



Water Quality

State of Water Quality of Prospect Lake 1980-1995

Canada - British Columbia Water Quality Monitoring Agreement

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

April, 1996

Executive Summary

Prospect Lake is located on southern Vancouver Island near Victoria, B.C. ([Figure 1](#)). The watershed for this small lake is 23 km². The surface area of Prospect Lake is 7.2 ha.

This report assesses 16 years of water quality data and makes the following conclusions:

- Spring overturn sampling indicates that in recent years there were less nutrients (e.g., total phosphorus, dissolved ammonia) in the water column. 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 1984. The criterion (0.01 mg/L) for recreational use and drinking water was exceeded in eight of eleven years between 1980 and 1995.
- Phosphorus is the limiting nutrient for algal growth in Prospect Lake.
- The Capital Regional District's Health Protection and Environmental Division has posted advisory notices at Prospect Lake (North Lakeside Park Beach) on several occasions between 1980 and 1995, warning of the potential for increased risk to bathers' health. These notices were posted when the geometric mean exceeded 200 fecal coliforms/100 mL over a 30-day period.
- There were insufficient fecal coliform data to assess the suitability of the lake water as a drinking source.
- True colour values exceeded the criteria for drinking water (aesthetics) and for recreation (15 colour units) in 1992 and 1995.
- Total organic carbon values exceeded the drinking water criteria (4 mg/L) in 1980. Prospect Lake water has the potential to form trihalomethanes in excess of the 0.1 mg/L criterion when chlorinated.
- Total aluminum values exceeded the 30-day average criterion for protecting aquatic life (0.05 mg/L) in 1992.
- Total copper values exceeded the criterion for protecting aquatic life (0.002 mg/L) in 1992.

We recommend monitoring:

**Ministry of Environment
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- to determine whether water quality objectives need to be established for aluminum, true colour, or copper in Prospect Lake.
- 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 nonpoint discharge.

Both monitoring programs could be implemented by a Prospect Lake stewardship group with assistance from the Ministry of Environment, Lands and Parks.

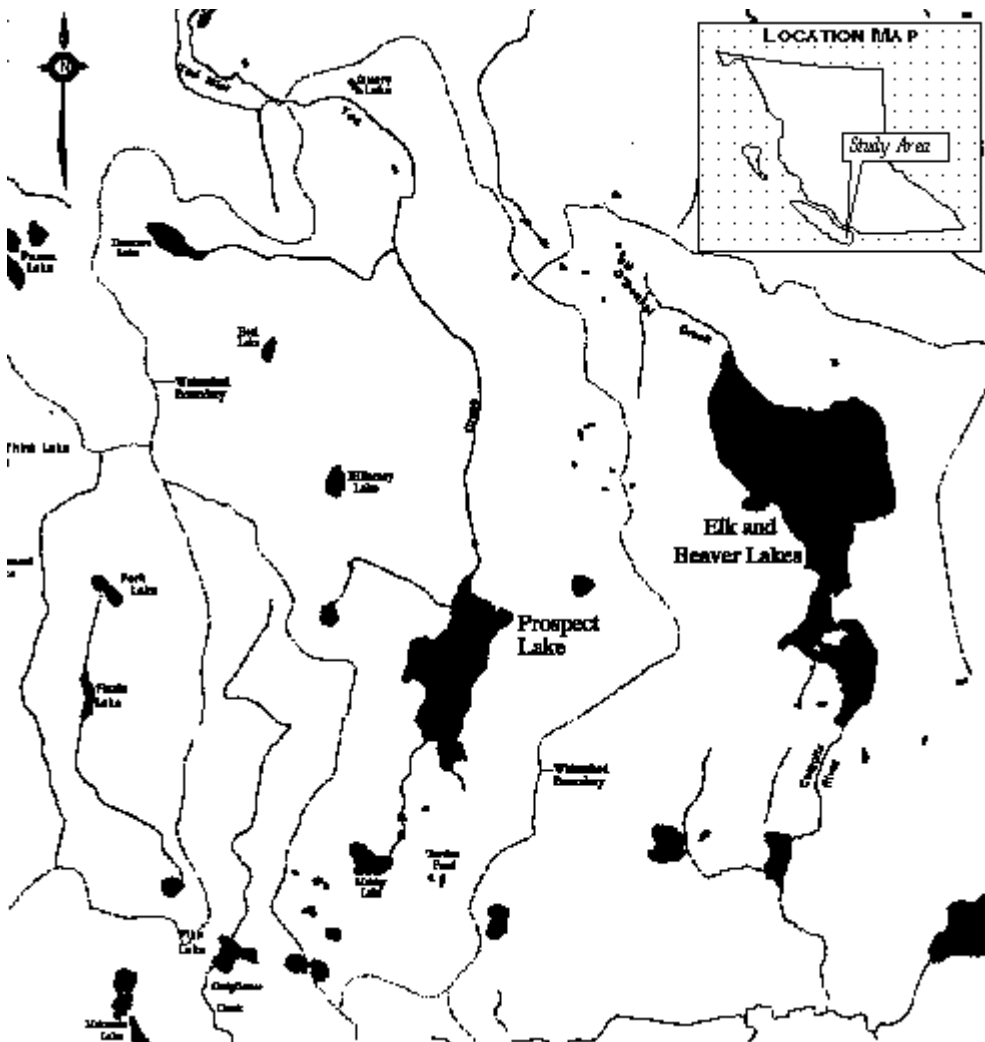
- to determine whether public beaches are suitable for bathing.

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

- to determine whether drinking water from the lake meets the fecal coliform criterion.

The monitoring program should be implemented by the Capital Regional District's Health Protection and Environmental Division or by a Prospect Lake stewardship group.

Figure 1 Prospect Lake Watershed
Scale 1:50,000



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Introduction

Prospect Lake is located on southern Vancouver Island near Victoria, B.C. (Figure 1). The watershed for this small lake is 23 km². The surface area of the Prospect Lake is 7.2 ha with a maximum depth of 13.5 m and a mean depth of 6.9 m (Coombes and Grant, 1981).

Miller (1980) identified a main tributary (Maltby Creek) and two smaller tributaries (Killarney Lake Creek, an unnamed Creek) as the inflows to Prospect Lake. These tributaries drain the southeast and southwest portions of the watershed. Tod Creek flows north out of Prospect Lake and drains into Tod Inlet which empties into Saanich Inlet and the Strait of Georgia.

The Ministry of Environment, Lands and Parks monitored the water quality at the deepest point (13.5 m) of the lake between 1980 and 1995. The data are stored on the provincial data base, SEAM, under station number 1102002 (Figure 2). The two purposes for monitoring the water quality of Prospect Lake are to identify:

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

The Capital Regional District's Health Protection and Environmental Division collected fecal coliform samples from a bathing beach (North Lakeside Park) on Prospect 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 16 years of water quality data. These data consist of 16 years (1980-1995) of spring overturn water quality sampling, and 12 years (1983-1995) of fecal coliform sampling. The water quality data are plotted in Figures 3 to 18 and summarized in Tables 1 and 2.

The box plots used in Figures 3 to 18 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.

Quality Assurance

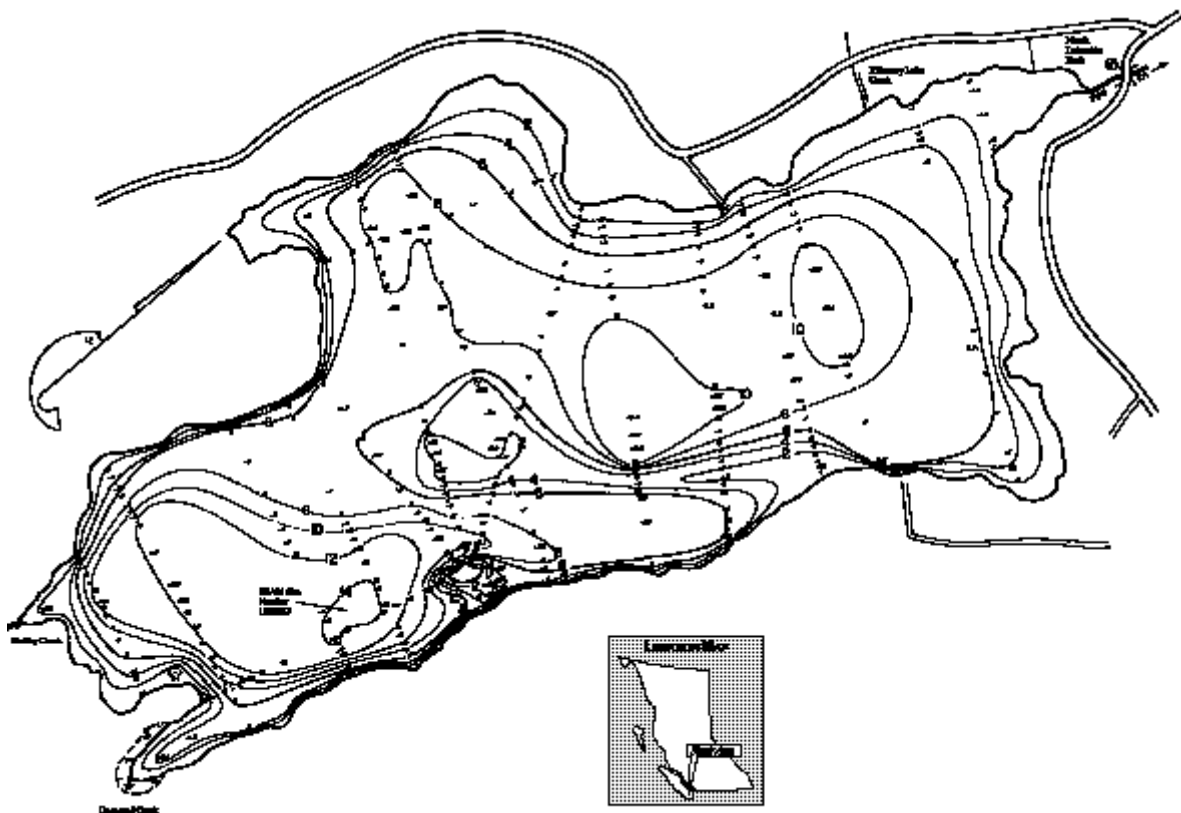
The water quality plots were reviewed. No questionable values or values that were known to be in error were collected from Prospect Lake.

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 from Prospect Lake is used for irrigation, water-based recreation, and to sustain aquatic life and wildlife. There are 10 domestic water licences that may be used as a drinking water source.

Figure 2 Bathymetric map of Prospect Lake
Scale 1:2800



Spring Overturn

The water in Prospect Lake is vertically mixed (no thermal stratification) between November and the end of April. A key time for sampling is in the spring 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 Prospect Lake.

Total phosphorus (Figure 3) values before thermal stratification, average of samples taken at different depths within the water column, were outside the limits (0.005-0.015 mg/L) for protecting aquatic life in 1984. Eight of the eleven total phosphorus values, collected between 1980 and 1995, exceeded the criterion for protecting recreational use and drinking water (0.010 mg/L). These criteria were not exceeded after 1993.

Generally, total phosphorus (Figures 3 and 4) and total dissolved phosphorus values (Figure 5) decreased over time; except for an increase in 1992 and 1993. This decrease may be attributed to:

- 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 loading to the lake, and
- an increase in the flushing rate of Prospect Lake.

Nitrogen, Dissolved ammonia (Figure 6) values were below the criterion (30-day average 1.69 mg/L) to protect aquatic life from toxicity. These values decreased after 1990. **Nitrate/nitrite** values (Figure 8) ranged from the minimum detectable limit (0.02 mg/L) to 0.23 mg/L and were below the drinking water criterion (10 mg/L). **Kjeldahl nitrogen** (Figure 7) 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 10). This ratio indicates (N:P > 15) that phosphorus is the limiting factor for algal growth. The dissolved ammonia:nitrate ratio (Figure 9) is relatively constant after 1989, while the N:P ratio (Figure 10) increased overtime. The trends in the ratios indicate that there are changes occurring in the lake systems (e.g., land use, flushing rate, biological activity) which affect water quality.

Total calcium (Figure 11) values show that the lake has a low sensitivity to acid inputs (the lake is well buffered).

Fecal coliform values, collected between 1983 and 1995, ranged between less than 1 MPN/100 mL to 4000 MPN/100 mL at North Lakeside Park Beach (Table 2). Fecal coliform values from this beach site may not be similar to values collected elsewhere in the lake. 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 Prospect Lake (North Lakeside Park Beach) on several occasions between 1980 and 1995 (Table 2).

There are 10 active domestic water licenses on Prospect Lake. The Ministry of Health recommends that all surface waters in the province must undergo some form of treatment (e.g., disinfection, filtration) before being used as a drinking source. Raw water fecal coliform values must not exceed the 90th percentile criterion for partially treated drinking water of 100 /100 mL, and 10 /100 mL for disinfected drinking water. Fecal coliform monitoring was not done near water intakes nor at a sufficient frequency to permit comparison to drinking water criteria.

Total organic carbon: Six total organic carbon values were reported in 1980. All values exceeded the drinking water criterion (4 mg/L). The water has the potential to form trihalomethanes in excess of the 0.1 mg/L criterion when chlorinated.

True colour: 23% of the total colour values from Prospect Lake (Figure 12) exceeded the aesthetic criterion (15 colour units) for drinking water and recreation. These values increased between 1993 and 1995.

Total aluminum (Figure 13) Maximum total aluminum values (0.11 mg/L) exceeded the 30-day average criterion (0.05 mg/L) for protecting aquatic life in 1992. Total aluminum values between 1993 and 1995 were at the minimum detectable limit of 0.06 mg/L. Analysis of samples from Prospect Lake for aluminum should use a minimum detectable limit 10 times lower than the lowest criterion (e.g., 0.005

mg/L). This would provide more accurate data for comparison to the 30-day average criterion (0.05 mg/L) for protecting aquatic life.

Total copper (Figure 14): 14% of the total copper values exceeded the 30-day average criterion (0.002 mg/L) in water with hardness less than or equal to 50 mg/L of CaCO₃. These values were constant (0.002 mg/L) between from 1993 to 1995. Analysis of samples from Prospect Lake for copper should use a minimum detectable limit 10 times lower than the lowest criterion (e.g., 0.0002 mg/L). This would provide more accurate data for comparison to the 30-day average criterion (0.002 mg/L) for protecting aquatic life in water with hardness less than or equal to 50 mg/L of CaCO₃.

Dissolved silica (Figure 15) Four sets of dissolved silica values (1980, 1992, 1993, and 1995) were collected between 1980 and 1995. These values indicate that dissolved silica is not a limiting factor (i.e., values were greater than 0.5 mg/L) for diatom growth in Prospect Lake (Wetzel, 1975). The decrease in dissolved silica values in 1992 may be attributed to an increase in diatom activity in the lake.

Total residue (i.e., dissolved plus suspended solids) values ranged from 66 mg/L to 134 mg/L (Figure 16). There are no criteria for total residues. The criterion for suspended solids could not be used because there were insufficient suspended solids data. **Specific conductivity (µS/cm)** can be used to indicate dissolved solid concentrations. These values (Figure 17) increased, from 93 µS/cm to 110 µS/cm, between 1992 and 1995 and were below all criteria for specific conductivity.

Turbidity values were collected in 1980 and in 1995. These values ranged between 0.5 NTU and 1.7 NTU. Turbidity values exceeded the maximum criterion (1 NTU) for drinking water in 1980. However, all turbidity values met this criterion in 1995.

pH (Figure 18) values ranged between 6.8 and 7.7 and met all criteria.

Conclusions - State of Water Quality

- Spring overturn sampling indicates that in recent years there were less nutrients (e.g., total phosphorus, dissolved ammonia) in the water column. 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 1984. The criterion (0.01 mg/L) for recreational use and drinking water was exceeded in eight of eleven years between 1980 and 1995.
- Phosphorus is the limiting nutrient for algal growth in Prospect Lake.
- The Capital Regional District's Health Protection and Environmental Division has posted advisory notices at Prospect Lake (North Lakeside Park Beach) on several occasions between 1980 and 1995, warning of the potential for increased risk to bathers' health. These notices were posted when the geometric mean exceeds 200 fecal coliforms/100 mL over a 30-day period.
- There were insufficient fecal coliform data to assess the suitability of the lake water as a drinking source.
- True colour values exceeded the criteria for drinking water (aesthetics) and for recreation (15 colour units) in 1992 and 1995.

- Total organic carbon values exceeded the drinking water criteria (4 mg/L) in 1980. Prospect Lake water has the potential to form trihalomethanes in excess of the 0.1 mg/L criterion when chlorinated.
 - Total aluminum values exceeded the 30-day average criterion for protecting aquatic life (0.05 mg/L) in 1992. Analysis of samples from Prospect Lake should use a minimum detectable limit of 0.005 mg/L to determine whether total aluminum values are exceeding this criterion.
 - Total copper values exceeded the criterion for protecting aquatic life (0.002 mg/L) in 1992. Analysis of samples from Prospect Lake for copper should use a minimum detectable of 0.0002 mg/L to be compared to the 30-day average criterion (0.002 mg/L) for protecting aquatic life in water with hardness less than or equal to 50 mg/L of CaCO₃.
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Recommendations for Water Quality Management

Remediation

We do not recommend any remediation activities at this time. However, proposals (e.g., retention ponds, changes to the weir on Tod Creek) to regulate water discharging through the Prospect Lake-Tod Creek watershed must include an assessment of the effects of these activities on water quality in the watershed. This assessment should identify changes in the limnological or hydrological processes (e.g., nutrient loading from lake sediments, retention time, quantity and quality of water entering the lakes) of Prospect Lake.

Monitoring

We recommend that minimum detectable limits for analytical procedures used to measure total aluminum and total copper in Prospect Lake water must be at least 10 times lower than the criterion level. Monitoring for these water quality indicators should be done in conjunction with the spring overturn and mid-summer sampling program.

We recommend that sampling at the surface and at depth during spring overturn and mid-summer be continued at SEAM site 1102002. The focus of this monitoring will be to identify changes in water quality attributed to activities within the watershed such as urbanization, changes in nonpoint discharge, changes in biological activity in the lake. This monitoring program would 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.

The monitoring program could be implemented by a Prospect Lake stewardship group with assistance from the Ministry of Environment, Lands and Parks.

We recommend that bacteriological sampling continue at the public beach on Prospect Lake (North Lakeside Park Beach). 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., Prospect Lake stewardship group, Municipality of Saanich) could assist with this ongoing monitoring.

We recommend that bacteriological sampling be started at the intakes of all domestic licences used for drinking water on Prospect Lake. The monitoring program would require that 5 samples be collected in 30 days at the intakes of these domestic licences. The fecal coliform values from these samples would be compared to criteria for drinking water. The monitoring program could be implemented by the Capital Regional District's Health Protection and Environmental Division, or by a Prospect Lake stewardship group.

Figure 3 Total phosphorus (average in the water column before stratification) from Prospect Lake

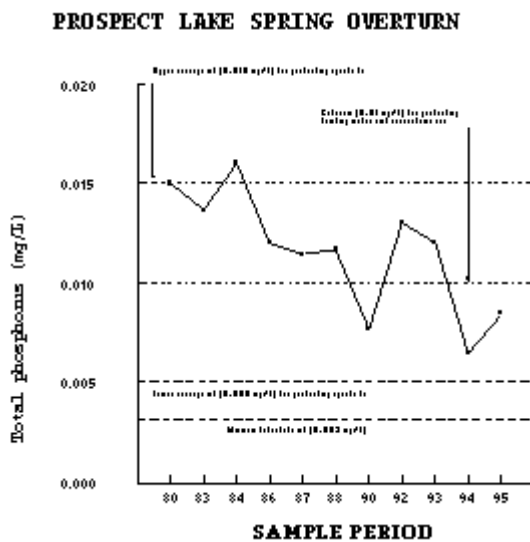


Figure 4 Total phosphorus from Prospect Lake

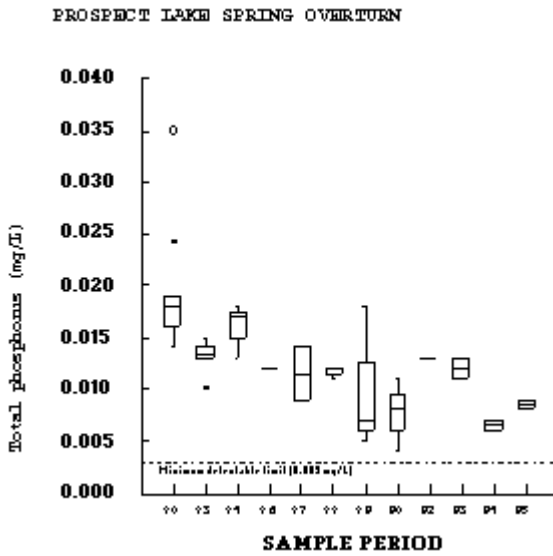


Figure 5 Total dissolved phosphorus from Prospect Lake

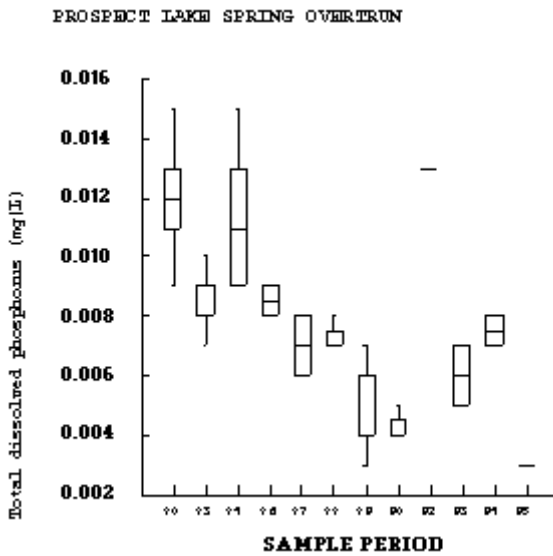


Figure 6 Dissolved ammonia from Prospect Lake

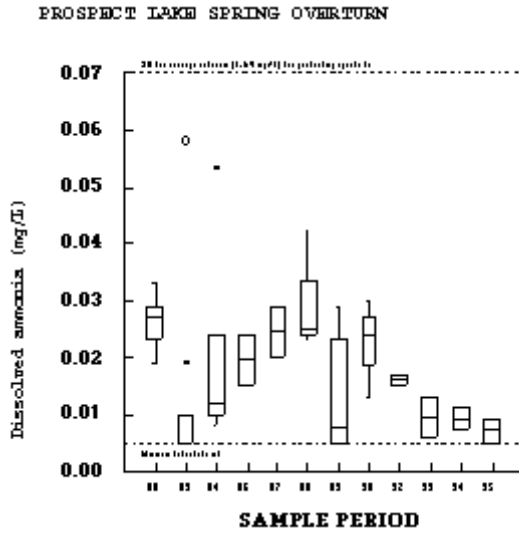


Figure 7 Kjeldahl nitrogen from Prospect Lake

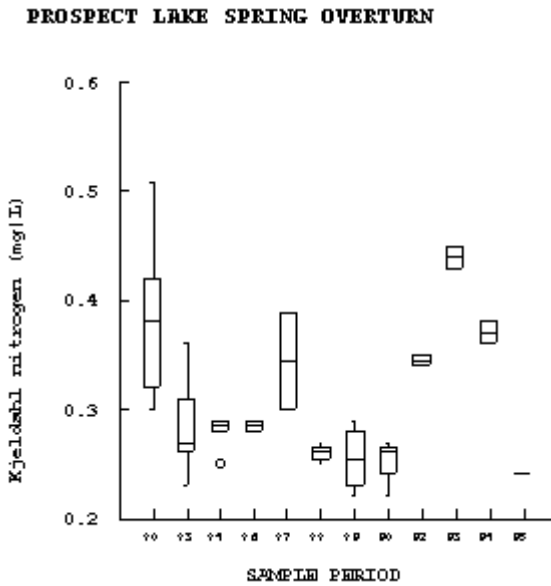


Figure 8 Nitrate/Nitrite from Prospect Lake

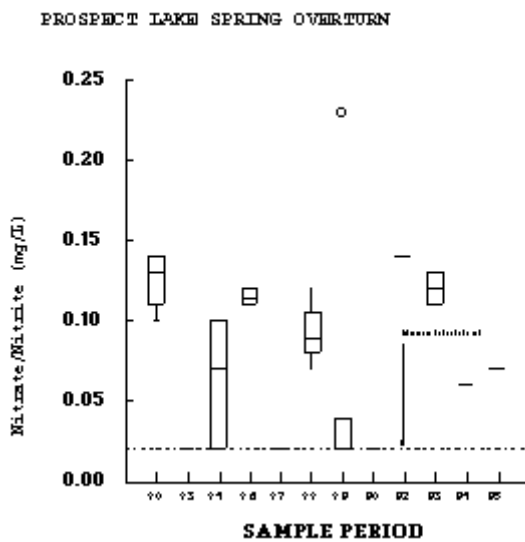


Figure 9 Ammonia:nitrate ratio from Prospect Lake

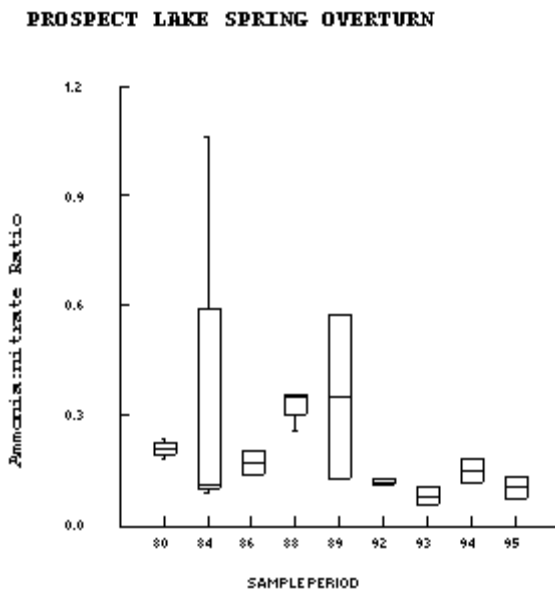


Figure 10 N:P ratio from Prospect Lake

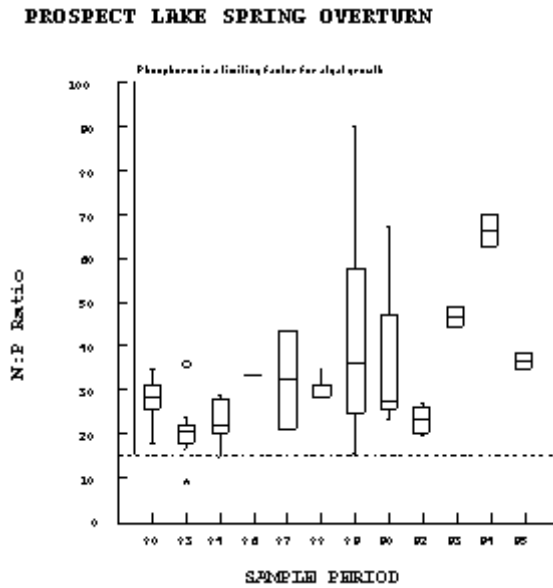


Figure 11 Total calcium from Prospect Lake

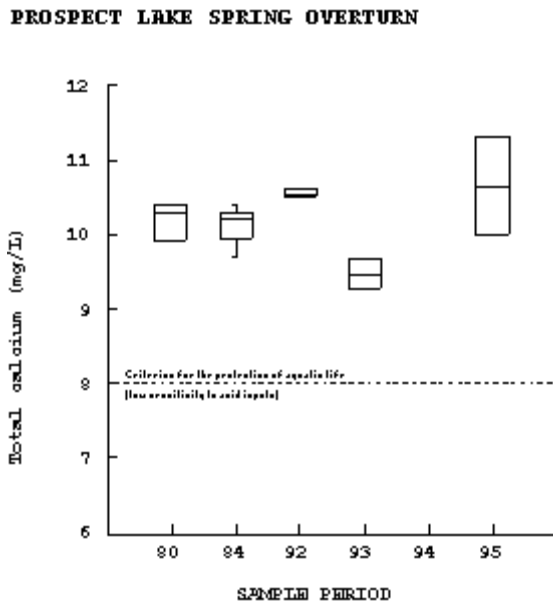


Figure 12 True colour from Prospect Lake

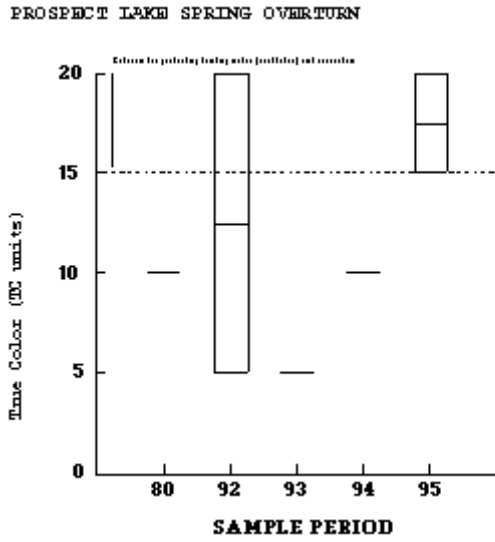


Figure 13 Total aluminum from Prospect Lake

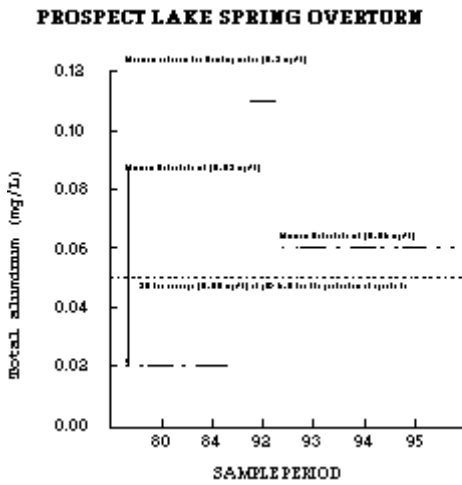


Figure 14 Total copper from Prospect Lake

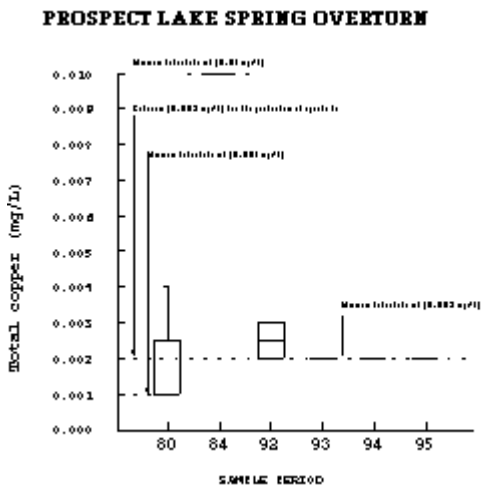


Figure 15 Dissolved silica from Prospect Lake

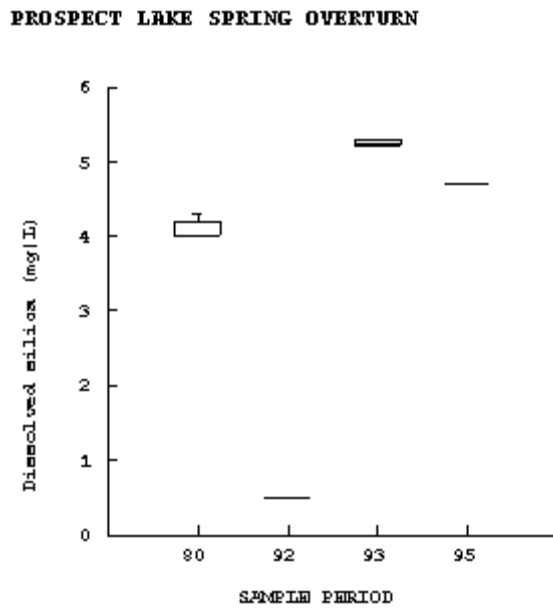


Figure 16 Total residues from Prospect Lake

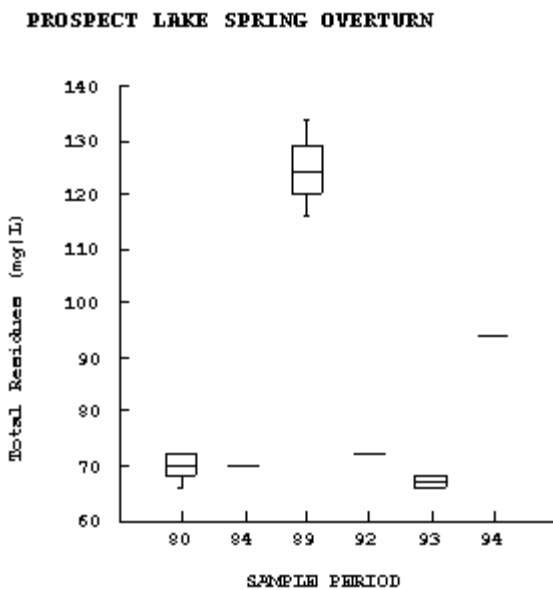


Figure 17 Specific conductivity from Prospect Lake

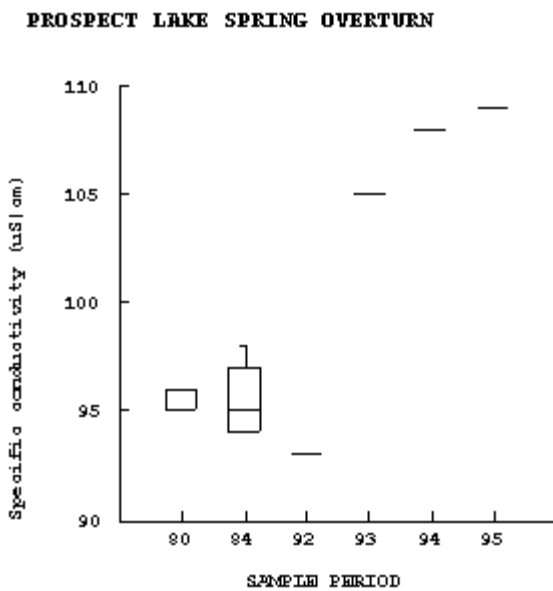


Figure 18 pH from Prospect Lake

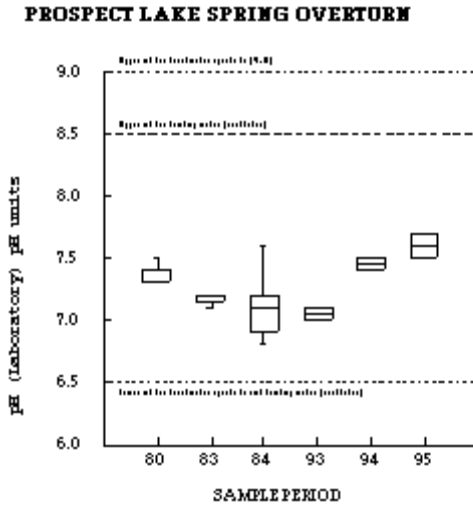


Table 1 Summary of water quality data from Prospect Lake (SEAM site 1102002)

Water Quality Indicator	Average	Std Dev	Number of samples	Maximum	Minimum
SPRING OVERTURN MONITORING					
Water Clarity and Colour					
Color, true (TCU)	11.2	5.83	13	20	5
Color, total absorbance (TAC)	17.5	0.71	10	19	17
Residues, non filterable (mg/L)	2.8	1.08	11	5	2
Extinction depth (m)	3.78	0.981	4	5	2.60
Turbidity (NTU)	1.19	0.425	11	1.7	0.5
General Ions					
pH (pH units)	7.28	0.223	24	7.7	6.8
Residues, filterable (mg/L)	67.1	2.17	8	70	64
Residues, total (mg/L)	80.6	20.64	20	134	66
Specific conductivity (μ S/cm)	97.9	5.62	25	109	93
Calcium, total (mg/L)	10.0	0.800	20	12	9.3
Chloride, dissolved (mg/L)	8.14	0.825	17	9.7	7
Magnesium, total (mg/L)	2.57	0.200	20	2.94	2.21
Silica, dissolved (mg/L)	3.8	1.42	15	5.3	0.5
Sulphate, dissolved (mg/L)	L 0.5	0.00	5	L 0.5	L 0.5
Temperature, water ($^{\circ}$ C)	10.44	1.828	5	11.5	7.2
Nutrients					
Carbon, total organic (mg/L)	6.17	0.98	6	7	5
Carbon, total inorganic (mg/L)	5.67	1.03	6	7	5
Nitrogen, total (mg/L)	0.40	0.12	28	0.64	0.23
Nitrogen, ammonia (mg/L)	0.018	0.0122	50	0.058	L 0.005

Nitrogen, Kjeldahl (mg/L)	0.31	0.118	50	0.51	0.22
Nitrogen, organic (mg/L)	0.31	0.068	27	0.48	0.17
Nitrogen, Nitrate+Nitrite (mg/L)	0.07	0.054	50	0.23	L 0.02
Nitrogen, Nitrate (mg/L)	0.14	0.005	6	0.14	0.13
Nitrogen, Nitrite (mg/L)	L 0.005	0.000	8	0.005	L 0.005
Phosphorus, total (mg/L)	0.02	0.009	54	0.04	0.004
Phosphorus, ortho (mg/L)	0.003	0.0012	34	0.009	L 0.003
Phosphorus, total dissolved (mg/L)	0.008	0.0032	48	0.015	L 0.003
Oxygen, dissolved (mg/L)	10.6	0.55	6	11	10
Tannin and Lignin (mg/L)	0.70	0.000	3	0.7	0.7
Metals
Aluminum, total (mg/L)	0.11	0	14	0.11	L 0.02
Antimony, total (mg/L)	.	.	9	L 0.02	L 0.015
Arsenic, total (mg/L)	.	.	11	L 0.25	L 0.04
Boron, total (mg/L)	.	.	9	L 0.04	0.008
Barium, total (mg/L)	0.004	0.001	8	0.005	0.003
Beryllium, total (mg/L)	.	.	9	L 0.002	L 0.001
Bismuth, total (mg/L)	.	.	9	L 0.02	L 0.02
Cadmium, total (mg/L)	.	.	14	L 0.01	L 0.0005
Chromium, total (mg/L)	.	.	11	L 0.01	L 0.002
Copper, total (mg/L)	0.004	0.003	14	0.01	L 0.001
Iron, total (mg/L)	0.06	0.030	14	0.13	L 0.01
Manganese, total (mg/L)	0.01	0.01	14	0.05	L 0.01
Molybdenum, total (mg/L)	.	.	14	L 0.01	0.004
Nickel, total (mg/L)	.	.	14	L 0.05	L 0.008
Selenium, total (mg/L)	.	.	9	L 0.03	L 0.03
Sodium, dissolved (mg/L)	5.0	0.30	10	5.6	4.8
Silicon, total (mg/L)	2.2	0.600	8	3.2	1.6
Silver, total (mg/L)	.	.	9	L 0.03	L 0.01
Strontium, total (mg/L)	0.030	0.0021	8	0.036	0.027
Tin, total (mg/L)	.	.	9	L 0.02	L 0.02
Zinc, total (mg/L)	0.020	0.0200	14	0.1	0.005

Note: L = less than

Table 2 Summary of Capital Regional District's Health Protection and Environmental Division's Bacteriological data (fecal coliforms/100 mL) from Prospect Lake (North Lakeside Park)

Year	1983	1984	1985	1986	1988	1989	1990	1991	1992	1993	1994	1995
Maximum	442	159	100	240	2400	2400	2400	2400	4000	1200	3600	1800
Minimum	15	7	9	3	3	11	4	L 3	L 1	2	2	2
Geometric Mean	105.3	34.8	31.04	23.3	78.52	96.4	91.1	79.6	200.6	121.6	198.5	115.8
Number of Samples	13	19	13	10	18	17	26	27	22	35	30	28

Note: L = less than

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