Water Quality

State of Water Quality of Elk and Beaver Lakes 1986-1995

Canada - British Columbia Water Quality Monitoring Agreement

Water Quality Section
Water Management Branch
Ministry of Environment, Lands and Parks

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Executive Summary

Elk and Beaver lakes are located on southern Vancouver Island (Figure 1). A shallow channel connects Elk lake and Beaver Lake. The Elk/Beaver watershed is 11.5 km².

This report assesses 10 years of water quality data. We made the following conclusions:

- Two water quality objectives (water temperature, water clarity) for Elk Lake and one water quality objective (water clarity) for Beaver Lake have been met since 1993.
- Three water quality objectives (dissolved oxygen, chlorophyll a, and Phytoplankton community) for Elk Lake and two water quality objectives (dissolved oxygen, Phytoplankton community) for Beaver Lake were not met.
- Spring overturn sampling indicates that the amount of nutrients (e.g., dissolved ammonia and total phosphorus) in the water column have generally decreased from 1986 to 1995. In 1992, there was a notable increase in nutrient values. These changes in nutrient values may be attributed to a change in the amount of nutrients entering the lake or to a change in lake processes.
- Total phosphorus values exceeded the criterion range for protecting aquatic life (0.005 mg/L to 0.015 mg/L) in 1986, 1988, and 1995. The criterion (0.01 mg/L) for recreational use was exceeded by all yearly averages.
- Phosphorus is the limiting nutrient for algal growth, and dissolved silica is the limiting nutrient for diatom growth in Elk Lake.
- The Capital Regional District's Health Protection and Environmental Division has posted beach advisory notices, warning of the potential for increased risk to bathers' health, at Elk Lake (Hamsterly Beach and Eagle Beach) and Beaver Lake (Beaver Beach) on several occasions between 1980 and 1995. These notices were posted when the geometric mean exceeded 200 fecal coliforms/100 mL over a 30-day period.
- Total zinc values exceeded the criterion for protecting phytoplankton populations (0.014 mg/L) in 1992, 1994 and 1995, probably due to uncertainty near the minimum detectable limit (0.01 mg/L).

We recommend monitoring:

- to determine whether water quality objectives are being met.
- to identify changes in water quality attributed to biological activity in the lakes, to activities within the watershed such as urbanization, and to changes in non-point discharge.

Both monitoring programs could be implemented by an Elk/Beaver Lake stewardship group with assistance from the Ministry of Environment, Lands and Parks.

- to determine whether public beaches are suitable for bathing.

The monitoring program is being implemented by the Capital Regional District's Health Protection and Environmental Division.

Figure 1 Elk and Beaver Lakes Watershed

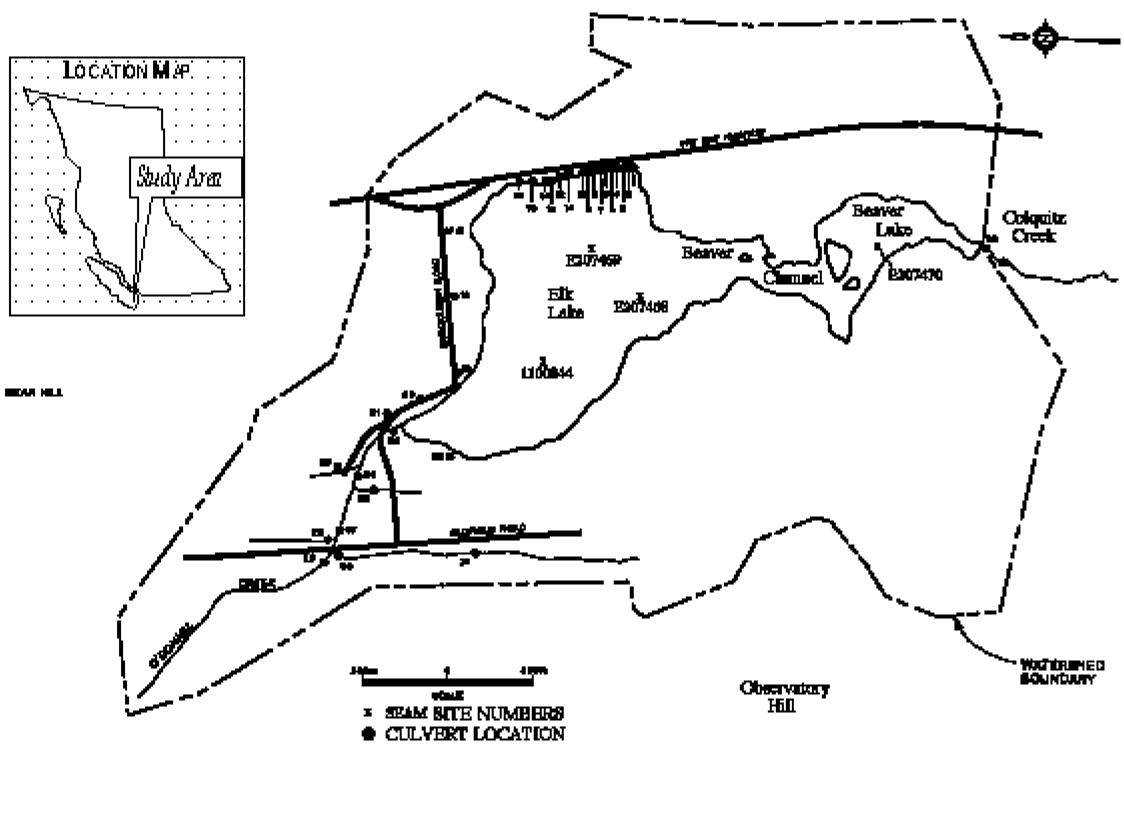

Table of Contents

List of Figures

List of Tables

Author

Holms, G. Bruce B.Sc. Research Officer. Water Quality Branch, Environmental Protection Department, Victoria, B.C.

Acknowledgements

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Introduction

Elk and Beaver Lakes are located on southern Vancouver Island (Figure 1). A shallow channel connects Elk Lake and Beaver Lake. The combined surface area of the Elk Lake, Beaver Lake, and Elk-Beaver channel is 246 ha. The Elk/Beaver watershed is 11.5 km^2 and is drained by three subdrainage areas (Munteanu*et al.*, 1988). Elk Lake has a maximum depth of 17.9 m and a mean depth of 9.2 m, while Beaver Lake has a maximum depth of 7.5 m and a mean depth of 3 m (Figure 2). McKean (1992) estimated the average water retention times for Elk (4.4 years) and Beaver Lakes (0.25 years).

O' Donnel Creek and its tributaries drain the northern subdrainage and is the major inflow into Elk Lake. Also, there are 20 intermittent ditches and creeks which drain the north-eastern subdrainage basin. There are no inflows within the south-eastern drainage. Drainage from this area of the watershed is by diffuse surface runoff or ground water movement (Munteanu *et al.*, 1988). The Elk basin drains into the Beaver basin which drains into Colquitz Creek. This creek flows southerly and drains into Portage Inlet which empties into Juan De Fuca Strait.

The Ministry of Environment, Lands and Parks monitored the water quality at the deepest point (17.9 m) of the Elk/Beaver basin between 1986 and 1995. Also, the ministry monitored at two other sites in Elk Lake and one other site in Beaver Lake between 1993 and 1995. Data collected from these three sites are used to determine compliance with the water quality objectives established in 1992. The data are stored on the provincial data base, SEAM, under station numbers 1100844 (at the deepest point), E207468 and E207469 (Elk Lake water quality objective monitoring), and E207470 (Beaver Lake water quality objective monitoring) (Figure 1). The three purposes for monitoring the water quality of Elk and Beaver Lake are to identify:

- long-term changes in water quality as a consequence of development within the watershed;
- how these changes may impinge on certain uses of water from the lake; and
- attainment of water quality objectives.

The Capital Regional District's Health Protection and Environmental Division collects water samples for bacteriological analyses from Hamsterly and Eagle Beach on Elk Lake and from Beaver Beach on Beaver Lake (Figure 2). Weekly sampling begins in April each year and continues through the bathing season, ending in September. Fecal coliform results from five samples collected within a 30-day period are used to establish a geometric mean at the beginning of the season. A beach advisory notice, warning of the potential for increased risk to bathers' health, is considered for posting if the geometric mean exceeds 200 fecal coliforms/100 mL over a 30-day period. More intense sampling may occur if the results of a single sample exceeds 400 fecal coliforms/100 mL.

This report assesses 10 years of water quality data. These data consist of:

- three years (1993-1995) of water quality objectives sampling,
- ten years (1986-1995) of spring overturn water quality sampling,
- 13 years (1980-1995) of fecal coliform sampling, and
- one year (1988) of intensive water quality sampling.

The water quality data are plotted in Figures 3 to 17 and summarized in Tables 1 and 2.

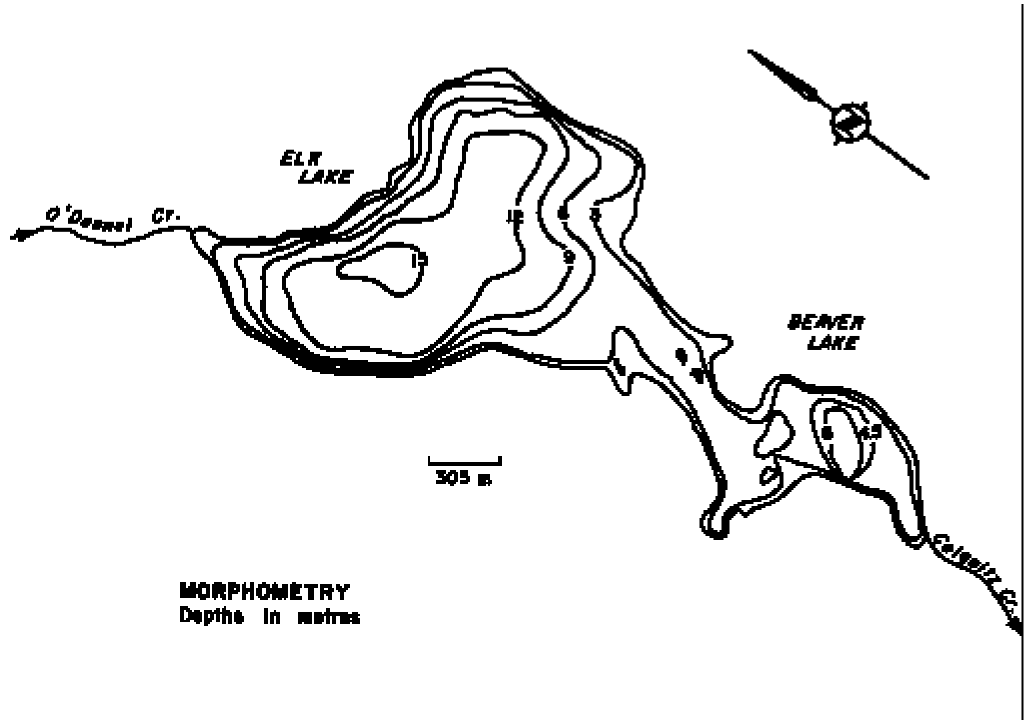
The box plots in Figures 3 to 17 represent the variability of water quality indicators collected at the surface, mid depth, and near the bottom of the lake. Each plot is comprised of a rectangle with the top portraying the upper quartile (75th percentile of the data series, Q(0.75)), the bottom portraying the lower portion (25th percentile of the data series, Q(0.25)), and a horizontal line within the rectangle portraying the median. Vertical lines extend from the ends of the rectangle to the adjacent values, also known as "whiskers", and are defined by:

- computing the interquartile range, IQR=Q(0.75)- Q(0.25);
- defining the upper adjacent value as the largest observed value between the upper quartile and the upper quartile plus 1.5 X IQR;
- defining the lower adjacent value as the smallest observed value between the lower quartile and the lower quartile minus 1.5 X IQR.

Values that fall outside the range of the adjacent values are defined as "outside values" and are plotted as asterisks (*). Values are defined as "far outside values" if they are located outside the outer range which is defined as the upper quartile plus 3 X IQR or the lower quartile minus 3 X IQR. These values are plotted as empty circles (O).

Trends in water quality data collected at different depths and at different frequencies over time are assessed by comparing yearly changes in median values in conjunction with the size of sample variability. The size of sample variability is represented in the box plots by the rectangle, whiskers, and the two types of outliers. A change is observed when the median values and sample variability do not overlap.

Figure 2 Bathymetric map of Elk and Beaver Lakes
(From Nordin, 1981)



Quality Assurance

The water quality plots were reviewed. No questionable values or values that were known to in error were collected from Beaver Lake or Elk Lake.

State of the Water Quality

The state of the water quality is assessed by comparing the values to any site-specific water quality objectives or to Ministry of Environment, Lands and Parks' Approved and Working Criteria for Water Quality (Nagpal *et al.*, 1995) if objectives have not been set. Any levels or trends in water quality that are deleterious to sensitive water uses, including drinking water, aquatic life and wildlife, recreation, irrigation, and livestock watering are noted.

Water Quality Objectives

McKean (1992) identified objectives for two water uses (primary contact water recreation, and aquatic life) for Elk and Beaver Lakes. Neither lake is presently being used for drinking water. The objectives are:

- Temperature shall not exceed a maximum of 15° C in the hypolimnion layer of the lake.
- Dissolved oxygen shall not be less than a summer minimum of 5 mg/L 1 m above the sediment in the lake.
- Chlorophyll a shall have a mean summer range of 1.5-2.5 g/L. The mean is determined from samples collected every four weeks from May to August at four depths (0, 2, 4, 6 m) in Elk Lake and at three depths (0, 2, 4 m) in Beaver Lake.
- Secchi depth, an indication of water clarity, must exceed 1.9 m.
- Phytoplankton community shall not be dominated by Cyanophytes. The number of Cyanophytes shall not exceed 50% of the cells/mL in discrete samples collected at the surface. These samples shall be collected every four weeks from May to August.

Elk Lake was sampled between May and September in 1993 and 1994 to check the attainment of these objectives. Beaver lake was sampled in May 1993, and in June 1994 and 1995.

Water temperature in the hypolimnion did not exceed the maximum temperature objective (15° C) at the deep station in Elk Lake. There were insufficient data from Beaver Lake to compare to this objective.

Dissolved oxygen values 1 m above the sediment of Elk and Beaver Lakes (Figures 3 and 4) did not meet the minimum objective of 5 mg/L.

Figure 3 Dissolved oxygen from Elk Lake

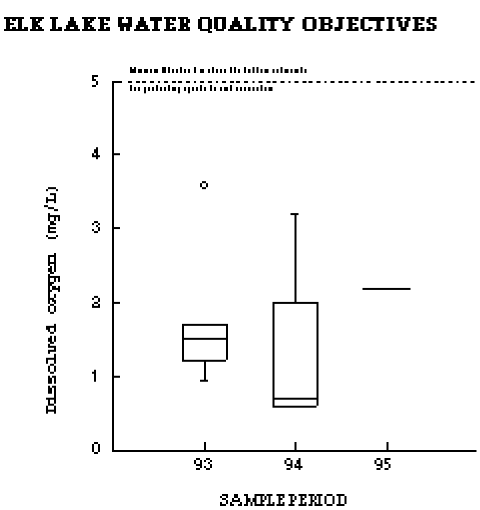
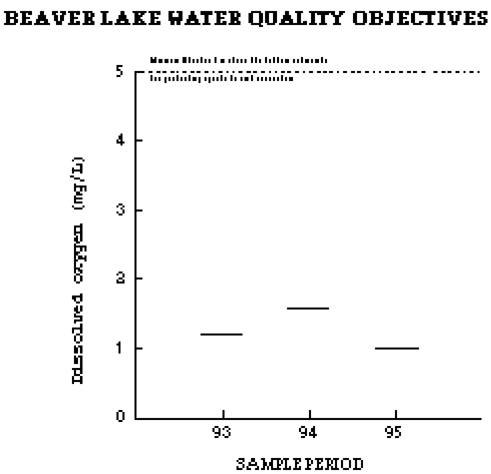


Figure 4 Dissolved oxygen from Beaver Lake



Chlorophyll a grand mean for duplicate samples collected at four depths from May to August exceeded the objective range in 1993 (3.73 µg/L) and in 1994 (2.88 µg/L) in Elk Lake. There were insufficient data from Beaver Lake to compare to the objective.

Secchi depth values met the objective in Elk and Beaver Lakes in 1993 and 1994.

Cyanophytes were the dominant species in the phytoplankton community samples collected at Elk and Beaver Lakes monthly between June and September, in 1994, and thus this objective was not met.

Spring Overturn

The water in Elk Lake is vertically mixed (no thermal stratification) between November and the end of April. A key time for sampling is late during this period of mixing. The objective of this monitoring is to assess water quality from year to year and to estimate the potential algal growth during the summer months in Elk Lake.

Total Phosphorus (Figure 5) values before thermal stratification, average of samples taken at different depths within the water column before stratification, were outside the limits (0.005-0.015 mg/L) for aquatic life in 1986-88, 1992, and 1995. All of these values exceeded the criterion for protecting recreational use (0.010 mg/L) between 1986 and 1995.

Total phosphorus values generally decreased over time (Figures 5 and 6), except when they increased in 1992. Dissolved phosphorus values (Figure 7) also increased in 1992. Changes in total phosphorus values in the water column may be attributed to several factors including:

- an increase in Ultra Violet light (UVb) penetration in the water column,
- an increase in phosphorus uptake by aquatic plants,

- an increase in phosphorus fixing by lake sediments,
- a reduction in phosphorus loadings to the lake, and
- an increase in the flushing rate of Elk and Beaver Lakes.

Nitrogen, Dissolved ammonia (Figure 8) values were below the criterion (30-day average 1.85 mg/L) to protect aquatic life from problems with toxicity. These values generally decreased over time, except in 1992. **Nitrate/nitrite** values (Figure 10) varied over time without a discernible trend. **Kjeldahl nitrogen** (Figure 9) and nitrite/nitrate concentrations are added together to represent total nitrogen in the lake. These concentrations are used to calculate the N:P ratio (Figure 12). The dissolved ammonia:nitrate ratio (Figure 11) decreased over time, while the N:P ratio (Figure 12) generally increased. The N:P ratios decreased in 1992. Phosphorus is the limiting nutrient for algal growth in Elk Lake (N:P > 15:1). The trends in the ratios indicate that there are changes occurring in the lake systems (e.g., land use, biological activity) which affect water quality.

Total residue (i.e., dissolved plus suspended solids) values, collected between 1993 and 1995, ranged from 104 mg/L to 250 mg/L. There are no criteria for total residues. The criterion for suspended solids could not be used because there were insufficient suspended solids (non filterable residues) data. **Specific conductivity (µS/cm)** can be used to indicate dissolved solid concentrations. These values were relatively constant (170-180 µS/cm) and were below all criteria for specific conductivity.

Total calcium (Figure 13) values show that the lake has a low sensitivity to acid inputs (the lake is well buffered against acidic inputs).

Fecal coliform values were collected between 1980 and 1995 at public bathing beach sites on Elk and Beaver Lakes (Table 3). These values range from less than 3 MPN/100 mL to 2400 MPN/100 mL. Fecal coliform values from these beach sites may not be similar to values collected elsewhere in the lakes. Resident waterfowl populations make these areas unique and may cause fecal coliform values to be higher than at other sites in the lakes. The Capital Regional District's Health Protection and Environmental Division has posted advisory notices at Elk Lake (Hamsterly Beach and Eagle Beach) and Beaver Lake (Beaver Beach) on several occasions between 1980 and 1995.

At this time, there are no active domestic water licenses on Elk Lake or Beaver Lake.

True colour: 89 % of the values from Elk Lake were less than the minimum detectable limit (5 colour units) for true colour. One value (20 colour units) exceeded the desirable criterion for recreation. No colour data for Beaver Lake were reported during this period.

Total iron (Figure 14) values did not exceed the maximum criterion (0.3 mg/L) for protecting aquatic life.

Total magnesium values were below all criteria for dissolved magnesium.

Total manganese (Figure 15) values met all criteria.

Dissolved silica: Seven values were collected between 1986 and 1995. All of these values were less than the minimum detectable limit (0.5 mg/L). These low values may be attributed to a highly active diatom population. Dissolved silica is the limiting nutrient (i.e., values were less than 0.5 mg/L) for diatom growth in Elk Lake (Wetzel, 1975).

Total zinc (Figure 16): 5 of 11 total zinc values exceeded the criterion for protecting phytoplankton (0.014 mg/L). These values occurred in 1992, 1994, and 1995. The variability in the analytical results for zinc values near the minimum detection limit of 0.01 mg/L, may have resulted in values exceeding the criterion for protecting phytoplankton. Analysis of samples from Elk Lake for zinc should use a minimum detectable limit 10 times lower than the lowest criterion (e.g., 0.001 mg/L). This would provide more accurate data for comparison to the criterion (0.014 mg/L) for protecting phytoplankton.

pH (Figure 17) values met all criteria. The values ranged between 7.4 and 7.9.

Conclusions - State of Water Quality

- Two water quality objectives (water temperature, water clarity) for Elk Lake and one water quality objective (water clarity) for Beaver Lake have been met since 1993.
- Three water quality objectives (dissolved oxygen, chlorophyll a, and Phytoplankton community) for Elk Lake and two water quality objectives (dissolved oxygen, Phytoplankton community) for Beaver Lake were not met.
- Spring overturn sampling indicates that the amount of nutrients (e.g., dissolved ammonia and total phosphorus) in the water column have generally decreased from 1986 to 1995. In 1992, there was a notable increase in nutrient values. These changes in nutrient values may be attributed to a change in the amount of nutrients entering the lake or to a change in lake processes.
- Total phosphorus values exceeded the criterion range for protecting aquatic life (0.005 mg/L to 0.015 mg/L) in 1986, 1988, and 1995. The criterion (0.01 mg/L) for recreational use was exceeded by all yearly averages.
- Phosphorus is the limiting nutrient for algal growth, and dissolved silica is the limiting nutrient for diatom growth in Elk Lake.
- The Capital Regional District's Health Protection and Environmental Division has posted beach advisory notices, warning of the potential for increased risk to bathers' health, at Elk Lake (Hamsterly Beach and Eagle Beach) and Beaver Lake (Beaver Beach) on several occasions between 1980 and 1995. These notices were posted when the geometric mean exceeded 200 fecal coliforms/100 mL over a 30-day period.
- Total zinc values exceeded the criterion for protecting phytoplankton populations (0.014 mg/L) in 1992, 1994 and 1995, probably due to uncertainty near the minimum detectable limit (0.01 mg/L).

Recommendations for Water Quality Management

Remediation

McKean (1992) recommended the following remediation measures to improve the water quality in Elk and Beaver Lakes:

- installing a hypolimnetic aerator, and

- regulating land use and activities (e.g., septic tanks, agricultural runoff) within the watershed.

Land use within the watershed and hydrological and limnological processes (e.g., nutrient loading from lake sediments, retention time, quantity and quality of water entering the lakes) should be considered in any strategy to improve the water quality of Elk and Beaver Lakes.

Monitoring

We recommend monitoring be continued at the station on Elk Lake (SEAM site 1100844) and at the station on Beaver Lake (SEAM site E207470) to determine whether water quality objectives are being met and to evaluate remediation activities. This monitoring program would require sampling of the following water quality indicators:

- water temperature and dissolved oxygen collected at 1 m intervals from the surface to the bottom. This sampling would occur in August of each year;
- duplicate chlorophyll a samples collected at 0 m, 2 m, 4 m, 6 m water depth. These samples should be collected every four weeks between May to August;
- phytoplankton samples collected at the surface. These samples should be collected every four weeks between May to August; and
- extinction depth (e.g., Secchi depth). These samples should be collected every four weeks between May to August at these stations and at recreational beaches.

This monitoring program could be implemented by an Elk/Beaver Lake stewardship group with assistance from the Ministry of Environment, Lands and Parks.

We recommend that sampling at the surface and at depth during spring overturn be continued at SEAM sites 1100844 and E207470. The focus of this monitoring will be to identify changes in water quality attributed to activities within the watershed such as urbanization, changes in non-point discharge, changes in biological activity in the lake. This monitoring program would the include the following water quality indicators:

- water temperature and dissolved oxygen profiles,
- total phosphorus, dissolved ammonia, nitrate/nitrite, kjeldahl nitrogen, total and dissolved organic carbon, true colour, turbidity, dissolved silica from 3 samples taken 1 m below the surface, at mid depth and 1 m above the bottom;
- chlorophyll a, taken near the surface; and
- extinction depth (i.e., Secchi depth) and UVb absorption.

This monitoring program could be implemented by an Elk/Beaver Lake stewardship group with assistance from the Ministry of Environment, Lands and Parks.

We recommend that bacteriological sampling continue at public beaches on Elk and Beaver Lakes. The monitoring program is currently being conducted by the Capital Regional District's Health Protection and Environmental Division. In future, local interest groups (e.g., Elk/Beaver Lake stewardship group, Municipality of Saanich) could assist with this ongoing monitoring.

Figure 5 Total phosphorus (average in the water column before stratification) from Elk Lake

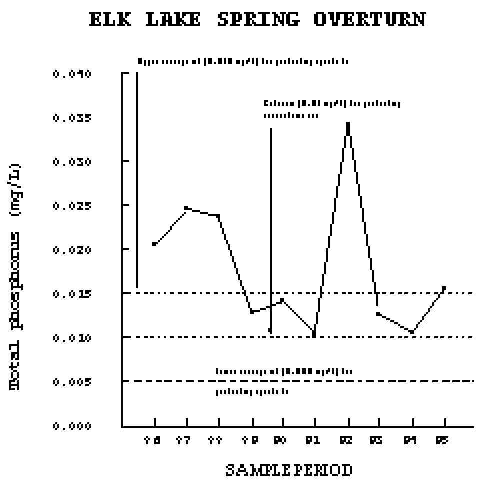


Figure 6 Total phosphorus from Elk Lake

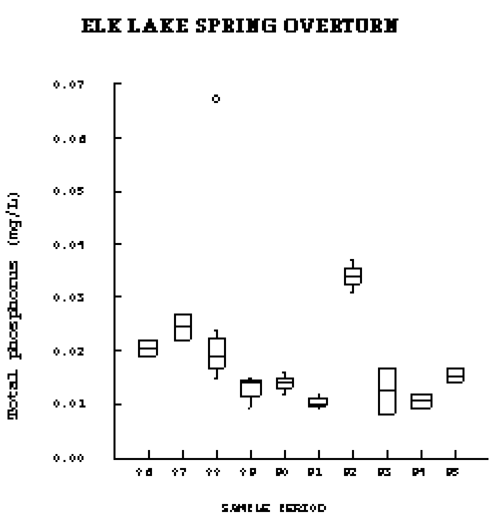


Figure 7 Total dissolved phosphorus from Elk Lake

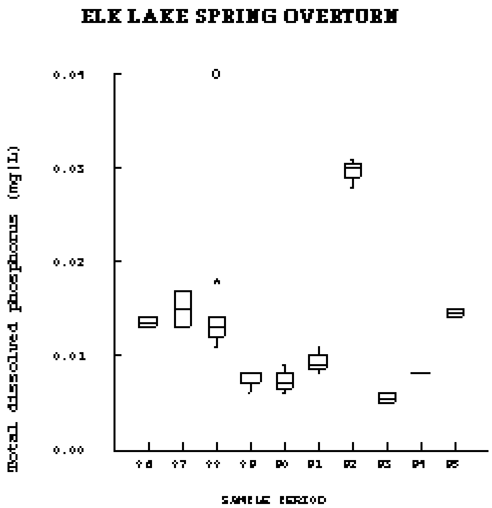


Figure 8 Dissolved ammonia from Elk Lake

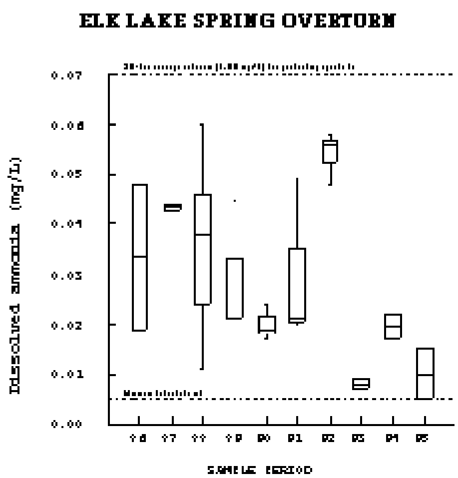


Figure 9 Kjeldahl nitrogen from Elk Lake

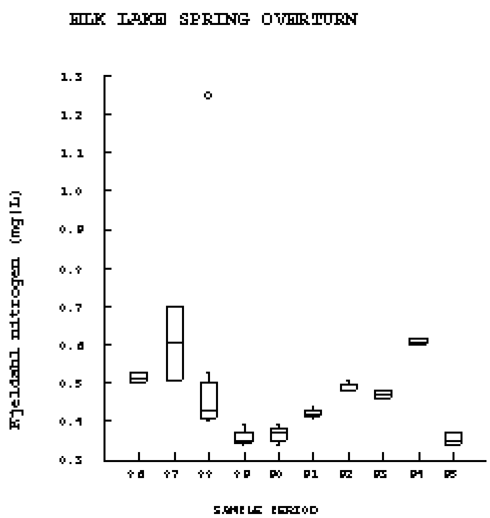


Figure 10 Nitrate/Nitrite from Elk Lake

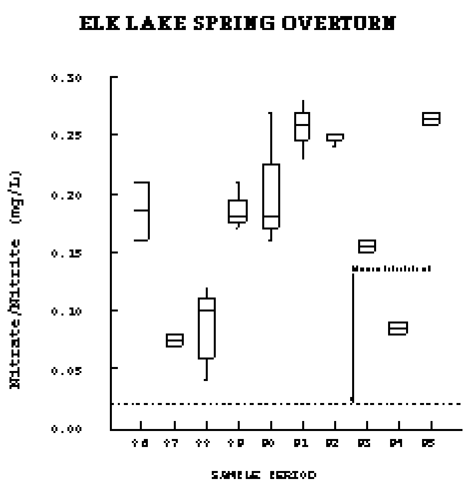


Figure 11 Ammonia:nitrate ratio from Elk Lake

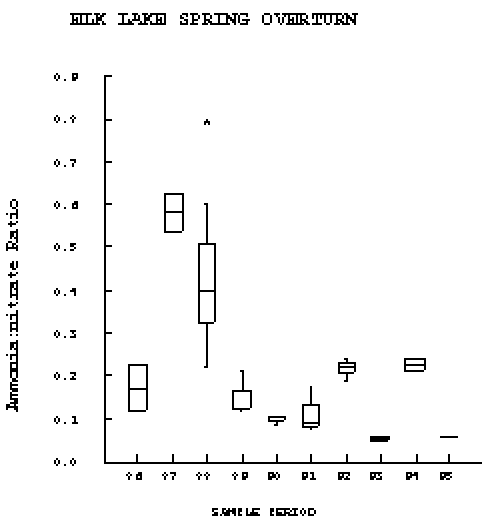


Figure 12 N:P ratio from Elk Lake

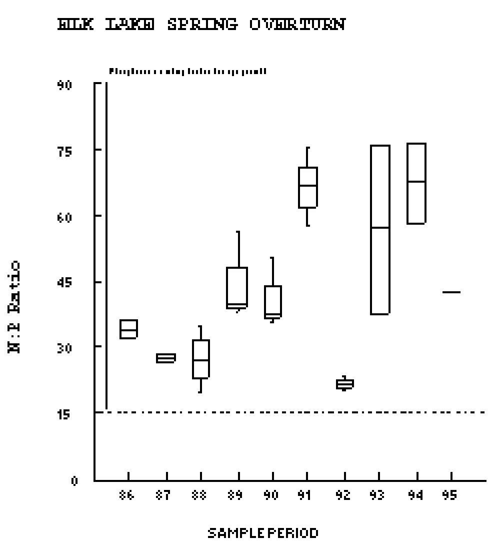


Figure 13 Total calcium from Elk Lake

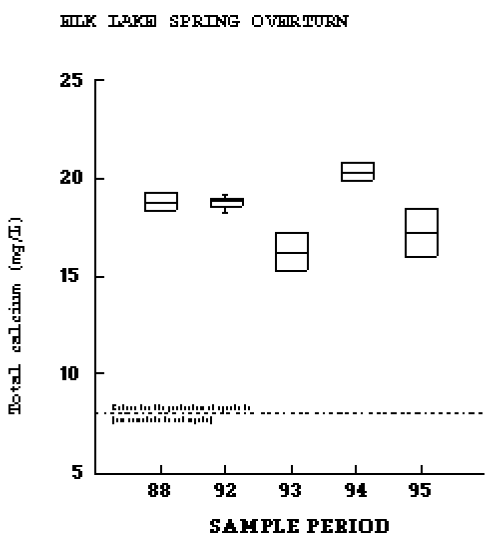


Figure 14 Total iron from Elk Lake

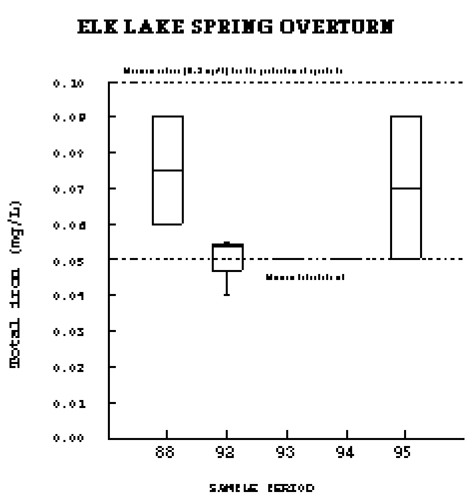


Figure 15 Total manganese from Elk Lake

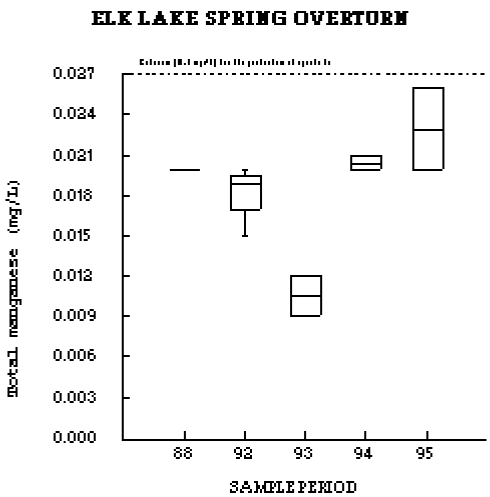


Figure 16 Total zinc from Elk Lake

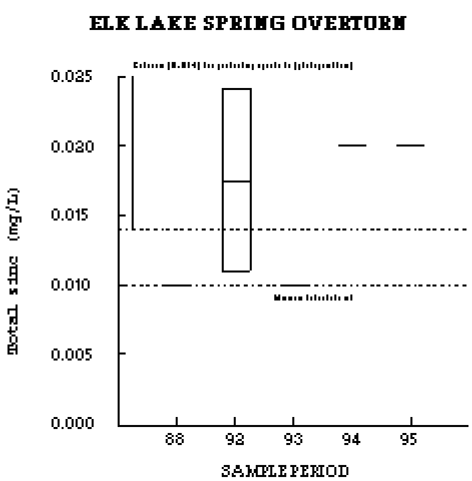


Figure 17 pH from Elk Lake

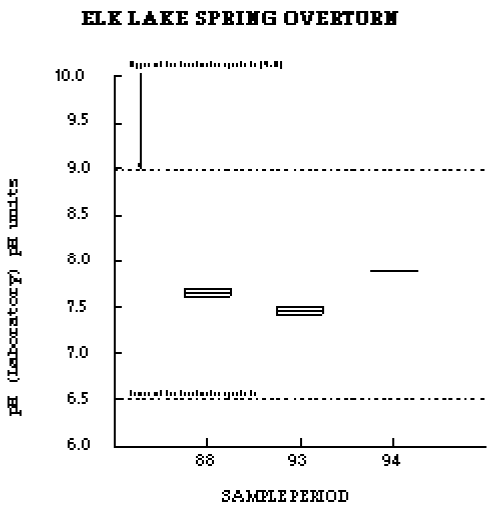


Table 1 Summary of water quality data from Elk Lake (SEAM site 1100844)

Water Quality Indicator	Average	Std Dev	Number of samples	Maximum	Minimum
OBJECTIVES MONITORING	.	.	.	.	.
Water temperature (°C)	16.6	5.35	94	24.2	6
Dissolved oxygen (mg/L)	7.40	3.74	94	17.8	0.59
Chlorophyll a (µg/L)	2	1.31	21	8	2
Secchi Disc depth (m)	3.32	1.84	62	7.8	0.5
Phytoplankton community % of Cyanophytes	62.3	24.5	9	87.5	15
SPRING OVERTURN MONITORING	.	.	.	.	.
Water Clarity and Colour	.	.	.	.	.
Colour, true (TCU)	6.7	5.00	9	20	L 5
Residues, non-filterable (mg/L)	L 4	0.00	2	L 4	L 4
Extinction depth (m)	5.92	0.625	11	7.47	5.18
General Ions	.	.	.	.	.
pH (pH units)	7.67	0.21	6	7.9	7.4
Residues, total (mg/L)	161.4	66.85	10	252	104
Specific conductivity (µS/cm)	174.5	4.27	11	180	169
Calcium, total (mg/L)	18.32	1.642	11	20.8	15.2
Chloride, dissolved (mg/L)	15.43	0.508	12	16.3	14.8
Magnesium, total (mg/L)	4.14	0.391	11	4.63	3.35
Silica, dissolved (mg/L)	L 0.5	0.00	7	L 0.5	L 0.5
Sulphate, dissolved (mg/L)	10.3	2.89	4	12.9	7.6
Temperature, water (° C)	6.68	3.582	165	15.5	0.75

Nutrients	.	.	.	.	.
Nitrogen, ammonia (mg/L)	0.03	0.017	29	0.06	L 0.005
Nitrogen, Kjeldahl (mg/L)	0.48	0.172	29	1.25	0.34
Nitrogen, organic (mg/L)	0.17	0.060	41	0.39	0.08
Nitrogen, Nitrate+Nitrite (mg/L)	0.16	0.076	31	0.28	0.04
Nitrogen, Nitrate (mg/L)	0.05	0.030	25	0.1	L 0.02
Nitrogen, Nitrite (mg/L)	0.23	0.073	41	0.46	0.09
Phosphorus, ortho (mg/L)	0.006	0.005	14	0.023	L 0.003
Phosphorus, total dissolved (mg/L)	0.014	0.008	31	0.04	0.005
Phosphorus, total (mg/L)	0.019	0.012	29	0.067	0.008
Metals	.	.	.	.	.
Alumina, total (mg/L)	.	.	9	L 0.06	0.04
Antimony, total (mg/L)	.	.	9	L 0.02	L 0.015
Arsenic, total (mg/L)	.	.	9	L 0.04	L 0.04
Boron, total (mg/L)	.	.	9	0.062	0.04
Barium, total (mg/L)	0.008	0.001	9	0.009	0.006
Beryllium, total (mg/L)	.	.	9	L 0.001	L 0.001
Bismuth, total (mg/L)	.	.	9	L 0.02	L 0.02
Cadmium, total (mg/L)	.	.	11	L 0.01	L 0.002
Cobalt, total (mg/L)	.	.	11	L 0.10	L 0.003
Chromium, total (mg/L)	.	.	11	L 0.01	L 0.002
Copper, total (mg/L)	.	.	11	L 0.01	L 0.001
Iron, total (mg/L)	.	.	11	0.09	0.04
Lead, total (mg/L)	.	.	11	L 0.1	L 0.02
Manganese, total (mg/L)	0.02	0.005	11	0.026	0.009
Molybdenum, total (mg/L)	.	.	11	L 0.01	0.004
Nickel, total (mg/L)	.	.	11	L 0.05	L 0.008
Selenium, total (mg/L)	.	.	9	L 0.03	L 0.03
Sodium, dissolved (mg/L)	9.39	0.26	8	9.8	9.1
Silicon, total (mg/L)	0.78	0.054	9	0.86	0.68
Silver, total (mg/L)	.	.	9	L 0.03	L 0.01
Strontium, total (mg/L)	.	.	9	L 0.02	L 0.02
Tin, total (mg/L)	.	.	9	L 0.02	L 0.02
Zinc, total (mg/L)	0.014	0.0068	11	0.024	0.002

Note: L = less than

Table 2 Summary of water quality data from Beaver Lake (SEAM site E207470)

Water Quality Indicator	Average	Std Dev.	Number of samples	Maximum	Minimum
OBJECTIVE MONITORING	.	.	.	.	.
Water temperature (°C)	17.9	3.46	19	24.2	13
Dissolved oxygen (mg/L)	9.8	6.13	19	20	1
Chlorophyll a (µg/L)	7.5	1.73	9	10.4	5.3
Secchi Disc depth (m)	4.7	1.02	3	5.8	3.8
Phosphorus total (mg/L)	0.02	0.004	4	0.028	0.019
Phytoplanton community % of Cyanophytes	87.5	6.47	9	97.2	76.5

Table 3 Summary of Capital Regional District Health Protection and Environmental Division's Bacteriological data (fecal coliforms/100 mL) from Elk and Beaver Lakes

Year	Elk Lake at Hamsterly 1	Elk Lake at Hamsterly 2	Elk Lake at Eagle Beach	Beaver Lake 1980-1990	Beaver Lake North	Beaver Lake West
1980	.	.	.	.	.	.
Max.	22	16	15	34	.	.
Min.	4	5	5	.	.	.
Geo. Mean	9.8	6.9	10.5	.	.	.

Number	Number=8	Number=7	Number=8	Number=1	.	.
1981	.	.	.	.	.	.
Max.	4	7	27	23	.	.
Min.	3	4	6	8	.	.
Geo. Mean	3.7	5.6	15.6	13.5	.	.
Number	Number=4	Number=4	Number=4	Number=4	.	.
1982	.	.	.	.	.	.
Max.	93	23	460	93	.	.
Min.	< 3	< 3	< 3	< 3	.	.
Geo. Mean	8.9	8.5	14.5	11.4	.	.
Number	Number=24	Number=24	Number=24	Number=24	.	.
1983	.	.	.	.	.	.
Max.	25	9	69	71	.	.
Min.	5	3	4	12	.	.
Geo. Mean	7.3	5.7	10.8	26.4	.	.
Number	Number=10	Number=10	Number=10	Number=10	.	.
1984	.	.	.	.	.	.
Max.	13	8	29	35	.	.
Min.	4	3	12	13	.	.
Geo. Mean	7.8	6.0	20.9	16.9	.	.
Number	Number=11	Number=10	Number=10	Number=10	.	.
1985	.	.	.	.	.	.
Max.	31	9	49	14	.	.
Min.	8	5	10	5	.	.
Geo. Mean	16.2	6.2	22.8	9.7	.	.
Number	Number=14	Number=14	Number=14	Number=14	.	.
1986	.	.	.	.	.	.
Max.	460	93	23	43	.	.
Min.	3	3	3	3	.	.
Geo. Mean	45.1	9.3	5.1	10.0	.	.
Number	Number=10	Number=10	Number=10	Number=10	.	.
1988	.	.	.	.	.	.
Max.	1100	2400	460	2400	.	.
Min.	3	3	3	3	.	.
Geo. Mean	19.4	43.2	21.4	26.4	.	.
Number	Number=19	Number=19	Number=18	Number=18	.	.
1990	.	.	.	.	.	.
Max.	85	.	.	128	.	.
Min.	13	.	.	7	.	.
Geo. Mean	31.7	.	.	25.8	.	.
Number	Number=5	.	.	Number=5	.	.
1991	.	.	.	.	.	.
Max.	179	34	.	.	126	17
Min.	3	14	.	.	8	6
Geo. Mean	19.3	26.0	.	.	23.3	12.1
Number	Number=12	Number=12	.	.	Number=12	Number=12
1992	.	.	.	.	.	.

Max.	20	34	.	.	174	26
Min.	4	7	.	.	4	1
Geo. Mean	10.5	14.4	.	.	45.7	1.7
Number	Number=13	Number=13	.	.	Number=13	Number=11
1993	.	.	.	.	.	.
Max.	137	51	.	.	971	.
Min.	5	1	.	.	8	.
Geo. Mean	15.7	13.5	.	.	84.2	.
Number	Number=12	Number=12	.	.	Number=12	.
1994	.	.	.	.	.	.
Max.	60	60	.	.	730	.
Min.	4	6	.	.	5	.
Geo. Mean	10.1	14.7	.	.	30.9	.
Number	Number=13	Number=13	.	.	Number=13	.
1995 *	.	.	.	.	.	.
Max.	19	49	.	.	135	.
Min.	4	14	.	.	9	.
Geo. Mean	5.8	20.7	.	.	31.9	.
Number	Number=10	Number=10	.	.	Number=10	.

* Samples collected to August 31, 1995

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