows
LF = Landfill (active)
OH = Overhead (birds seen flying over, no specific habitat association)
S = Status

Abundance:
o = occasional, 1-2 sitings
u = uncommon, 3-5 sitings, regular occurrance
c = common, >5 sitings
a = abundant
b = breeder

Status:
o = observed
e = expected
s = spring and summer
w = winter
y = year-round

TABLE H-3

OBSERVED AND POTENTIALLY OCCURRING SPECIES OF MAMMALS

COMMON NAME SCIENTIFIC NAME	HABITAT										
	OW	SL	SmS	SWS	F	UG	RCG	SM	LF	OH	S
Opossum Didelphis virginiana		x			x						o
Vagrant Shrew Sorex vagrans		x		x	x			x			e
Dusky Shrew Sorex obscurus				x	x						e
Pacific Water Shrew Sorex bendirei				x				x			e
Shrew Mole Neurotrichus gibbsi					x						e
Coast Mole Scapanus orarius					x						e
Little Brown Bat Myotis lucifugus										x	e
Long-eared Myotis Myotis evotis										x	e
Hairy-winged Myotis Myotis volans										x	e
California Myotis Myotis californicus										x	e
Big Brown Bat Eptesicus fuscus										x	e
Brush Rabbit Sylvilagus bachmani		x	x	x	x	x	x	x	x		e
Eastern Cottontail Sylvilagus floridanus		x	x	x	x	x	x	x	x		o
California Ground Squirrel Spermophilus beecheyi						x					e
Western Pocket Gopher Thomomys mazama						x					e
Beaver Castor canadensis	x	x									o

TABLE H-3 (cont.)

COMMON NAME / SCIENTIFIC NAME	HABITAT										
	OW	SL	SmS	SWS	F	UG	RCG	SM	LF	OH	S
Deer Mouse / Peromyscus maniculatus					x						e
Bushy-tailed Woodrat / Neotoma cinerea					x						e
Oregon Vole / Microtus oregoni							x	x			e
Townsend Vole / Microtus townsendii							x	x			e
Muskrat / Ondatra zibethicus	x	x		x							o
Nutria / Myocastor coypus	x	x	x	x							o
Coyote / Canis latrans		x	x	x	x	x	x	x	x		e
Feral Domestic Dog / Canis familiaris		x	x	x	x	x	x	x	x		o
Raccoon / Procyon lotor		x	x	x	x	x	x	x	x		o
Short-tailed Weasel / Mustela erminea		x			x	x	x	x			o
Long-tailed Weasel / Mustela frenata		x			x	x	x	x			o
Mink / Mustela vison	x	x	x	x							e
Striped Skunk / Mephitis mephitis		x			x	x	x				e
River Otter / Lutra canadensis	x	x	x	x							o
Black-tailed Deer / Odocoilius hemionus					w						o

Codes:

OW = Open Water
SL = Shore Line
SmS = Smartweed Swamp
SWS = Smartweed/Willow Swamp
F = Forest
UG = Upland Grassland (old parts of landfill)
RCG = Reed Canarygrass Grassland
SM = Sedge Meadows
LF = Landfill (active)
OH = Overhead (birds seen flying over, no specific habitat association)
S = Status
o = observed
e = expected

TABLE H-4

BIRD SPECIES OBSERVED ON SMITH AND BYBEE LAKES
MARCH 17, 1987

Double-crested cormorant
Canada goose
Mallard
Gadwall
Widgeon
Shoveler
Northern harrier
Red-tailed hawk
Bald eagle
Great blue heron
American coot
Glaucous-winged gull
Herring gull
Ring-billed gull
Mourning dove
Kingfisher
Downy woodpecker
Tree swallow
Violet-green swallow
American crow
Black-capped chickadee
Bewick wren
Marsh wren
Robin
Ruby-crowned kinglet
Cedar waxwing
Starling
Yellow-rumped warbler
Red-winged blackbird
House finch
Song sparrow