

SYLVAN LAKE WATER QUALITY ASSESSMENT AND WATERSHED MANAGEMENT CONSIDERATIONS

PREPARED FOR:
LACOMBE COUNTY
RED DEER COUNTY
TOWN OF SYLVAN LAKE
SUMMER VILLAGE OF BIRCHCLIFF
SUMMER VILLAGE OF HALF MOON BAY
SUMMER VILLAGE OF JARVIS BAY
SUMMER VILLAGE OF NORGLIWOLD
SUMMER VILLAGE OF SUNBREAKER COVE
ALBERTA ENVIRONMENT
ALBERTA SUSTAINABLE RESOURCE DEVELOPMENT
FISHERIES AND OCEANS CANADA

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AXYS Environmental Consulting Ltd.

Sylvan Lake Water Quality Assessment and Watershed Management Considerations

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Table of Contents

1	Introduction.....	1-1
1.1	Background.....	1-1
1.2	Study Objectives.....	1-1
1.3	Report Organization.....	1-5
2	Baseline Characterization of Lake Water Quality, Sediment Quality and Limnology	2-1
2.1	Introduction.....	2-1
2.2	Methods.....	2-1
2.3	Results and Discussion	2-1
2.3.1	Water Balance.....	2-7
2.3.1.1	Lake Physical Characteristics	2-7
2.3.1.2	Total Inflows (Water Entering the Lake).....	2-7
2.3.1.3	Total Outflows (Water Leaving the Lake).....	2-8
2.3.1.4	Major Findings of the Constructed Water Balance.....	2-11
2.3.2	Nutrient Balance	2-12
2.3.2.1	Nutrient Inputs	2-12
2.3.2.2	Nutrient Outputs (Losses).....	2-15
2.3.2.3	Major Findings of the Nutrient Balance for Sylvan Lake.....	2-15
2.3.3	Lake Mass Balance Model.....	2-15
3	Implications for Watershed Planning and Development	3-1
3.1	Lake Sensitivities to Land Development	3-1
3.2	Short-term Management Recommendations for Residential Developments.....	3-2
3.2.1	Effective Protection of Surface Water Courses and Wetlands	3-2
3.2.2	Use of Communal Sewage Holding Tank Systems	3-3
3.2.3	Landscaping Restrictions on Lawns and Gardens	3-3
3.2.4	Storm Water Ponds and Monitoring Systems.....	3-4
3.3	Medium- to Long-term Management Recommendations.....	3-4
3.3.1	Broader Protection of Surface Watercourses and Wetlands.....	3-7
3.3.2	Maintenance Of Lake Water Balance	3-7
3.3.3	Septic Field Performance Monitoring.....	3-8
3.4	Additional Data Needs and Monitoring Requirements.....	3-8
3.5	Adaptive Management	3-9
3.5.1	The Adoption of Adaptive Management	3-10
3.5.2	Summary	3-12
3.6	Summary of Recommendations.....	3-12
3.6.1	Immediate Term.....	3-12
3.6.2	Medium to Long-Term	3-13
3.6.3	Best Management Practices	3-13
4	References.....	4-1
4.1	Literature Cited	4-1
Appendix A Detailed Water Quality Assessment and Watershed Management Considerations		
Appendix B Hydrogeology Baseline and Modelling Studies		

**Appendix C Bathymetry, Water Quality, Sediment Chemistry, and Phytoplankton
in Sylvan Lake: September, 2004**

Appendix D Detailed Water Balance for Sylvan Lake

List of Tables

Table 3-1	Residential Property BMPs	3-14
Table 3-2	Stormwater Management BMPs	3-15
Table 3-3	Agriculture and Livestock Operation BMPs	3-17
Table 3-4	Golf Course Operation BMPs	3-18
Table 3-5	Educational BMPs	3-18

List of Figures

Figure 1-1	Sylvan Lake Watershed and Surrounding Area	1-3
Figure 2-1	Land Cover Classes within the Sylvan Lake Watershed	2-5
Figure 2-2	Bathymetric Map of Sylvan Lake.....	2-9
Figure 3-1	Recommended Buffers to Waterbodies and Proposed Developments	3-5
Figure 3-2	Adaptive Management: A six-step cyclic process.....	3-10

Abbreviations

%.....	percent
<.....	less than
>.....	greater than
~.....	approximately
°C.....	degrees Celsius
µg/g.....	microgram per gram
µg/kg.....	microgram per kilogram
µg/L.....	microgram per Litre
AB.....	Alberta
AENV.....	Alberta Environment
AES.....	Atmosphere Environment Service
ALMS.....	Alberta Lake Management Society
ANOVA.....	technique used to analyze variance
ASL.....	above sea level
AXYS.....	AXYS Environmental Consulting Ltd.
BC.....	British Columbia
CaCO ₃	calcium carbonate
CCME.....	Canadian Council of Ministers of the Environment
CFU.....	colony forming units
cm.....	centimetre
DIN.....	dissolved inorganic nitrogen
DL.....	detection limit
DO.....	dissolved oxygen
DP.....	dissolved phosphorus
<i>E. coli</i>	<i>Escherichia coli</i>
e.g.....	for example
i.e.....	<i>id est</i> (that is)
et al.....	<i>et alii</i> (and others)
FWMC.....	flow-weighted mean concentration
km.....	kilometres
L/kg.....	Litres per kilogram
LEL.....	lowest effect level
m.....	metre
m ³ /d.....	metres cubed per day
m ³ /s.....	metres cubed per second
MAC.....	maximum acceptable concentration
mg/L.....	milligram per Litre
mL.....	milliLitre
mm.....	millimetre
mV.....	milliVolt
N.....	nitrogen
no.....	number
NO ₃	nitrate
OECD.....	Organisation for Economic Co-operation and Development
P.....	phosphorus
pers. comm.....	personal communication
PFRA.....	Prairie Farm Rehabilitation Agency

pH	the measurement of a substance's acidity or alkalinity
PSC	phosphorus sorption capacity
PSI	phosphorus sorption index
redox	oxidation-reduction potential
SEL	severe effect level
sp.	species
SQG	sediment quality guideline
TDS	total dissolved solids
TKN	total kjeldahl nitrogen
TN	total nitrogen
TOC	total organic carbon
TP	total phosphorus
TSS	total suspended solids
USEPA	United States Environmental Protection Agency
vs.	versus
x	times

1 Introduction

1.1 Background

Sylvan Lake is a popular recreation destination in Alberta, and its location halfway between the cities of Calgary and Edmonton has resulted in increasing development pressure. Currently, there are five summer villages around the lake and the Town of Sylvan Lake is situated at its southeast end (Figure 1-1). In addition, several camp facilities are located along the lakeshore, and new subdivisions are also appearing along the lake's edge and elsewhere in the watershed.

Management of development within the watershed falls under the jurisdiction of eight municipal authorities, which include:

- Town of Sylvan Lake
- Summer Village of Jarvis Bay
- Summer Village of Sunbreaker Cove
- Summer Village of Halfmoon Bay
- Summer Village of Norglenwold
- Summer Village of Birchcliff
- Lacombe County
- Red Deer County

To help manage growth and development within the watershed, the municipalities adopted the Sylvan Lake Management Plan: 2000 Update. To minimize the potential for significant, adverse environmental effects on the lake and its watershed, the municipalities, represented by the Sylvan Lake Management Committee (the committee), agreed that a study was required to assess cumulative pressures on the lake, as well as the sensitivity of the lake to further development. This study was to be used to permit science-based planning and development decisions.

In July 2004, the committee invited AXYS Environmental Consulting Ltd. (AXYS) attend a meeting to discuss study objectives. At the meeting, participants unanimously agreed that water quality was the environmental variable (or valued ecosystem component) of paramount importance for ensuring the long-term ecological and recreational value of the lake, and that the maintenance of acceptable water quality standards should be the primary criterion for planning and development decisions. As a result, the committee retained AXYS to initiate a study focused on lake water quality, and the cumulative land use pressures that potentially threaten water quality.

1.2 Study Objectives

A number of preliminary objectives for the study were developed prior to its initiation, pertaining to both the characterization of lake conditions and the development of site-specific constraints and recommendations for land use activities around the lake. While the water quality objectives of the study were largely achieved, it soon became apparent that the inherent characteristics and sensitivities of the lake's water and nutrient balance did not lend themselves to site-specific planning recommendations. In particular, it was originally anticipated that groundwater would play a much greater role in the water

balance of the lake, and that localized groundwater discharge features such as fens and springs would be of particular significance from a hydrogeological perspective. Proposed study objectives included the preparation of a “development constraints” map that would provide protection for such features through avoidance. However, once into the study, investigations indicated that groundwater contributed only 10% of the total inflow to the lake, that groundwater discharge into the lake was widely dispersed within a relatively consistent clay-rich till blanket that dominates the surficial geology around the lake, and that point discharge features (e.g., fens, springs) were relatively uncommon hydrogeological features in the basin. Consequently, planning recommendations for the protection of groundwater became more regional and generally in nature, rather than site-specific, than was originally proposed.

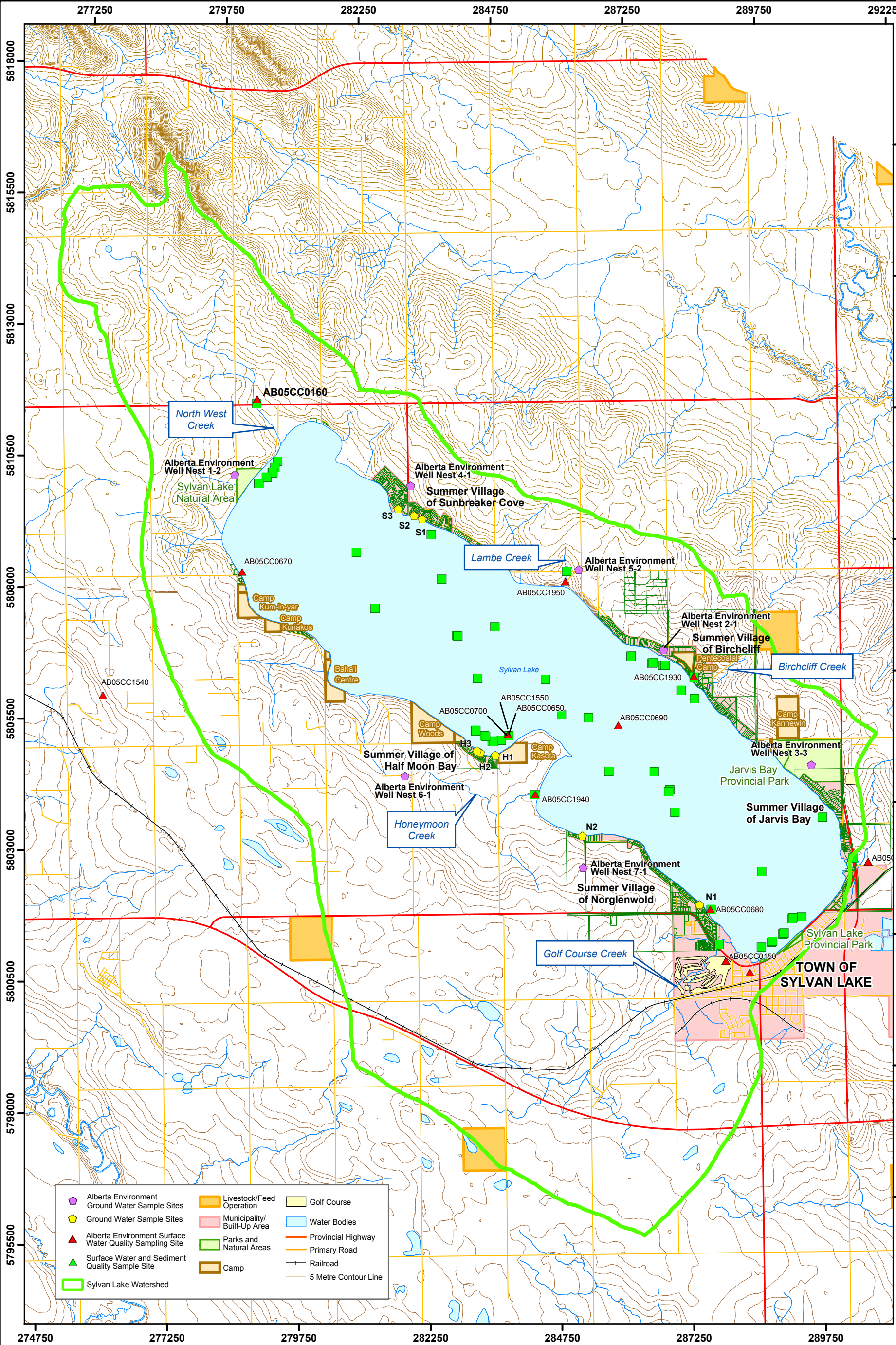
The study provides the following:

Baseline Characterization

- Current water quality conditions and trends in the lake that could adversely affect the lake’s recreational potential and ecological conditions, both in the short and medium term.
- The relative contribution of surface flow and groundwater to the lake’s water balance, and identify the inflow sources and locations that are key to the lake’s water balance.
- Estimated nutrient flows into the lake from surface and groundwater sources, and their relationship to different land use activities.
- Current water withdrawal rates from groundwater sources and the implications to the lake’s water and nutrient balance.
- Identify an overall nutrient mass-balance for the lake.

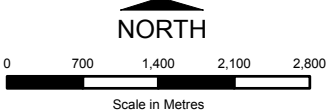
Implications for Watershed Planning and Development

- Assessment of the lake’s overall ability to assimilate additional nutrient inputs without measurable changes to water quality conditions.
- Sensitivity of the lake to increased nutrient input or nutrient management programs.
- Identify the land use activities that contribute most to nutrient inflows into the lake, and the ability of the lake to accommodate additional inputs from increased development without adverse effects to water quality.
- The ability of the local groundwater resources to accommodate additional water use from new developments within the watershed, without resulting in adverse effects to lake water quantity or quality.
- Management principles and recommendations for immediate term development plans.
- Management principles and recommendations for longer term development plans and watershed protection.
- Ongoing monitoring requirements for both surface water and groundwater.



SYLVAN LAKE WATER QUALITY STUDY

Sylvan Lake Watershed and Surrounding Area



Acknowledgements:
Original Drawing by AXYS Environmental Consulting Ltd.

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			FIGURE NO. 1-1

Note that this study does not address cumulative pressures on other resources that may be considered valued ecosystem components of the lake (e.g., fisheries, waterfowl). Similarly, it does not address social issues associated with increasing residential and recreational pressures on the lake (e.g., noise, quality of recreational experience).

Water quality is without question the valued ecosystem component of paramount importance for ensuring the long-term ecological and recreational value of the lake. The maintenance of acceptable water quality standards should be the primary criterion for planning and development decisions.

1.3 Report Organization

Section 2 provides a summary of the Baseline Characterization study including a discussion on the nutrient mass-balance for the lake.

Section 3 discusses the implications of further land use development around the lake on lake health, and provides recommendations for managing cumulative effects on water quality.

Appendices A to D for a more detailed description of the data collection tasks and results of the baseline and nutrient balance study. Section A.1.1 provides a description of the water quality parameters used in this study.

2 Baseline Characterization of Lake Water Quality, Sediment Quality and Limnology

2.1 Introduction

The primary concerns about water quality in Sylvan Lake are relate to nutrients and nutrient enrichment (i.e., eutrophication). Nitrogen and phosphorus are key nutrients necessary for plant and algal growth. As such, both nutrients are important constituents of aquatic ecosystems as they directly influence primary production (i.e., algal growth) which is a fundamental component of the aquatic foodweb. Consequently, these two nutrients were the focus of water quality and nutrient balance evaluation done for this study. Very low levels of nitrogen and phosphorus may result in very low levels of primary production in surface waters. This is important because low levels of primary production can result in a relatively non-productive ecosystem, as invertebrates and fish rely directly or indirectly on this component of the ecosystem. However, excessive introduction of nutrients may lead to development of ‘nuisance’ plant and algal growth (i.e., eutrophic conditions).

2.2 Methods

To address the objectives of this study, available historical data on water quality, sediment quality, and limnology in Sylvan Lake were compiled and evaluated. A field sampling program was also conducted in September 2004 to:

- provide information on the spatial variability of water quality in the lake
- evaluate conditions in nearshore areas
- update and digitize lake bathymetry
- evaluate sediment quality in deep and nearshore areas of the lake
- evaluate potential historical changes in sediment quality through collection of a sediment core

Additionally, water quality of inflowing tributary streams was examined to assist in the determination of the sources and loads of nutrients to Sylvan Lake. Data collected by Alberta Environment (AENV), as well as samples collected in September 2004, were evaluated.

2.3 Results and Discussion

The following is a summary of major findings and conclusions of this study with respect to water quality, sediment quality, and limnology; as well as descriptions of the water and nutrient balances constructed for the lake. See Appendix A for a presentation and more detailed discussion of the results of this study.

Lake Water Quality

Sylvan Lake is alkaline, extremely insensitive to acidification (based on pH and alkalinity), very hard, contains low levels of major ions and salts, and is of high clarity. Thermal stratification develops in some summers and winters and dissolved oxygen (DO) depletion in the hypolimnion has been observed in both seasons. AENV monitoring has revealed that concentrations of DO near the bottom of the water column can drop below the AENV water quality guideline of 5.0 mg/L for the protection of aquatic life at depth. However, DO concentrations have remained relatively high in the euphotic zone of the lake, typically ranging from 90 to 100 percent saturation.

Nutrient concentrations in Sylvan Lake are relatively constant over the period of record (i.e., 1983–2003) and there is no overt indication of enrichment over time. Concentrations of total phosphorous (TP) are below the AENV guideline of 0.050 mg/L and are relatively low compared to other Alberta lakes.

Concentrations of total nitrogen (TN), although measured very infrequently, have remained largely below the AENV guideline of 1 mg/L. The nitrogen pool in Sylvan Lake is overwhelmingly dominated by organic nitrogen, and inorganic forms, such as ammonia and nitrate/nitrite, are present in low concentrations.

Levels of chlorophyll *a* have remained relatively low in Sylvan Lake, compared to other Alberta lakes but occasional algal blooms have been reported at least as far back as the 1970s. Historical data collected from the lake in the 1970s indicate that concentrations of chlorophyll *a* have not varied much since that time. Secchi disk depth measurements indicate the lake is characterized by high water clarity.

Results of nearshore water quality sampling conducted in September 2004 indicate that conditions were generally similar across the lake (i.e., only minor differences between areas) and also similar to data collected from deep-water locations. Those minor differences that were observed between nearshore areas could not be linked to differences in adjacent land use activities. Furthermore, all water quality parameters were within water quality guidelines for the protection of aquatic life in all areas. Low levels of fecal coliform bacteria and *Escherichia coli* were observed in the nearshore areas and there was no indication of a bacteriological issue or spatial differences. The nearshore zones were also well-oxygenated.

Lake Sediment Quality

Mitchell (1999) expressed concern that Sylvan Lake sediments may have accumulated significant levels of nutrients from the water column, specifically phosphorus. Phosphorus concentrations in lake sediments can potentially be several orders of magnitude greater than those measured in the water column (Wetzel 1983). Sediment quality is important in defining the current water quality and nutrient status of Sylvan Lake for two main reasons, namely:

- Sediments act as a sink by accumulating waterborne nutrients over time. Nutrients that are not flushed out of the lake (i.e., through outlet channels) ultimately become incorporated in the sediments.
- Under certain physical (e.g., low dissolved oxygen, temperature, turbulence), chemical (low redox potential, iron availability) and biological (invertebrate burrowing activity) conditions, sediments can also act as an uncontrolled internal

source of nutrients to the water column (Wetzel 1983; Marsden 1989). This is referred to as the internal loading of phosphorus within a lake.

Low redox potentials (i.e., reducing conditions as a result of low oxygen levels) in Sylvan Lake have only been measured on a few occasions. However, available data indicate that redox potentials may vary substantively over the open-water season and may decline to levels that are generally conducive to the release of phosphorus from sediments to the overlying water column. There is some indication of nutrient fluxes from sediments to the overlying water column (i.e., internal loading), based on the available historical data. Depth profiles for dissolved phosphorous (DP) and total phosphorous (TP) collected at the deepest site in the lake indicate that vertical differences do develop sometimes in some years, reflecting the release of phosphorus from the sediments.

Offshore sediments contained approximately double the total phosphorus concentration and 4 to 11 times the total nitrogen concentrations reported for nearshore areas. Higher nutrients concentrations in offshore areas are typical for lakes as the deeper areas tend to be depositional environments and are less prone to sediment resuspension. Smaller sediment particles (i.e., silt and clay) bind more nutrients than coarser particles (i.e., sand), therefore offshore sediments, which have greater fractions of clay and silt, would be pre-disposed to sorbing more nutrients. Lake sediments from the nearshore and offshore areas, sampled in September 2004, do not appear to be more enriched with phosphorus than other lakes in Alberta.

There appeared to be no enrichment of phosphorus, nitrogen or organic carbon in sediments close to developed areas, relative to the sediment quality determined for a site close to the undeveloped shoreline in the Sylvan Lake Natural Area. Neither offshore nor nearshore sediments were saturated in phosphorus, as all sediments tested were able to take up additional phosphorus from solution. There is some evidence that phosphorus may be released from the sediments in Sylvan Lake at certain times of year. However, the available lake monitoring data and estimates of external nutrient loading to the lake are insufficient to derive estimates of internal loading rates in the lake.

The particle size composition and concentrations of TN and TP measured in sediment core collected at an offshore site indicate that at this site, sediment composition and nutrient status of the lake has not changed greatly over time.

Lake Limnology and Trophic Status

Study of the species composition of phytoplankton communities can provide information about the productivity and diversity of an aquatic ecosystem. This information is also valuable for indicating the trophic status of a waterbody (i.e., how much a lake or stream is enriched with nutrients). The presence and abundance of a certain type of algae, 'blue-green algae', is also of significance as these organisms can produce microtoxins that may affect aquatic biota, wildlife, and humans. The occurrence of blue-green algal blooms is also considered an indicator of nutrient enrichment.

Historical studies conducted in the 1970s as well as the results of the single sample collected from the lake in September 2004 indicate that blue-green algae comprised a significant fraction of algal communities in late summer and early fall.

Lake trophic status can be defined based on concentrations of phosphorus, nitrogen, chlorophyll *a*, and Secchi disk depth (i.e., water clarity). AENV routinely classifies Alberta lakes using the mean concentrations of TP and chlorophyll *a*, measured in the open-water season.

Sylvan Lake (based on the mean open-water season water quality conditions for 1983–2002) is classified as meso-eutrophic (CCME 2004) on the basis of TP (mean = 0.021 mg/L), mesotrophic (OECD 1982) on the basis of chlorophyll *a* (mean = 4.6 µg/L), meso-eutrophic (Wetzel 1983) to eutrophic (Nürnberg 1996) on the basis of TN (mean = 0.715 mg/L), and oligotrophic on the basis of dissolved inorganic nitrogen (Mean = 0.046 mg/L, Wetzel 1983) and Secchi depth (Mean = 4.8 m, OECD 1982; Nürnberg 1996). The upper range of mean concentrations of TP measured in the open-water season (mean for open-water season of 1992 was 0.034 mg/L) in Sylvan Lake over the period of record approaches the boundary of meso-eutrophic and eutrophic status (i.e., 0.035 mg/L).

Based on nitrogen to phosphorus ratios, Sylvan Lake may be nitrogen limited at certain times of the year (at a minimum). This may pre-dispose the lake to the development of blue-green algal blooms due to their ability to fix atmospheric nitrogen (i.e., blue-green algae can take up nitrogen from the atmosphere and can grow in waters with little available nitrogen). Algal blooms have been documented on Sylvan Lake at least as far back as the 1970s.

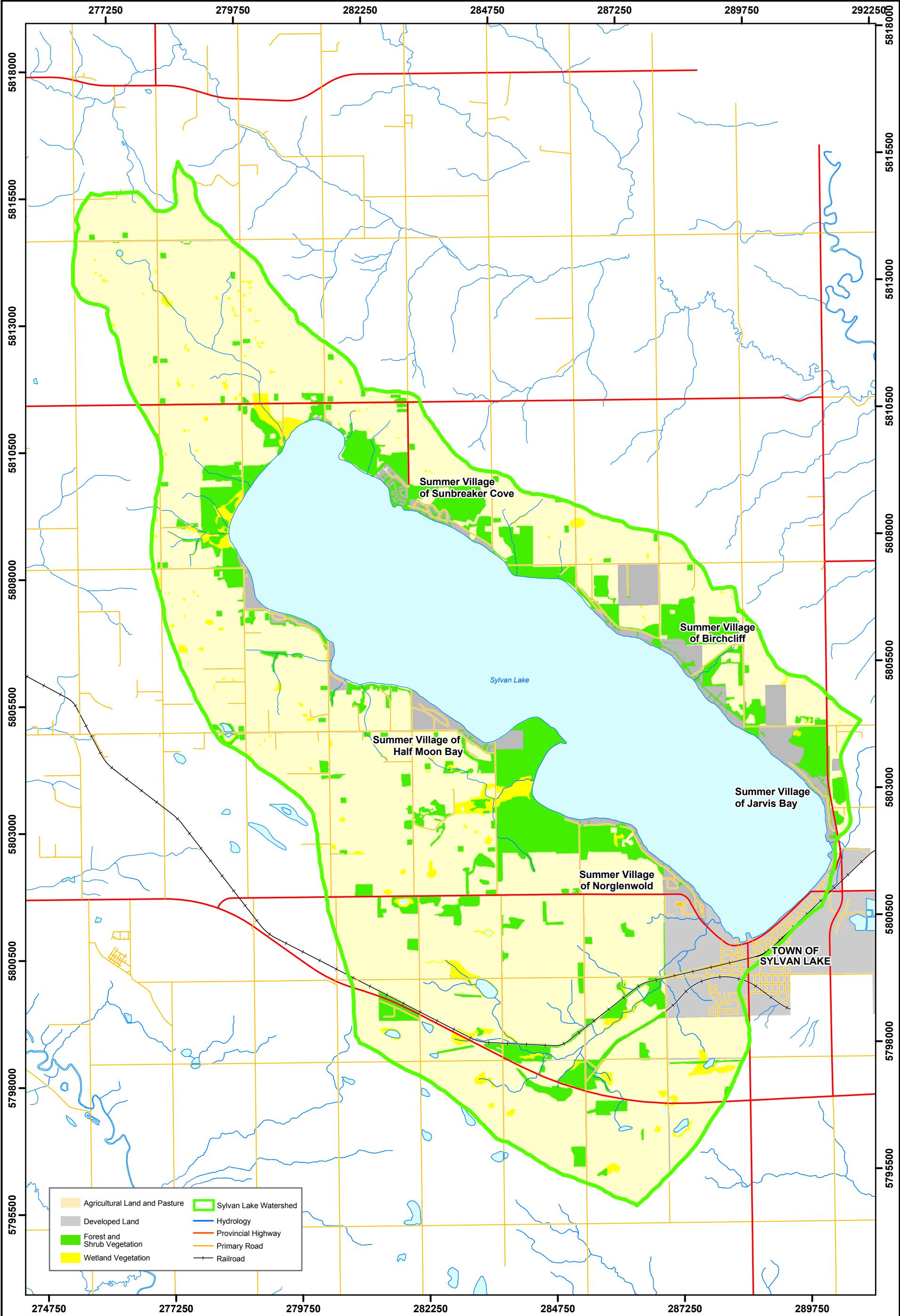
Tributary Streams

Historical water quality data for the five ephemeral tributaries that flow into Sylvan Lake (Golf Course Creek, Northwest Creek, Birchcliff Creek, Honeymoon Creek and Lambe Creek) and the Sylvan Lake outflow are limited because of intermittent flows in these watercourses (Figure 1-1). Sylvan Lake does not have a permanent outflow and only discharges (at the Sylvan Lake outflow) when water levels reach 936.66 m ASL (metres above sea level). The water quality of these streams is discussed in detail in Appendix A.

The dominant land use type in the Sylvan Lake drainage basin is agriculture, and the upper and middle reaches of tributary streams tend to flow through agricultural land (Figure 2-1). The lower reaches of these streams, just prior to entering Sylvan Lake, flow through different shoreline land use types depending on the entry location. Differences in TP and TN concentrations between streams observed in March 2001, and April 2003, 2004, likely do not reflect shoreline habitat. Rather they reflect the degree and nature of agricultural land use upstream.

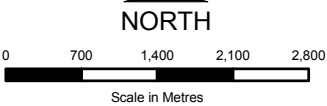
When flowing, the streams can be classified as eutrophic according to the stream trophic classification criteria suggested by the USEPA (2000). The provincial aquatic life water quality guidelines for TP (0.05 mg/L) and TN (1 mg/L) were generally exceeded when these streams were flowing and concentrations of the dissolved bioavailable fractions (i.e., forms of nutrients that are readily taken up by plants and algae) were also high (AENV 1999a). Elevated levels of fecal coliform and *E. coli* bacteria also periodically occurred in most streams.

Golf Course and Northwest creeks are most likely to exhibit some prolonged flow throughout the year, and so are most likely to make the largest contribution to the nutrient budget of Sylvan Lake. It was previously thought that there was no significant surface inflow to the lake due to the size and intermittent nature of the tributaries (Baker 2003). Yet due to the elevated nutrient, total suspended solids (TSS) and bacterial levels in some of these streams, they may actually account for a large proportion of the total nutrient input to the lake.



SYLVAN LAKE WATER QUALITY STUDY

**Land Cover Classes within
the Sylvan Lake Watershed**



Acknowledgements:
Original Drawing by AXYS Environmental
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DRAFT DATE		25/01/2005		SCALE	
				1:70,000	
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TP levels recorded for the Sylvan Lake outflow (summer 1993) remained below the aquatic water quality guideline (0.014 and 0.038 mg/L) and were similar to values recorded from composite samples from the euphotic zone of Sylvan Lake.

2.3.1 Water Balance

Details of the Sylvan Lake water balance constructed for the period 1956–2000 are given in Appendices A and D. A summary of the main components and major findings of the water balance is discussed here.

2.3.1.1 Lake Physical Characteristics

Water Levels and Lake Morphometry

Sylvan Lake water levels are remarkably stable and have fluctuated by less than a metre between years (approximately 0.7 m). The average, minimum and maximum lake elevations for the period of 1956–2000, were 936.57, 936.10 and 936.95 m ASL, respectively. Due to these relatively stable water levels, Sylvan Lake morphometry (the physical shape of the lake) does not vary considerably from year to year. This was confirmed from bathymetric data collected in 2004. Bathymetry is the measurement and charting of the depths of waterbodies to determine underwater topography. A bathymetric map was generated from this information, which displays the topographic contours of the bottom of the waterbody (Figure 2-2).

Drainage Area

The mean drainage area, excluding Sylvan Lake, for the time frame of 1956–2000 was 109.25 km², based on an average lake area of 41.75 km² calculated from the bathymetric model. Sylvan Lake is therefore characterized by a low drainage ratio (i.e., the ratio of drainage area to lake area), averaging approximately 2.6 over a 45 year period. Gull Lake which is located nearby, also shares a drainage ratio of 2.6 (Mitchell and LeClair 2003) whereas Pine Lake has a much higher ratio of 38.6 (Mitchell and Prepas 1990).

2.3.1.2 Total Inflows (Water Entering the Lake)

Precipitation and Surface Inflow

The period of precipitation data collection for Sylvan Lake was insufficient for input to the water balance. Therefore, an appropriate surrogate data set was selected. Thus monthly averages of total precipitation (mm) between January 1956 and December 2000 from the Atmospheric Environment Service (AES) meteorological monitoring station Red Deer (Red Deer A station) were used in the water balance. The estimated mean annual contribution to inflow from precipitation was 19.9 million m³.

Discharge of the ephemeral tributary streams into Sylvan Lake was only measured periodically in 2001 and 2003 and data are not sufficient to adequately characterize the surface inflows to the lake. Therefore, surface inflow was calculated using precipitation data from Red Deer A station, surface run off coefficients for Lloyd Creek Station 05CC009, and the average area of the Sylvan Lake drainage basin. Lloyd Creek was also used as a surrogate or representative stream, for derivation of surface inflow estimates for a water balance for Gull Lake, in the absence of sufficient surface inflow data from the

Gull Lake tributaries (Mitchell and LeClair 2003). The estimates of surface inflows to the lake were adjusted to reconcile with the estimates of groundwater inflow to the lake, derived through the groundwater model. Final total annual surface inflow estimates averaged 10.8 million m³/a for the period of 1956–2000 and the period of 1983–2000.

Groundwater Inflow

Sylvan Lake is situated within a groundwater basin that generally coincides with the Sylvan Lake - Cygnet Lake watershed. The groundwater basin extends from the uplands to the northeast and southwest of Sylvan Lake, and from the upland northwest of Sylvan Lake to the Red Deer River. The upland areas of the basin are groundwater recharge areas (areas where groundwater moves downwards). Sylvan Lake and the area immediately adjacent to the lake is a groundwater discharge area (area where groundwater moves upwards). The discharge area extends southeast of Sylvan Lake to the Red Deer River. A flowing well zone (an underground zone in which aquifers are over-pressurized and water flows out of wells without pumping) occurs in the vicinity of Cygnet Lake.

Groundwater in the upland (recharge) areas flows downward and laterally towards the lake. A portion of the downward-moving groundwater flows deeper into the groundwater basin. Shallow groundwater at the northwest, northeast and southwest sides of the lake discharges into the lake, and shallow groundwater also seeps into the lake from beneath. The same shallow groundwater flow pattern is associated with Cygnet Lake where shallow groundwater flows into this lake from the sides and from beneath. Shallow groundwater southeast of Cygnet Lake and the deeper groundwater in the basin flows in a southeasterly direction, and discharges into the Red Deer River and the streams (e.g., Sylvan Creek) in between.

A groundwater flow model of the Sylvan Lake groundwater basin was constructed to simulate groundwater flow within the basin and, specifically, to estimate the volume of groundwater inflow to Sylvan Lake. Without considering the effects of groundwater pumping from water wells, the modelling results indicate the groundwater inflow to Sylvan Lake is 12,498 m³/d.

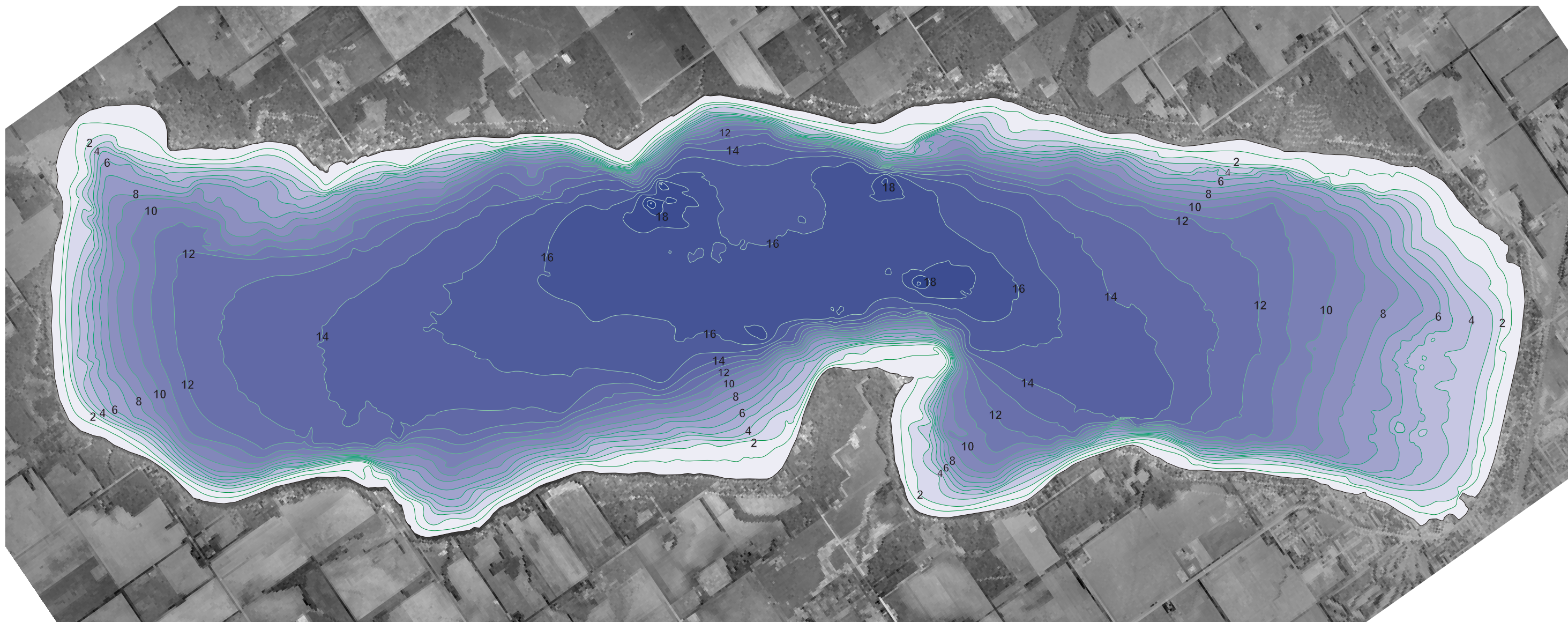
2.3.1.3 Total Outflows (Water Leaving the Lake)

Evaporation

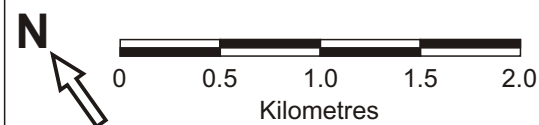
Evaporation has not been monitored at Sylvan Lake. Therefore, published monthly evaporation rates for Sylvan Lake for a 30-year period (1971–2000) were obtained from PFRA (2002). Mean annual total evaporation for 1956–2000 was 787.1 mm, amounting to approximately 32.9 million m³ per year.

Surface Outflow

Discharge from the Sylvan Lake outflow has not been regularly measured. Therefore, a stage-discharge rating curve for the outflow channel was constructed using lake level and the available discharge data. The rating curve indicated that outflow from Sylvan Lake occurs at lake levels above elevation 936.66 m ASL. Based on this calculation the channel would have had significant discharge for the periods of 1956 to 1958 and 1990 to 2000.



Sylvan Lake Bathymetric Mapping:
 [based on lake surface elevation of 936.55 mASL]
 Surface Area = 42.19 km²
 Lake Volume = 420,080,983 m³
 Mean Depth = 9.9 m
 Maximum Depth = 20.3 m



Projection: UTM Zone 10
 Datum: NAD83
 Contour Intervals: 1.0 m

Produced: KK

Checked: CF

Date: Jan. 17, 2005

Figure 2-2
 Bathymetric Map
 of Sylvan Lake

Groundwater Outflow

Hydrogeologic data for the area between Sylvan and Cygnet Lakes are limited and, as a result, the shallow groundwater flow conditions at the southeast end of Sylvan Lake are unknown. However, the available data suggest that this area of shallow groundwater flows towards Cygnet Lake, and that Sylvan Lake water flows out of the lake and into the subsurface at the southeast end, thereby recharging the surficial till deposit (clay-rich soils above the bedrock) and perhaps the shallow bedrock. The till deposit is relatively thick and likely has a very low permeability. A flowing well zone is present southeast of the lake. Consequently, for the purposes of the water balance, groundwater outflow was assumed to be negligible.

Effect of Groundwater Use

To examine the effect of groundwater use on the inflow to Sylvan Lake, a review was undertaken with the objective of identifying uses that would remove groundwater from the groundwater basin, thereby reducing the volume of groundwater available for discharge into Sylvan Lake. Information on groundwater use is provided in AENV's Groundwater Information System database and in AENV's listing of licensed water wells.

The listing of licensed water wells obtained from AENV shows a total of 145 licensed wells are located in the study area. The total maximum allowable diversion volume for the wells is 1,841,388 m³/a. The majority of the licensed groundwater use (79 percent) is for the Town's use of its water wells. The remaining groundwater use is for individuals, agriculture, golf courses, other recreational needs and schools.

Based on this information, the majority of the water wells within the Sylvan Lake groundwater basin are used for domestic and livestock-watering purposes. It is likely that essentially all of this pumped groundwater remains in the groundwater basin through seepage back into the subsurface (e.g., septic fields, ground discharge of livestock effluent).

Almost all of the groundwater pumped from the Town's water wells (seven wells are currently in use) ultimately gets discharged into the Town's sewage system. Sewage is piped to the sewage lagoon located northeast of the Town, next to the outlet channel that flows from Sylvan Lake to Cygnet Lake. Water in the lagoon is discharged into the natural surface water system (i.e., Cygnet Lake via the outlet channel). Consequently, the majority of the groundwater pumped from the Town's water wells is removed from the groundwater basin.

The groundwater flow model was used to estimate the effect of the Town's water wells on the groundwater inflow to Sylvan Lake. In the model, the pumping of groundwater from the Town's water wells using the 2003 production volume of 1,061,730 m³ (2,908 m³/d) was incorporated without returning the pumped groundwater back into the groundwater basin. The modelling results indicate the groundwater inflow to Sylvan Lake is reduced from 12,498 m³/d to 9,727 m³/d. This reduction of 2,771 m³/d represents 3 percent of the total water inflow (34.2 million m³/a) to the lake.

2.3.1.4 Major Findings of the Constructed Water Balance

Sylvan Lake inflows are dominated by surface drainage from the surrounding drainage basin. For the period 1956–2000, the calculated mean annual surface inflow was

approximately 10.8 million m³, while the estimated mean annual precipitation was 19.9 million m³. Thus the total mean annual surface inflow to the lake was estimated to be 30.7 million m³. The estimated mean net annual groundwater inflow to the lake (i.e., excluding volumes extracted by the town of Sylvan Lake) was 3.5 million m³, resulting in a total mean annual inflow to Sylvan Lake of 34.2 million m³. The major inputs to Sylvan Lake appear to be surface inflows associated with the six ephemeral tributary streams.

The largest pathway for water loss from Sylvan Lake is evaporation. The mean annual loss of water to evaporation in Sylvan Lake was estimated to be approximately 32.9 million m³, while the estimated mean annual surface outflow was 1.6 million m³. As the groundwater outflow was assumed to be zero, the total mean annual outflow to Sylvan Lake was calculated to be 34.5 million m³.

The water balance shows that, for large periods of time, Sylvan Lake does not have a surface outflow and, consequently, the lake is characterized by very long water residence times (>100 years) and low flushing rates. Over the last decade there has been almost continuous surface outflow through the outlet channel in the open-water season and so during this time, the calculated water residence time has been lower (approximately 90 years).

2.3.2 Nutrient Balance

Phosphorus and nitrogen levels, and consequently the trophic status of Sylvan Lake, are dependent upon the balance between external and internal nutrient inputs into the lake, and nutrient outputs from the lake. Details of the Sylvan Lake nutrient balance developed for the period 1983–2000 are given in Appendix A. A summary of the main components and major findings of the nutrient balance are discussed following.

2.3.2.1 Nutrient Inputs

Atmospheric Deposition

Rain, snow and dust falls directly onto the surface of the lake, carrying small amounts of nutrients (i.e., atmospheric deposition). Atmospheric loads of nutrients deposited directly onto Sylvan Lake were estimated using loading rates collected on an Alberta lake (Narrow Lake, Shaw et al. 1989) and the mean surface area of the lake. The lake receives an estimated 835 kg/a of TP and 1,069 kg/a of TN from atmospheric deposition.

Surface Inflows

During spring snowmelt and summer rainstorms, nutrients are picked up from forests, agricultural land, cottage property and other land. The resulting mix of dissolved and suspended materials (soil particles, nutrients, organic matter, microorganisms and chemical substances) eventually makes its way to the lake. Drainage basins are typically major sources of nutrients to lakes and streams. Additionally, nutrient inputs from drainage basins are potentially controllable. For Sylvan Lake, two different methods were used to estimate the amount of nutrients entering the lake each year from the drainage basin.

1. Nutrient loadings or flow weighted mean concentrations (FWMCs) were calculated using available discharge and nutrient concentrations in the six ephemeral tributaries draining to Sylvan Lake, in conjunction with estimates of surface inflow volumes

generated from the water balance. Based on this method, the lake receives an estimated 6,564 kg/a of TP and 29,572 kg/a of TN from surface inflows.

2. Export coefficients were applied to various land uses in the Sylvan Lake drainage basin. These coefficients represent the yearly amount of phosphorus or nitrogen estimated to move off of a hectare of land in the drainage basin and enter the lake. The phosphorus and nitrogen coefficients applied here were based on those previously applied to other Alberta lakes (Trew et al. 1978; Rast and Lee 1978; Reckow et al. 1980; Mitchell 1985). Land use categories included:

- developed land (highest coefficients)
- agricultural land and pasture (second highest coefficients)
- forest and shrub vegetation (second lowest coefficients)
- wetland vegetation (lowest coefficients)

Based on this method, the lake receives an estimated 3,125 kg/a of TP and 16,343 kg/a of TN from surface inflows.

Septic Effluent Inflows

The volume of septic effluent entering the lake annually was estimated by multiplying the number of septic fields by the average daily water use per residence. Septic holding tanks were not factored into the calculations as the effluent is not released to the lake. To be conservative, lots with unknown septic systems were considered to be septic fields for the purpose of estimating effluent discharge. Information on the number and types of septic systems was available for the summer villages of Birchcliff, Norglenwold, Sunbreaker Cove and Halfmoon Bay. Records were not available for subdivisions outside the summer villages or the Town. The summer village of Jarvis Bay is connected to the Town's sewage system which removes all effluent from the watershed. Information on sewage handling was also obtained for Camp Woods (Scouts Canada), the Baha'I Camp and Camp Kum-in-Yar.

The estimated annual septic effluent inflow to the lake is 142,447 m³. This is about 0.4 percent of the total water inflow to the lake of approximately 34.2 million m³/a.

A field program involving the installation, testing and sampling of eight shallow groundwater monitoring wells was undertaken as a part of the study. The objective of installing these wells was to determine the nutrient concentrations in the shallow groundwater adjacent to the Sylvan Lake shoreline, downslope from existing septic fields. The concentration data obtained were used to estimate the nutrient loading to the lake from septic field effluent. These wells are identified as H1-H3, N1-N2, and S1-S3 on Figure 1-1.

The TP concentrations in the eight samples ranged from 0.784 mg/L to 12.7 mg/L and the TN concentrations ranged from 1.00 mg/L to 14.1 mg/L. The mean concentrations of TP and TN were 3.39 mg/L and 7.51 mg/L, respectively. *E. Coli* was not detected in seven of the samples. The one detection was 2 CFU/100 ml (2 colony-forming units per 100 ml of water). Fecal coliforms were detected in two of the samples at 3 CFU/100 ml and greater than 200 CFU/100 ml.

Based on the above, estimates of annual loads of TP and TN associated with septic field inputs to Sylvan Lake were derived using the estimated annual discharge volume for

septic fields of 142,447 m³, and the mean concentrations of TP (3.39 mg/L) and TN (7.51 mg/L). The estimated annual loads of TP and TN are 483 kg and 1,069 kg, respectively.

Groundwater Inflow

As discussed above, the groundwater flow model was used to estimate the volume of groundwater inflow to Sylvan Lake. From the modelling results, the estimated volume is 9,727 m³/d (3.5 million m³/year). In consideration of the annual septic effluent volume of approximately 0.1 million m³/year, the net groundwater inflow volume not affected by septic effluent is approximately 3.4 million m³/year.

A field program involving the collection of groundwater samples from seven observation wells installed by AENV in 1990 and 1992 was conducted. The chemical quality data obtained were used to estimate the nutrient loading to the lake from groundwater not affected by septic effluent. The wells are located at seven sites around the watershed.

The samples were collected from the seven wells on September 30, 2004 and submitted to Enviro-Test Laboratories for analysis of various parameters including nutrients. The nutrient concentrations in the samples ranged from 0.075 mg/L to 0.55 mg/L for TP and from 0.997 mg/L to 5.57 mg/L for TN. The mean concentrations of TP and TN were 0.278 mg/L and 1.624 mg/L, respectively.

The seven wells are either surrounded by downslope from land used for agricultural crop production. Therefore, the higher concentrations of TP and TN may indicate impact from fertilizers. Overall, the concentrations are low compared to concentrations in other areas in the Prairies where the land use includes high-density feedlot operations or areas where the soils receive manure and are intensively irrigated.

Estimates of annual loads of TP and TN associated with groundwater inflow to Sylvan Lake were derived using the estimated annual discharge volume of approximately 3.4 million m³/year and the mean concentrations of TP (0.278 mg/L) and TN (1.624 mg/L). The estimated annual loads of TP and TN are 946 kg and 5,523 kg, respectively.

Internal Loading from Phosphorus Enriched Sediments

In many Alberta lakes during summer, phosphorus incorporated into lake sediments may be released and move into the overlying water (i.e., internal loading). In such cases the sediments become a source of nutrients that can then be used by algae. This internal loading process, is complex but may occur in association with: phosphorus saturated sediments; low DO conditions, elevated temperatures, reducing conditions, turbulence, biological activities of sediment biota, and iron availability.

Unfortunately, the water quality data available for Sylvan Lake were not sufficient to estimate net internal loading over a specified time period. Even though Sylvan Lake sediments do not appear to be strongly enriched with phosphorus, relative to other Alberta Lakes, there was some indication that phosphorus may be released from these sediments under specific conditions. Due to the uncertainties and lack of data required for deriving estimates of internal loading for TP and particularly TN, the nutrient balance was constructed assuming no internal loading.

2.3.2.2 Nutrient Outputs (Losses)

Phosphorus and nitrogen are potentially exported from the lake via surface and groundwater outflows.

Surface Outflow

Some of the nutrients in Sylvan Lake are lost via the outflow at the south-eastern end of the lake. Measurements of nutrient concentrations in the lake outflow were insufficient for application in the nutrient balance. Therefore, outflow estimates were calculated by multiplying the average in-lake concentrations of TN and TP for the open-water season (1983–2000) by the mean annual outflow volume (2.9 million m³/a). Outflow concentrations of nutrients tend to be generally similar to those in a lake. Based on this method, the lake loses an estimated 62 kg/a of TP and 1,934 kg/a of TN from surface inflows.

Natural Groundwater Outflow

The available data suggest that Sylvan Lake water flows out of the lake and into the subsurface at the southeast end but the volume of this natural outflow could be negligible. Consequently, a nutrient loss calculation was not made for natural groundwater outflow.

2.3.2.3 Major Findings of the Nutrient Balance for Sylvan Lake

- Nutrient inputs to Sylvan Lake are dominated by surface loading from the surrounding drainage basin. Using stream inflow data rather than land export coefficients (i.e., worst case), surface inflows (i.e., tributary streams) are estimated to contribute an annual average of approximately 74 percent and 55 percent of TP and TN loads to the lake, respectively.
- Atmospheric inputs are more significant for TN than for TP, comprising approximately 33 percent and 9 percent of total inputs respectively.
- Groundwater and septic field effluent inflow collectively contribute an estimated 16 percent and 12 percent of annual loads of TP and TN respectively.
- As the lake has a relatively low annual average outflow and a high water residence time, the lake is characterized by high (>95 percent) nutrient retention rates. This means that the vast majority of nutrients entering the lake are deposited in the sediments. This makes Sylvan Lake particularly vulnerable to both external and internal nutrient loading.

2.3.3 Lake Mass Balance Model

To evaluate the lake's capacity to accommodate increased nutrient loading from various sources, a Lake Mass Balance modeling exercise was undertaken for three different nutrient loading simulations (see Appendix A). These were:

1. Predictive Simulation 1: Watershed Loading Increase

Model iterations were run until the appropriate external load of phosphorus was increased sufficiently to predict a lake concentration of TP of 35 µg/L, which represents the threshold between meso-eutrophic and eutrophic conditions. TN loads were increased proportionately to the TP load.

2. *Predictive Simulation 2: Internal Loading Increase*

A second predictive simulation was undertaken to evaluate the sensitivity of the lake to internal phosphorus loading. In this case, an internal loading rate was assigned to the calibrated model and was adjusted until such time that the model predicted TP concentration reached 35 µg/L.

3. *Predictive Simulation 3: Effect of Present Development*

A third simulation was conducted to try to estimate the current impacts of existing land use and development and septic effluent on lake water quality. To accomplish this pre-development analysis, all land in the drainage basin was specified as 'woodland' (i.e., agriculture and urban areas were converted to forest), and septic effluent was assumed to be zero. Other variables in the calibrated model remained the same.

The main findings of the Lake Mass Balance Modeling Exercise were:

- Data are insufficient to estimate the occurrence and rate of internal phosphorus loading. However, a reasonably good approximation of mean total phosphorus concentrations in the lake was obtained using the BATHTUB model and the estimated nutrient loading derived from the nutrient balance assessment.
- The lake was predicted to be capable of assimilating an additional loading of approximately 5,500 kg TP/a, while still maintaining its meso-eutrophic phosphorus status (i.e., <35.1 µg/L), based on average hydrological and chemical conditions for the 1983–2000 period. This represents an approximate 62 percent increase above the estimated annual average loads of TP to the lake of 8,828 kg/a. However, this simulation does not account for the potential for conditions in the lake to shift causing a net internal loading from the sediments.
- A similar effect to lake water quality could be achieved through an increase in TP loading of 5,500 kg TP/a from internal loading. This equates to an annual internal loading rate of approximately 0.4 mg TP/m²/day, or about half the estimated annual internal loading rate for Pine Lake (Sosiak 1997).
- The results of the third predictive simulation (i.e., the pre-development analysis) indicate that nutrient loading has doubled since European settlement of the watershed began. This increased loading from the existing land use types and septic field effluent have converted the lake from an average TP concentration of 6.6 µg/L to 21.0 µg/L. Chlorophyll *a* levels are also predicted to have been very low (approximately 1 µg/L). Therefore, these simulation results indicate that the lake would be oligotrophic (nutrient poor) if the drainage basin consisted of natural woodlands and was free of septic effluent and loading from agriculture and cottage/town development.

3 Implications for Watershed Planning and Development

3.1 Lake Sensitivities to Land Development

The baseline characterization of Sylvan Lake has identified the following key properties of the lake:

- The lake is moderately productive (i.e., mesotrophic) and healthy, with good water quality from a recreational and ecological perspective.
- The nutrient conditions of the lake appear to be stable with no obvious increasing or decreasing trends in water quality parameters.
- Land use activities along the shoreline of the lake do not appear to be influencing nearshore water quality conditions, and near shore water quality parameters are generally similar to deeper water areas.
- Lake sediments from the nearshore and offshore areas do not appear to be more enriched with phosphorus than other lakes in Alberta. There appears to be no enrichment of phosphorus, nitrogen or organic carbon in sediments close to developed areas, relative to the sediment quality determined for a site close to the undeveloped shoreline in the Sylvan Lake Natural Area.
- Precipitation and surface inflows are the predominant water source for the lake. Groundwater inflow represents only 10 percent of the overall yearly inflow to the lake.
- Surface streams are the predominant nutrient source for the lake, contributing 74 percent and 55 percent of the TP and TN entering the lake each year.
- As the lake has a relatively low annual average outflow and a high water residence time, the lake is characterized by high (>95 percent) nutrient retention rates.

Although historic settlement and associated forest clearing of the Sylvan Lake drainage basin has likely resulted in the lake moving from a natural oligotrophic to a mesotrophic status, there is no indication that current land use activities are moving the lake to a more enriched status.

Output from the lake mass balance model also suggests that, from a nutrient balance perspective, the lake has some capacity to accommodate further clearing and development around the lake, assuming internal nutrient loading factors associated with lake sediments stay the same. However, the latter three bullets above identify the particular sensitivities of the lake to future development. If such development incrementally adds to nutrient flows into the lake, such nutrients would largely be retained in the lake, either in the water column or lake sediments, and could trigger increased internal loading of the lake from the sediments. Therefore, the level of additional development that the lake can tolerate from a water quality perspective will be directly related to the ability of the developments to limit their incremental nutrient contributions to the lake, and cannot be simply calculated from the lake mass balance model. The following sections provide both regional and localized guidelines that can be used to implement a “minimum nutrient contribution” policy for development.

3.2 Short-term Management Recommendations for Residential Developments

Because the dynamics of internal nutrient loading of the lake from the sediments are not well understood with available data, future developments must proceed with a “minimum nutrient contribution” policy to ensure the on-going health and sustainability of the lake. This section provides recommendations for achieving such a policy.

Currently, six new residential developments are being proposed for the lake shoreline area, with a combined total of approximately 250 residential lots. Although many of the dwellings in these developments will be summer or weekend cottages, the developments will nevertheless require water wells and effluent collection systems, and will be placing additional pressure on the lake water and nutrient balance.

Sources of nutrients from such developments could potentially include:

- Sewage effluent
- Stormwater run-off from the developed lands

To meet the intent of a “minimum nutrient contribution” policy, the following recommendations are considered important for these developments:

3.2.1 Effective Protection of Surface Water Courses and Wetlands

As indicated in the baseline characterization study, surface streams are the predominant contributors of TP and TN to Sylvan Lake. Many of the larger streams that intersect a variety of upstream land use activities (e.g., agricultural areas) are likely already carrying high nutrient loads before they reach shoreline areas. Those that intersect shoreline development areas may experience additional nutrient loading from these sites. To prevent such incremental loading, “no development” protection zones around such surface water features are recommended as part of the development complex design.

Lacombe County has developed guidelines for residential developments, designed to protect shoreline areas of the lake through an environmental reserve. Starting from the high water mark of the lake, “the environmental reserve should be not less than 30 m (100 feet) wide except that where the lakeshore has moderate or steep slopes, the reserve should include the slope face and extend beyond the top of the bank (or crest of the escarpment) a distance of not less than 5 meters (16.4 feet)” (Lacombe County, February 2005, *Residential Lakeshore Development Supplementary Guidance*).

A minimum 30 m reserve or leave strip has been adopted as an appropriate land development guideline for the protection of watercourses and lakes by a number of provincial and federal authorities (Chilibeck 1992). Assuming that the leave strip supports native vegetative cover, it can effectively capture surface flows and associated sediment and nutrient loads in the vegetated area before they enter the waterbody of interest. The leave strip also provides a level of protection against surface introductions of contaminants or nutrients into shallow groundwater adjacent to lake or stream shores.

For the proposed new developments, it is recommended that the same “no development” reserve be assigned to all streams, as well to the boundaries of all wetlands occurring on or adjacent to the development site. As defined under the Wetlands of Canada (National Wetlands Working Group 1988), wetland types include bogs, fens, marshes, swamps or shallow water. It is recognized that some localized encroachments on this reserve may

have to be accommodated for access roads, provided that the road is designed to maintain cross-right-of-way drainage. However, housing should be prohibited from the reserve.

Figure 3-1 provides development constraints map, based on the known distribution of streams and wetlands around the lake, with recommended buffers.

3.2.2 Use of Communal Sewage Holding Tank Systems

The surficial geology surrounding the lake is dominated by a relatively consistent clay-rich till blanket. While the fine-textured nature of this material allows it to effectively adsorb nutrients such as phosphorous, the material has relatively slow water percolation rates and has a limited capacity for water retention. Therefore, this material is not a particularly good receptor for effluent from septic fields. Unless a network of natural cracks or fissures are present in the material, septic effluent may resurface before adequate nutrient removal or assimilation has occurred, leading to the potential for localized nutrient loading of the lake. During groundwater sampling conducted down gradient of septic fields for this study, wide ranging nutrient concentrations were measured among the wells, suggesting that septic field performance is highly variable around the lake.

Based on these conditions, all new development should be required to install communal holding tank systems, rather than septic fields. Holding tank effluent, for, the immediate term, should be trucked to the Sylvan Lake treatment facility for treatment and release. However, such a procedure would increase the amount of groundwater leaving the drainage basin; would reduce inflow into the lake; and would incrementally add to the already long retention time of the lake. Therefore, longer term plans to reintroduce this water back into the drainage basin would be required, and are discussed under medium- to long-term management recommendations below.

3.2.3 Landscaping Restrictions on Lawns and Gardens

The replacement of natural tree and shrub cover with buildings, roads, lawns and gardens can increase run-off rates into the lake from developed areas. This run-off, in turn, can be a contributing source of TP and TN to the lake if it encounters areas subjected to fertilizer applications. Therefore, to limit this nutrient source, restrictions on lawn and garden development should be implemented as a best management practice for those lots immediately adjacent to the recommended “no development” reserve for the lake, inflow streams and wetlands. A “no fertilizer” policy, although difficult to enforce, should also be encouraged for these areas. It would appear that lawn and garden development restrictions are not unlike architectural restrictions that can be placed on developments as a condition of purchase, and they would be the most effective means of limiting fertilizer requirements and use.

3.2.4 Storm Water Ponds and Monitoring Systems

To further limit the potential for surface run-off to contribute nutrients to the lake, detailed stormwater management plans should be submitted to the approving county for all new developments. These plans should clearly identify all features of the stormwater management system, such as catch basins, drainage swales, detention pond location and capacity, discharge procedures and water quality monitoring procedures proposed for the system. At the very least, these systems should ensure the following:

- Stormwater run-off will not be permitted to empty directly into the lake, streams or localized standing waterbodies on or adjacent to the development site without first passing through a detention pond where some ground infiltration and sedimentation reduction can occur.
- The detention pond should have the capacity to reduce post development peak run-off rates to pre-development levels for the developed area.
- Periodic monitoring of water quality parameters (e.g., TP, TN) in the detention pond should be undertaken to identify potential nutrient or contaminant issues.

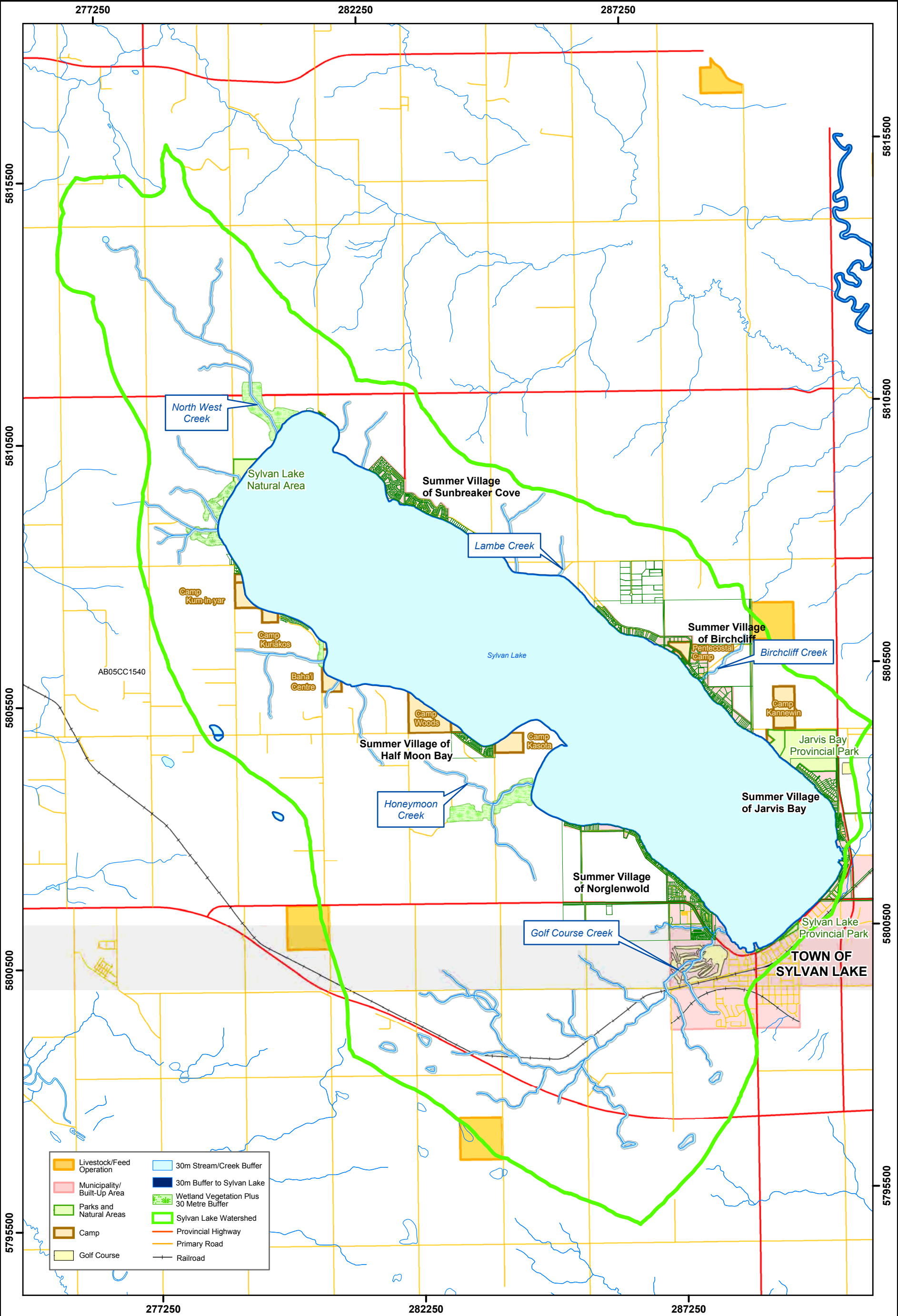
Stormwater management plans commonly incorporate natural or constructed wetlands as stormwater depositional areas, under the assumption that wetlands have a natural capacity to remove nutrients and contaminants from such water. However, natural wetlands are sensitive to changes in nutrient loading, pH, TDS and other water quality parameters, and changes in these parameters can degrade the natural characteristics and water “polishing” abilities of the wetland. Therefore, where such a system is being proposed, periodic (i.e., yearly) groundwater quality monitoring in the wetland should be required as part of development approvals to ensure that unforeseen nutrient or contaminant pathways are detected and mitigated. More details on best available practices for stormwater management are presented in Table 3-2 below.

The use of detention ponds in the management system, rather than direct inflow into wetland areas, provides the option of pumping stormwater into the communal sewage holding tanks for export and treatment, on the occasions that water quality in the pond does not meet surface release standards. This would ensure that stormwater would be an acceptable source of nutrients or contaminants to the lake.

3.3 Medium- to Long-term Management Recommendations

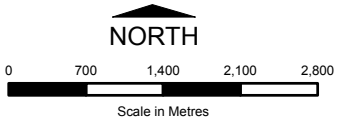
Currently, almost 75 percent of the Sylvan Lake drainage basin is occupied by agricultural land uses, and only 9 percent supports residential developments. While the area supporting residential developments will increase slightly with the six new proposals, the majority of land will still be agricultural.

Although lands supporting residential areas have a higher nutrient export coefficient than agricultural lands, the nutrient inflows into the lake are still very much dominated by agricultural sources because of the predominance of this land use activity in the drainage basin. Therefore, over the long term, the level of cumulative nutrient inputs into the lake can only be effectively managed with the cooperation of all land users in the basin, including the agricultural community. The following recommendations are more regional in context, and do not pertain specifically to proposed residential developments.



- Livestock/Feed Operation
- Municipality/ Built-Up Area
- Parks and Natural Areas
- Camp
- Golf Course
- 30m Stream/Creek Buffer
- 30m Buffer to Sylvan Lake
- Wetland Vegetation Plus 30 Metre Buffer
- Sylvan Lake Watershed
- Provincial Highway
- Primary Road
- Railroad

**Recomended Buffers to Waterbodies
and Proposed Developments**



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Consulting Ltd.

PREPARED BY					
		AXYS		Environmental Consulting Ltd.	
DRAFT DATE			SCALE		
25/01/2005			1:70,000		
REVISION DATE			PROJECT		FIGURE NO.
27/06/2005			POGDS 1250		3-1
DRAWN		CHECKED	APPROVED		
CS	DC	DB		VOL	

3.3.1 Broader Protection of Surface Watercourses and Wetlands

As discussed above, surface streams are the predominant contributors of TP and TN to Sylvan Lake. Many of the larger streams that intersect a variety of upstream land use activities (e.g., agricultural areas, golf courses) are likely receiving the majority of their nutrient loads from these upstream areas. Consequently, the same level of stream protection discussed for shoreline developments is required for the upstream reaches of these streams to effectively manage cumulative nutrient loads. It is recognized that the implementation of such protection is a regional initiative not linked to residential development approvals, requiring the buy-in and cooperation of all regional landowners. Such protection can be coordinated through such groups as the Alberta Riparian Habitat Management Society, and their Cows and Fish program. This program provides an interface to:

- Work with producers and communities on riparian health and management
- Provide an opportunity to help producers and communities present a proactive approach as good stewards of the land
- Assist in building community-based and producer driven groups to address local riparian issues
- Provide technical assistance on riparian management and health assessment
- Provide better information so producers can make informed decisions

Source: Alberta Riparian Habitat Management Society. <http://www.cowsandfish.org>

3.3.2 Maintenance Of Lake Water Balance

As previously discussed, Sylvan Lake has a relatively low annual average outflow, a high water residence time, and high (>95 percent) nutrient retention rates. Consequently, any action that reduces water input into the lake exacerbates this characteristic.

Currently, groundwater use by the town of Sylvan Lake reduces total water inflow into the lake by approximately 3 percent. Because this water is largely discharged into the town's sewage treatment system, it is lost to the basin and water balance.

Communal wastewater systems being proposed by most new residential developments will direct effluent into holding tanks, and the effluent in the tanks will be taken to a sewage treatment facility located outside of the Sylvan Lake watershed (i.e., no return of treated sewage effluent to the subsurface within the watershed). While this will prevent nutrient contributions from the developments, it will also further reduce groundwater flows into the lake. The results of this study suggest the impact could be minor. For example, the groundwater requirements to support the addition of 3,000 year-round residents would only decrease the total inflow to the lake from 3 percent (based on the 2003 withdrawals by the Town of Sylvan Lake) to 4 percent. Regardless, this represents additional cumulative inflow loss for the lake.

As a longer term planning initiative, consideration should be given to returning treated sewage back into the lake drainage basin from the town and future developments, provided that nutrient levels in the treated sewage can be reduced to acceptable levels that would not add to a nutrient loading problem. Depending on effluent quality, the re-introduction could be directly into the lake, or indirectly through groundwater by using

the effluent for agricultural or golf course irrigation. There may be the need for the construction of a second sewage treatment facility at the northern end of the lake to better accommodate developments.

3.3.3 Septic Field Performance Monitoring

The surficial materials dominating much of the area around the lake are not ideally suited to effective septic field operation. While new developments can be directed to employ communal collection systems to eliminate new risks from septic field installations, there are still a number of fields operating in the drainage basin, with little information on their performance and contributions to lake nutrient loading. During groundwater sampling conducted down gradient of septic fields for this study, wide ranging nutrient concentrations were measured among the wells, suggesting that septic field performance is variable around the lake.

While the summer villages are accredited with the authority to monitor septic field performance, the counties currently are not. Therefore, a regional body with appropriate authority needs to be identified in the counties to monitor field performance and identify potential problem sites.

3.4 Additional Data Needs and Monitoring Requirements

This study has identified that Sylvan Lake has the capacity to support additional residential developments without compromising its recreational and ecological values, providing that the developments adopt a “minimum nutrient contribution” strategy. However, some key data deficiencies still need to be addressed to better define the lake’s sensitivities to additional development and protection needs. In addition, several on-going monitoring initiatives are recommended to continue to track nutrient sources, transport pathways and lake health. Key initiatives are highlighted below.

- Monitoring of nutrient concentrations across lake depths (i.e., depth profiles) is required beginning in May and continuing until September to provide adequate information to determine whether internal nutrient loading is significant in Sylvan Lake. This should be done for a time frame where reasonably accurate information is available detailing all external loading to the lake, which is required for estimation of internal nutrient loading
- More rigorous monitoring of discharge of tributary streams to Sylvan Lake is required to provide estimates of surface inflow volumes to the lake, in conjunction with monitoring of nutrient concentrations in these streams. This would assist in reducing the uncertainties in the water balance, as well as the nutrient balance.
- More rigorous monitoring of discharge from the outflow channel, also in conjunction with monitoring of nutrient concentrations, to provide accurate estimates of outflow volumes and ultimately nutrient outputs from the lake. This is particularly important given that non-point sources of nutrients are the largest source to Sylvan Lake.
- A program aimed at evaluating the major sources of nutrients within tributary stream sub-basins would be of benefit. This information would serve to identify those activities that may be the largest contributors and areas that could benefit from remediation or additional management, and would provide information to assist in basin-wide management of nutrients.

- Septic systems should be inspected regularly to identify any faulty or sub-standard systems. The long-term goal of a program for the Sylvan Lake watershed would be to achieve a way in which the regulatory agencies can monitor septic systems and prevent further impacts to groundwater and the lake. The program would also raise public awareness of the relationship between water quality and malfunctioning septic systems. Consideration should be given to initiating a septic system re-inspection program, similar to those underway in southern Ontario (Vella 2002).
- A targeted monitoring program, focussed upon addressing the data gaps and uncertainties for a period of one or two years would be of benefit. An example is the Pine Lake Project: Diagnostic Study (Sosiak and Trew 1996), in which an intensive monitoring program was implemented for one year. Many of the activities conducted during the Pine Lake study have been undertaken already in the present study, but targeted monitoring to reduce uncertainties would be beneficial. This would, in turn, assist in future management activities by increasing the accuracy of nutrient loading from surface inflows to the lake and would increase the robustness of the water and nutrient balances. Furthermore, more targeted monitoring of nutrients within the lake would shed light on its current status as a sink for nutrients and the occurrence of internal nutrient loading. Without knowledge of the significance of internal nutrient loading in the lake, it is particularly difficult to project how future activities may affect the trophic status of the lake. Therefore, future monitoring directed at this particular issue would be recommended.
- A groundwater monitoring program should be initiated to develop a database of groundwater quality data for use in any future, similar studies. The program could include the annual sampling of some or all of the Alberta Environment observation wells and the semi-annual or annual sampling of the eight shallow monitoring wells installed for this study. In addition, consideration should be given to installing shallow monitoring wells near the lakeshore, downslope from future developments constructed in close proximity to the lake. Monitoring of those wells can provide early detection of any groundwater/lake impacts associated with the developments followed by appropriate remedial investigations or actions.

3.5 Adaptive Management

This study forms an important step in constructing an adaptive nutrient management strategy for Sylvan Lake that we recommend be developed to assist in responsible watershed planning and development to protect water quality. This approach has been recently advocated by governmental agencies responsible for nutrient management in Canada (e.g., Chambers et al. 2001; CCME 2004). Adaptive management is a key component of the nutrient management strategy and has been effectively used in many sectors of environmental assessment and management (e.g., forestry, fisheries management, lake management). Adaptive Management is “*A systematic process for continually improving management policies and practices by learning from the outcomes of operational programs. Adaptive management also provides a framework for actively responding to any inaccurate forecasts and ineffective mitigation measures.*” (CEAA 2005).

Adaptive management embodies the principle of linking monitoring with periodic adjustment of management regimes. Essentially, the iterative nature of adaptive management facilitates the incorporation of new information gained through data

collection and the ability to adjust management initiatives accordingly. This allows for effective allocation of resources and streamlined and targeted monitoring and/or remediation. It also incorporates the principle of scientific uncertainty which assists in determining risks and reaching management decisions.

3.5.1 The Adoption of Adaptive Management

Adaptive management involves six main steps which are represented in Figure 3-2. The first step in the Sylvan Lake Adaptive Management Strategy was to assess and define the current and historical water quality status of the lake (Section 2 of this study). This is a key step and the five subsequent steps are dependent on the conclusions and information generated by this first assessment step. Steps 2-6 of the cyclic process (i.e., design, implement, monitor, adjust) are addressed in this section of the report (Section 3.5).

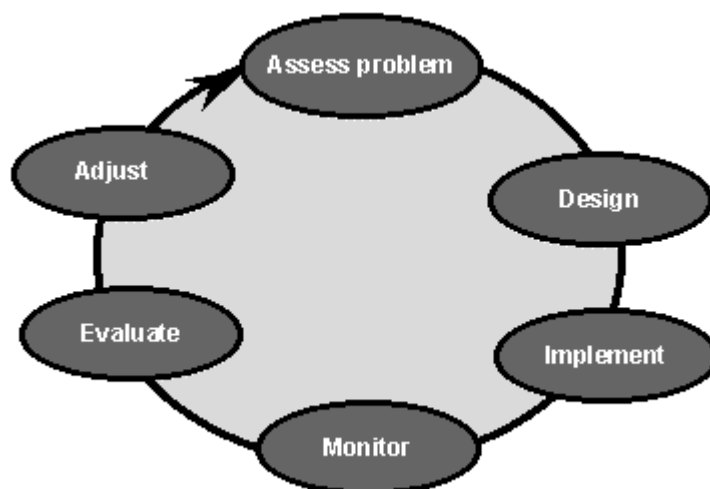


Figure 3-2 Adaptive Management: A six-step cyclic process

Source: BC Ministry of Forests (2005) <http://www.for.gov.bc.ca/hfp/amhome/Amdefs.htm>

Steps 2 and 3: Design management objectives and implement management options

Management objectives should be designed with input from watershed residents, stakeholders, regulatory agencies and other interested/affected parties (e.g., farmers, developers). Specific targets and measurement thresholds should be established for the area reflecting the desired level of protection. Based on the conclusions of the Sylvan Lake water quality and quantity assessment (Section 2), the most appropriate management options were identified for major land uses within the watershed (e.g., development; agriculture). These management options were in form of Best Management Practices (BMPs). Essentially, nutrient management in Canadian provinces and territories is implemented by the use of nutrient legislation, regulations, objectives, guidelines, BMPs and other measures (Chambers et al. 2001). From a watershed planning perspective, BMPs are the management options that can be specifically tailored towards the identified issues specific to that watershed and therefore the most useful at the local level. However, only BMPs that are recommended by reputable agencies and therefore have been proven to some extent should be considered.

Steps 4 and 5: Monitor and Evaluate

Water Quality monitoring for Sylvan Lake was first initiated in the 1970's but regular monitoring began in 1983. Some water quality variables, most notably TKN, have only recently been measured. Water quality in watershed streams has been monitored sporadically but most of the monitoring has occurred in the last 2 years. Synthesis and analysis of these data were undertaken in this study to evaluate the current water quality conditions in Sylvan Lake. Concomitant to that was the identification of areas where uncertainty still exists. Those data gaps were prioritized with the view that the higher priority issues would be carried through as monitoring recommendations to feed into the adaptive management process. Given that the current state of the lake has been assessed in terms of nutrients, monitoring should be directed towards addressing some of those high priority data gaps to gain the maximum benefit from funds allocated for future water quality monitoring in Sylvan Lake.

Thus ongoing water quality monitoring serves two main tasks:

- To address the high priority data gaps identified by the present study (Sections 3 and A.6) and build on the current water quality and limnological data set where required. This will improve the accuracy and reduce uncertainty associated with the water balance and the nutrient budget.
- To monitor the effectiveness of BMPs and management options adopted and implemented by watershed planners.

The fifth important step in the adaptive management process is to evaluate the monitoring and management outcomes with respect to the original management objectives. The importance of this step is sometimes underestimated in monitoring programs. In order to effectively implement a watershed nutrient management strategy for Sylvan Lake, the nutrient status of the lake should be periodically evaluated because the nutrient balance and thus the nutrient status of the lake are dynamic in nature and are not static entities.

Step 6: Adjust

This is a key step in the process which is often neglected. The conclusions drawn and uncertainties identified from the ongoing monitoring and evaluation steps should be fed back into the management process. This enables current data and conclusions derived from that data to be incorporated into future management decisions. Therefore the management process can be truly adaptive and able to respond to improvements in the understanding of the water quality, the water balance and the nutrient budget of the lake.

3.5.2 Summary

This adaptive management approach is consistent with the new federal framework for the management of phosphorus and other lake watershed management plans (e.g., Pine Lake). It is also consistent with current environmental practices and initiatives. This widely accepted approach brings many benefits to the watershed planner.

In terms of Sylvan Lake, the present study as a whole has provided the following specific tools to assist in responsible watershed planning and development based on water quality parameters:

- Supplemental data to partly address priority data gaps
- Compilation and synthesis of existing data to determine the current nutrient, hydrological, hydrogeological and trophic status of the lake
- A nutrient model (BATHTUB [Version 6.1]) calibrated for the Sylvan Lake watershed
- Prioritized data gaps to direct and focus future monitoring activities
- A constructed water balance
- A constructed nutrient balance
- An assessment of the trophic, hydrogeological and water quality status of the lake to date
- A comprehensive list of recognized BMPS recommended as options for nutrient management within the Sylvan Lake watershed
- A nutrient management strategy specific to Sylvan Lake based on the principles of adaptive management.

3.6 Summary of Recommendations

3.6.1 Immediate Term

- In addition to existing environmental setback requirements from the high water mark of the lake shore, the same “no development” setback should be assigned to all streams, as well to the boundaries of all wetlands occurring on or adjacent to a development site.
- All new development should be required to install communal holding tank systems, rather than septic fields.

-
- Lawn and garden restrictions should be implemented as part of purchase conditions for development lots immediately adjacent to the recommended “no development” reserve for the lake, inflow streams and wetlands.
 - Stormwater run-off should not be permitted to empty directly into the lake, streams or localized standing waterbodies on or adjacent to the development site without first passing through a detention pond where some ground infiltration and sedimentation reduction can occur.
 - Stormwater detention ponds should have the capacity to reduce post development peak run-off rates to pre-development levels for the developed area
 - Periodic monitoring of water quality parameters in the detention pond should be undertaken to identify potential nutrient or contaminant issues

3.6.2 Medium to Long-Term

- Protect the upstream reaches of streams in the sylvan lake watershed to effectively manage cumulative nutrient loads through regional initiatives such as the Alberta Riparian Habitat Management Society Cows and Fish program.
- To maintain the lake’s water balance, consideration should be given to returning treated sewage back into the lake drainage basin from the town and future developments, provided that nutrient levels in the treated sewage can be reduced to acceptable levels that won’t add to a nutrient loading problem.
- Continue to monitor septic field performance in the Summer Villages, and identify a regional body with appropriate authority in the counties to monitor field performance and identify potential problem sites.
- Develop an adaptive nutrient management strategy for Sylvan Lake to assist in responsible watershed planning and development to protect water quality

3.6.3 Best Management Practices

In addition to the key recommendations above, consideration should be given to the implementation of a number of additional best management practices that are widely propopmoted by provincial and federal agencies for the protection of land and water values. These BMPs have been summarized in Tables 3-1 through 3-5 below for a number of land use activities.

Table 3-1 Residential Property BMPs

Type	BMP	Description/Rationale	Source
Septic system	Develop an inspection program	Consideration should be given to initiating a septic system re-inspection program, similar to those underway in southern Ontario. The purpose of a re-inspection program is to identify and resolve hazards associated with malfunctioning septic systems.	Vella (2002)
	Require future development to install holding tanks	Although Lacombe County requires holding tanks for all new development, Red Deer County should also consider implementing this practice within the Sylvan Lake watershed.	Lacombe County Land Use ByLaw No. 772/92
Lawn care	Establish a buffer strip	A strip of natural vegetation between the lawn and a shoreline or wetland will provide localized erosion protection as well as filter nutrients, sediments and other pollutants from surface runoff before they reach receiving waters A minimum 30 m buffer is recommended. <i>Buffer strip: a permanent setback established from a shoreline or streambank which remains or is to be returned to a self-sustaining vegetated state of trees, shrubs and other vegetation.</i>	Ford (2004), F.X. Browne Inc. (2004), Lake Simcoe EMS (2003), MWLAP (2002), Nature Canada (2005), Valastin (1999), U of M (1998)
	Use sod when establishing a new lawn on a slope	Installing sod, rather than seeding, minimizes soil exposure which reduces erosion potential from runoff.	U of M (1998)
	Create a winding path or use stairs on any slope leading to the shoreline	Try to keep the path vegetated or the ground beneath the stairs vegetated. Path width should not exceed 2 m. This will aid in reducing erosion.	Valastin (1999)
Shoreline	Do not create an artificial beach.	The sand from artificial beaches can introduce nutrients into the lake. Once the sand erodes, it smothers spawning areas for fish, buries mayflies and covers aquatic vegetation. A swimming raft in deep water is an alternative to consider.	Ford (2004), FOC (2003), MWLAP (2002), Nature Canada (2005), Valastin (1999)
	Leave natural rocks and wave hardened sand in place	This substrate aids in reducing shoreline erosion. Rocks may also provide habitat for fish and other aquatic life.	Valastin (1999)

Table 3-1 Residential Property BMPs (cont'd)

Type	BMP	Description/Rationale	Source
Docks	Use a floating, pipe or pile dock.	These types of docks are the top environmental choices due to their minimal disturbance. Avoid the use of crib docks and concrete piers. Consult Fisheries and Oceans Canada prior to building or replacing a dock regarding proper permitting.	Ford (2004)
	Use appropriate building materials	Untreated wood such as cedar, fir, hemlock and tamarack are the safest options for docks. Use plastic wood as an alternative to untreated wood. Treated wood leaches wood preservative (chemicals) into the water.	FOC (2003), Ford (2004)
Construction/Landscaping	Install erosion and sediment control measures	Any activities that expose soil require the use of sediment and erosion control measures to mitigate potential sediment transport.	F. X. Browne Inc. (2004)

Table 3-2 Stormwater Management BMPs

Type	BMP	Description/Rationale	Source
Source Control	Installation of catch basins	If not already part of the town's storm sewer system, catch basins should be installed with a sump to trap silt and other debris that fall through the grates. To ensure proper spacing and capacity of catch basins, a stormwater engineer should be consulted.	AENV (1999b), AENV (1997)
	Semi-annually cleaning of all catch basins	Cleaning catch basins is effective in removing large runoff particulates and associated pollutants, but not fecal bacteria. Studies in the U.S. show cost effectiveness if this task is completed semi-annually.	AENV (1999b), AENV (1997)
Lot-Level	Reduced lot grading	This BMP should be considered during the planning stage of new development. In areas with relatively flat gradient, a reduction to minimum lot grades should be considered. In areas containing natural depressions and hills, alterations to the natural topography should be limited. Reducing the lot gradient limits the volume of runoff from small storm events that are usually the main stormwater contributor. This practice increases the travel time of runoff and increases the availability and opportunity for depression storage and infiltration.	AENV (1999b), AENV (1997)
	Use on-lot infiltration systems (soakaway pits)	On-lot infiltration systems allow stormwater to percolate into the groundwater and reduce stormwater surface flows.	AENV (1999b)

Table 3-2 Stormwater Management BMPs (cont'd)

Type	BMP	Description/Rationale	Source
Lot-Level (cont'd)	Direct roof leaders to surface ponding areas	When roof leaders are directed to rear yard depressions, stormwater is allowed to infiltrate and evaporate, limiting downstream flooding and erosion.	AENV (1999b), AENV (1997)
Road Surface	Use permeable paving surfaces	Permeable paving can result in 10-15% more surface infiltration by allowing water to seep through the roadway surface, so that natural filtration can still occur. Since engineered storm drainage systems are costly to design and build, use of permeable pavement systems can also result in a reduction of construction costs for developers or municipalities.	Andrade et. al. (2000), Toolbase Services (2004)
Stormwater Conveyance	Use grassed swales to convey stormwater	Grassed swales can reduce runoff volumes by as much as 95% compared to curb and gutter stormwater conveyance systems. Grassed swales increase the removal of pollutants and the amount of infiltration of stormwater, resulting in reduced erosion when compared to curb and gutter controls.	AENV (1999b)
End-of-Pipe	Construct stormwater wetlands	Constructed wetlands can provide deleterious substance removal through biological activity, uptake and conversion by plants, microbial degradation, and through physical processes such as sedimentation and filtration. Wetlands also have the benefit of providing habitat for wildlife. Constructed wetlands provide better opportunities for stormwater treatment than natural wetlands do because they can be designed for specific stormwater quality and quantity parameters.	AENV (1999b), Chilibeck (1992), Pries (1994)
	Use wet ponds	Wet ponds hold runoff and release it at slower rates than incoming flow, allowing the settlement of pollutants and nutrient uptake through biological processes. Provides a very reliable end-of-pipe BMP for water quality treatment when designed properly. Drainage area must be greater than 5 ha.	AENV (1999b), AENV (1997), Barr Engineering Co. (2003), Chilibeck (1992)
	Use infiltration trenches	One of the few BMPs that can reduce the amount of dissolved pollutants in stormwater. Infiltration trenches increase the rate of stormwater infiltration and are effective in managing runoff from small residential areas. Infiltration trenches are best used in conjunction with other stormwater management techniques.	AENV (1999b), AENV (1997), Barr Engineering Co. (2003), Chilibeck (1992)

Table 3-3 Agriculture and Livestock Operation BMPs

Type	BMP	Description/Rationale	Source
Land	Establish buffer strips along all water bodies (i.e., lake, river, stream, wetland)	A strip of natural vegetation between land use activities and water bodies will provide localized erosion protection as well as filter nutrients, sediments and other pollutants from surface runoff before they reach receiving waters. A minimum 30 m buffer is recommended. No fertilizer application should occur within buffer strips. Fencing the buffers should also be considered to ensure livestock and machinery cannot access this area. <i>Buffer strip: a permanent setback established from a shoreline or streambank which remains or is to be returned to a self-sustaining vegetated state of trees, shrubs and other vegetation.</i>	AAFRD (2004), Corkal (1997), Prepas and Charette (2003), U of M (1998)
Manure Management	Build a manure catchment	This catchment/pond contains built up manure and prevents it from draining into water bodies.	U of M (1998), AAFRD (2000), Lake Simcoe EMS (2003)
	Establish a grass filter strip to surround any manure catchments	A filter strip of grass sod surrounding the catchment captures sediment and utilizes excess nutrients from the manure catchment area. Based on studies conducted on the effectiveness in filter strips, a minimum width of 5 m should be implemented. The effectiveness of the filter strip in removing sediment and nutrients will increase with width up to a maximum of 20 m, but the first 5 m appears to be the most critical in filtration. <i>Filter strip: Often used interchangeably with buffer strip; however, in this report a filter strip refers to a strip or area of vegetation used for removing sediment, organic matter, and other pollutants from runoff and stormwater. Typically, a filter strip is comprised of dense grass.</i>	DEQ (1997), Gharabaghi et al. (2003), U of M (1998)
Watering	Develop livestock watering alternatives	Keeping cattle away from the water body is important. Cattle trample stream banks and shorelines, resulting in erosion and sediment issues; they also directly introduce waste into the receiving water. Watering alternatives include watering ponds/reservoirs, pumping systems, livestock nose pumps and pipelines. A less preferred approach would be to fence a restricted access area to the water body.	AAFRD (2000), AAFRD (2003), Corkal (1997), Fitch et al. (2003), Lake Simcoe EMS (2003), Prepas and Charette (2003), Valastin (1999)

Table 3-4 Golf Course Operation BMPs

Type	BMP	Description/Rationale	Source
Construction - sediment and erosion control	Design and implement a sediment and erosion control plan	A detailed plan must be written to ensure isolation of construction site. No sediment should be transported from the construction site or enter any water bodies.	Gartner Lee Ltd. (2001)
Operations at existing (older) courses	Development of buffers around watercourses	Naturalization of a minimum 5 m buffer strip can be achieved by establishing a “no mow” zone in these areas. No pesticides or fertilizers are to be applied in the buffer strips. <i>Buffer strip: a permanent setback established from a shoreline or streambank which remains or is to be returned to a self-sustaining vegetated state.</i>	Gartner Lee Ltd. (2001)
	Re-vegetation of eroded areas	Planting native species should aid in stabilizing these problem areas.	Gartner Lee Ltd. (2001)
	Redirect stormwater discharge	Stormwater discharge should be redirected, where applicable, into vegetated filter strips or swales.	Gartner Lee Ltd. (2001)
	Alter play and out of play areas	Reassess layout to see where to discontinue mowing or plant native species.	Gartner Lee Ltd. (2001)

Note: For more information, please refer to Best Management Practices and Guidelines for the Development and Review of Golf Course Proposals Gartner Lee Ltd. (2001).

Table 3-5 Educational BMPs

Type	BMP	Description/Rationale	Source
Lakeshore Residential Property Owners			
Septic system	Conserve water	Excessive water use is the most common cause of septic failure. A few ways to conserve water include shortening shower times, and installing low-volume toilets and showerheads.	Nature Canada (2005), Lake Simcoe EMS (2003), U of M (1998)
	Do not dispose of certain products down the drain	This includes coffee grounds, facial tissue, paper towel, tea leaves, fat or grease, cigarette butts, filters, disposable diapers, metal or metal items and products containing phosphate. Also refrain from using garbage disposals.	Nature Canada (2005), Lake Simcoe EMS (2003), U of M (1998)
	Do not add “starters” to your septic system	Additives cause the accumulated sludge to increase in volume, which will plug soil pores. They may also be carcinogens that will flow into ground water with treated waste.	Nature Canada (2005), U of M (1998)
	Pump the septic tank every year.	Annual pumping of septic tanks will maximize the efficiency of the septic system. Frequent pumping also helps rid your system of phosphorus and nitrogen which can make their way into surface water.	Nature Canada (2005), U of M (1998)

Table 3-5 Educational BMPs (cont'd)

Type	BMP	Description/Rationale	Source
Garden	Locate gardens properly	Do not locate garden on a slope because it will promote soil erosion and runoff. Do not locate garden on septic system because it will promote septic system freezing.	Ford (2004), Nature Canada (2005), Valastin (1999), U of M (1998)
	Use intense growing techniques	Techniques such as inter-cropping, succession planting, and raised beds will minimize the amount of exposed soil.	U of M (1998)
Lawn care	Do not use lawn fertilizer	Lawn fertilizers can contribute to nutrient build-up in the lake, especially if the lawn is sloped and runoff drains directly into the lake or tributary stream.	Ford (2004), MWLAP (2002), Valastin (1999), U of M (1998)
	Water lawn efficiently	Water deeply but infrequently to obtain maximum absorption. Water early in the morning to prevent evaporation of water.	Lake Simcoe EMS (2003), U of M (1998)
	Avoid the use of pesticides	Residues can contaminate water.	Ford (2004), Lake Simcoe EMS (2003), MWLAP (2002), U of M (1998)
	Rake and remove leaves from lawn and garden area.	These leaves will rot and their breakdown products will end up in the lake.	Valastin (1999)
	Do not rake wooded areas	These leaves aid in trapping and filtering runoff.	Valastin (1999)
	Compost grass clipping and vegetable waste away from the lake	Composting away from water bodies prevents the runoff of breakdown products to receiving waters.	Lake Simcoe EMS (2003), Valastin (1999), U of M (1998)
	Reduce lawn size and plant native vegetation	Reducing the size of a lake front lawn can aid in reducing runoff and erosion. Planting native plants and shrubs or leaving areas of the lawn to re-establish can aid in filtration of runoff.	Nature Canada (2005)
	Leave trees where they fall	Fallen trees and branches provide food and habitat for fish and wildlife, return nutrients to the soil, and protect shorelines and stream banks from erosion.	Nature Canada (2005), Ford (2004), Valastin (1999)

Table 3-5 Educational BMPs (cont'd)

Type	BMP	Description/Rationale	Source
Shoreline	Do not remove aquatic plants	Aquatic plants stabilize the lake bed and shore, reduce soil erosion, provide fish and wildlife habitat, and utilize excess nutrients in the lake. Removing aquatic plants for boat access requires a permit.	Valastin (1999), Ford (2004)
Stormwater Management			
Source control	Develop a dog faeces control program	Control programs can reduce up to 35% of fecal coliform bacteria reaching receiving waters. Such a program would provide plastic bags and place garbage bins near public use areas such as parks and trails as well as facilitate public awareness.	AENV (1999b), AENV (1997), Lake Simcoe EMS (2003)
Agriculture			
Fertilizing	Develop a nutrient management plan	Focuses on minimizing fertilizer input and optimizing crop yield to obtain a balance.	AAFRD (2004), F. X. Browne Inc. (2004), Hillard and Reedyk (2000)
	Test the soil regularly	Allows assessment of nutrient management by knowing the soil's nutrient levels. (recommend at least annual testing)	AAFRD (2004), Prepas and Charette (2003)
	Apply fertilizer/manure properly	Ensure the appropriate rate, timing, method and nutrient form are applied.	AAFRD (2004), Corkal (1997), Hillard and Reedyk (2000), Prepas and Charette (2003)
	Check fertilizer equipment regularly	Proper working condition ensures excess fertilizer is not applied.	AAFRD (2004)
	Avoid applying nitrogen to wet areas	When nitrogen is applied to wet areas it dissolves in water to form dissolved nitrogen forms (e.g., nitrite and nitrate). These are the most bioavailable forms of nitrogen to aquatic biota such as algae.	AAFRD (2004)
Land	Decrease the amount of summer-fallow land	Prevents soil erosion and reduces the amount of sediment and nutrient runoff.	AAFRD (2000), AAFRD (2004)
	Practice erosion control of cropped land	Practices such as mulch tillage, no-till and ridge till systems, contouring and grass field borders, and strip cropping reduce erosion and improve water quality as well as enhance farm operations.	Corkal (1997), Prepas and Charette (2003), U of M (1998)

Table 3-5 Educational BMPs (cont'd)

Type	BMP	Description/Rationale	Source
Livestock Operations			
Land	Manage pasture land appropriately	To prevent overgrazing and consequently the high potential for erosion and sediment transport.	Corkal (1997), Fitch et al. (2003)
Feed	Ensure proper storage/placement of silage and feed	Improperly contained silage can contaminate ground and surface water.	U of M (1998)
Golf Courses			
Turf Management	Choose appropriate grass (preferably native species)	As mentioned previously, grass type should be suited to the local climate and growing conditions. The grass chosen should also be efficient with water use and drought tolerant as well as minimize nitrogen loss through volatilization, leaching and surface runoff.	Gartner Lee Ltd. (2001)
	Set mowers to cut 1/3 of the grass height	This will improve infiltration and soil moisture retention, reduce surface runoff and encourage deeper root systems.	Gartner Lee Ltd. (2001)
	Retain the clippings on the course	In conjunction with good fertilizer practices, this will encourage better thatch and moisture retention.	Gartner Lee Ltd. (2001)
Fertilization	Use fertilizer appropriately	Use fertilizer in response to demonstrated needs and not as a preventative measure.	Gartner Lee Ltd. (2001)
	Develop and implement a fertilizer management plan	This plan should: ensure operator is informed of application procedures and requirements; minimize the amount of fertilizer applied; implement an irrigation plan that does not generate runoff; and specify that fertilizer should only be applied when required and at times when they can be lightly watered into the ground.	Gartner Lee Ltd. (2001)

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Appendix A:
Detailed Water Quality Assessment and
Watershed Management Considerations

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POGDS 1250

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Table of Contents

Appendix A	Detailed Water Quality Assessment and Watershed Management Considerations.....	A-1
A.1	Review of Water Quality and Limnological Conditions of Sylvan Lake.....	A-1
A.1.1	Background and Description of Water Quality and Sediment Quality Variables	A-1
A.1.2	Approach and Methods.....	A-7
A.1.3	Data Sources	A-8
A.1.4	Data Analysis.....	A-12
A.2	Results and Discussion	A-12
A.2.1	Water Quality Conditions	A-12
A.2.2	Sediment Quality	A-78
A.2.3	Phytoplankton Community	A-90
A.3	Water Balance.....	A-105
A.3.1	Historical Water Levels	A-106
A.3.2	Lake Bathymetry.....	A-106
A.3.3	Drainage Basin Area.....	A-108
A.3.4	Groundwater Component.....	A-112
A.3.5	Surface Water Component.....	A-113
A.4	Sylvan Lake Nutrient Balance	A-123
A.4.1	Nutrient Inputs: Sources and Loading Rates to Sylvan Lake	A-123
A.4.2	Nutrient Outputs from Sylvan Lake.....	A-132
A.4.3	Nutrient Balance	A-132
A.4.4	Lake Mass Balance Model.....	A-133
A.4.5	Discussion.....	A-137
A.5	Summary and Conclusions	A-138
A.5.1	Lake Water Quality, Sediment Quality and Limnology	A-138
A.5.2	Tributary Streams.....	A-139
A.5.3	Water Balance	A-140
A.5.4	Nutrient Balance	A-140
A.6	Uncertainties and Data Gaps.....	A-141
A.6.1	Water Quality and Limnology	A-141
A.6.2	Groundwater Outflow	A-142
A.6.3	Water Balance.....	A-143
A.6.4	Nutrient Balance	A-143
A.7	Implications for Watershed Planning and Development	A-144
A.7.1	Maintenance of the Lake's Trophic Status	A-144
A.7.2	Potential Effects From Increased Groundwater Use.....	A-149
A.8	Recommendations.....	A-149
A.9	References.....	A-150
A.9.1	Literature Cited	A-150
A.9.2	Personal Communication	A-153

List of Tables

Table A-1	Summary of Water Quality, Sediment Quality, and Limnological Sampling Conducted in Sylvan Lake and its Tributaries in September 2004.....	A-11
Table A-2	Statistical Summaries of Major Ions and Related Variables in the Euphotic Zone of Sylvan Lake: 1983–2003 ¹	A-18
Table A-3	Summary statistics for TKN, nitrate/nitrite, and ammonia for the open-water seasons of 1983-2004 (Data from Alberta Environment).....	A-39
Table A-4	Comparison between water balances and trophic status of several Alberta lakes. Data for the Sylvan Lake water balance were derived from this study and refer to the average for the period of 1956-2000. Water quality data for Sylvan Lake were provided by AENV and refer to the averaging period of 1983-2002 (May–September).....	A-40
Table A-5	Mean (and range) concentrations of major ions in Alberta lakes (Mitchell and Prepas 1990).....	A-41
Table A-6	Fecal coliform bacteria measured in the nearshore zone of Sylvan Lake, June 08- August 22, 1988. Samples were collected weekly (Mitchell 1989)...	A-51
Table A-7	Means, ranges, and number of samples of fecal coliform bacteria and <i>E. coli</i> measured in nearshore areas of Sylvan Lake, September 06, 2004.....	A-52
Table A-8	Water quality measured in situ in the open-water season of 2000, as presented in Carson and Allan 2001).....	A-53
Table A-9	Total phosphorus concentrations measured in four Sylvan Lake tributaries during March 2001, and April 2003 and 2004.....	A-75
Table A-10	Land Use Surrounding the Major Tributaries to Sylvan Lake.....	A-75
Table A-11	Total Nitrogen Concentrations Measured in Four Sylvan Lake Tributaries during March 2001, and April 2003 and 2004.....	A-76
Table A-12	Sediment Total Phosphorus Concentrations in Select North American Lakes	A-89
Table A-13	Classification schemes for lake trophic status. Means of water quality parameters for Sylvan Lake derived from historical data (1983-2003) for the open-water season	A-100
Table A-14	Summary and Comparison of Sylvan Lake’s Morphometric Characteristics, 2004 and 1961	A-108
Table A-15	Lake Morphometrics for a 1956-2000 and 1983-2000 Averaging Periods	A-108
Table A-16	Comparison between physical properties of several Alberta lakes. Data for Sylvan Lake were derived from this study and refer to the average for the period of 1956-2000.....	A-112
Table A-17	Mean Annual Inflows and Outflows for Sylvan Lake Water Balance: 1956-2000 and 1983-2000	A-116
Table A-18	Comparison between water balances and trophic status of several Alberta lakes. Data for the Sylvan Lake water balance were derived from this study and refer to the average for the period of 1956-2000. Water quality data for Sylvan Lake were provided by AENV and refer to the averaging period of 1983-2003 (May–September).....	A-121

Table A-19	Estimated Annual TP and TN Loading to and out of Sylvan Lake Associated with Surface Inflow, Groundwater Inflow, and Lake Outflow	A-124
Table A-20	Extent of Land Use Types within Sylvan Lake Watershed	A-124
Table A-21	Estimates of Annual TP and TN Loading to Sylvan Lake Based on Land Use Export Coefficients.....	A-125
Table A-22	Estimated Annual Septic Effluent Volume Discharged to Sylvan Lake by the Summer Villages.....	A-126
Table A-23	Annual Nutrient Balance for Sylvan Lake Using Flow-weighted Mean Concentrations (FWMC) of TP and TN for Surface Inflows and Using Land Use TN and TP Export Coefficients for Estimating Surface Inputs.....	A-129
Table A-24	Comparison between physical properties of several Alberta lakes. Data for Sylvan Lake were derived from this study and refer to the average for the period of 1956-2000.....	A-134
Table A-25	BATHTUB (Version 6.1) Model Settings for the Sylvan Lake Water Quality Model	A-135
Table A-26	Comparison Between Model Predicted and Observed Water Quality for the Calibration Period (1983–2000).....	A-135

List of Figures

Figure A-1	Sylvan Lake Watershed and Surrounding Area.....	A-3
Figure A-2	Sylvan Lake Water and Sediment Quality Sampling Sites, September 2004...	A-10
Figure A-3	Dissolved oxygen (A) and temperature (B) depth profiles measured at the AENV monitoring site AB05CC0650 in Sylvan Lake, open-water season, 1996.....	A-14
Figure A-4	Temperature depth profiles measured at the AENV monitoring site AB05CC0650 in Sylvan Lake: (A) profiles for the month of August; and (B) profiles in winter (January to March)	A-15
Figure A-5	Dissolved oxygen (DO) depth profiles measured at the AENV monitoring site AB05CC0650 in Sylvan Lake: (A) profiles for the month of August; and (B) profiles in winter (January to March)	A-16
Figure A-6	Dissolved oxygen (A) and temperature (B) depth profiles measured at three deepwater sites in Sylvan Lake in September, 2004.....	A-17
Figure A-7	Redox potential depth profiles at AENV monitoring site AB05CC0650 over the 1996 open-water season.....	A-19
Figure A-8	Redox potential depth profiles measured at the AENV monitoring site AB05CC0650 in Sylvan Lake: (A) profiles for the month of August; and (B) profiles for the month of February	A-20
Figure A-9	Redox potential depth profiles measured at three deepwater sites in Sylvan Lake in September, 2004	A-21
Figure A-10	pH depth profiles measured at the AENV monitoring site AB05CC0650 in Sylvan Lake: (A) profiles for the month of August; and (B) profiles in winter (January to March).....	A-23
Figure A-11	pH depth profiles measured over the open-water season at AENV monitoring site AB05CC0650 in Sylvan Lake, 1996	A-24

Figure A-12	pH depth profiles measured at three deepwater sites in Sylvan Lake in September, 2004	A-25
Figure A-13	Mean, minimum and maximum total phosphorus (TP) concentrations and mean chlorophyll <i>a</i> concentrations in composite samples from the euphotic zone of Sylvan Lake, 1983-2003	A-26
Figure A-14	Total phosphorus (TP) concentrations measured in composite samples collected from the euphotic zone of Sylvan Lake: (A) May; (B) June; (C) July; (D) August; and (E) September.....	A-27
Figure A-14	Total phosphorus (TP) concentrations measured in composite samples collected from the euphotic zone of Sylvan Lake: (A) May; (B) June; (C) July; (D) August; and (E) September (cont'd).....	A-28
Figure A-15	Median $\pm$ SE concentrations of total phosphorus (TP) and chlorophyll <i>a</i> measured in the euphotic zone of Sylvan Lake between May and September, 1983-2003. Data provided by AENV	A-29
Figure A-16	Seasonal variation of: (A) total phosphorus (TP), chlorophyll <i>a</i> , and Secchi disk depth; and (B) Total Kjeldahl Nitrogen (TKN), ammonia, and nitrate/nitrite in the euphotic zone of Sylvan Lake during the open-water season of 1996.....	A-30
Figure A-17	Seasonal variation of: (A) total phosphorus (TP), chlorophyll <i>a</i> , and Secchi disk depth; and (B) Total Kjeldahl Nitrogen (TKN), ammonia, and nitrate/nitrite in the euphotic zone of Sylvan Lake during the open-water season of 2000.....	A-31
Figure A-18	Seasonal variations in phosphorus concentrations in samples from the euphotic zone of Sylvan Lake in 1996: (A) total phosphorus (TP); and (B) dissolved phosphorus (DP)	A-33
Figure A-19	Total phosphorus (TP) (A) and dissolved phosphorus (DP) (B) depth profiles measured in winter (January – March) in Sylvan Lake.....	A-34
Figure A-20	Dissolved phosphorus (DP) (A) and total phosphorus (TP) (B) depth profiles measured in samples collected from sites on Sylvan Lake on September 06, 2004. Analytical detection limits (DL) are indicated by the dashed line	A-35
Figure A-21	Ammonia depth profiles measured in samples collected from Sylvan Lake in winter (January – March), 1986 to 2002.....	A-37
Figure A-22	Ammonia (A) and Total Kjeldahl Nitrogen (TKN) (B) depth profiles measured in samples collected from Sylvan Lake on September 06, 2004. Analytical detection limits (DL) are indicated by the dashed line.....	A-38
Figure A-23	Specific conductance measured in Sylvan Lake during: (A) August (1983-2002); and (B) the 1996 open-water season	A-42
Figure A-24	Relationship between Secchi disk depth and chlorophyll <i>a</i> concentrations in the euphotic zone of Sylvan Lake, 1983-2003. $p=0.05$	A-44
Figure A-25	Monthly mean ($\pm$ SE) Secchi disk depths for the euphotic zone of Sylvan Lake between May and September, 1983-2003.....	A-44
Figure A-26	Chlorophyll <i>a</i> concentrations measured in composite samples collected from the euphotic zone of Sylvan Lake: (A) May; (B) June; (C) July; (D) August; and (E) September	A-45

Figure A-27	Chlorophyll <i>a</i> and total phosphorus (TP) in the euphotic zone of Sylvan Lake during the 1988 open-water season.....	A-47
Figure A-28	Mean Secchi disk depths and chlorophyll <i>a</i> concentrations in the euphotic zone of Sylvan Lake, 1983–2003.....	A-49
Figure A-29	Chlorophyll <i>a</i> and total phosphorus (TP) in the euphotic zone of Sylvan Lake during: (A) 1992; and (B) 2001	A-50
Figure A-30	pH in the nearshore zone of Sylvan Lake, September 2004. Values represent mean and SE for Birchcliff (BC), Town of Sylvan Lake (TSL), Half Moon Bay (HB) and Sylvan Lake Natural Area (SLNA), and single measurements at Norglenwold (NORG), Jarvis Bay (JB) and Sunbreaker Cove (SBC).....	A-53
Figure A-31	Mean ($\pm$ SE) pH at deepwater sampling sites in Sylvan Lake, September 2004. Values represent averages of depth profiles at sites SLA, SLB and SLC and the single euphotic zone composite sample collected at SLD	A-54
Figure A-32	Water temperature, dissolved oxygen (DO) concentrations and DO saturation levels in the nearshore zone of Sylvan Lake, September 2004. Values represent mean and SE for Birchcliff (BC), Town of Sylvan Lake (TSL), Half Moon Bay (HB) and Sylvan Lake Natural Area (SLNA), and single measurements at Norglenwold (NORG), Jarvis Bay (JB) and Sunbreaker Cove (SBC).....	A-56
Figure A-33	Oxidation reduction potential in the nearshore zone of Sylvan Lake, September 2004. Values represent mean and SE for Birchcliff (BC), Town of Sylvan Lake (TSL), Half Moon Bay (HB) and Sylvan Lake Natural Area (SLNA), and single measurements at Norglenwold (NORG), Jarvis Bay (JB) and Sunbreaker Cove (SBC).....	A-57
Figure A-34	Oxidation reduction potential at deepwater sampling sites in Sylvan Lake, September 2004. Values represent averages of depth profiles at sites SLA, SLB and SLC and the single euphotic zone composite sample collected at SLD	A-57
Figure A-35	Concentrations of total phosphorus (TP) in the nearshore zone of Sylvan Lake, September 2004. Values represent mean and SE for Birchcliff (BC), Town of Sylvan Lake (TSL), Half Moon Bay (HB) and Sylvan Lake Natural Area (SLNA), and single measurements at Norglenwold (NORG), Jarvis Bay (JB) and Sunbreaker Cove (SBC)	A-58
Figure A-36	Concentrations of dissolved phosphorus (DP) in the nearshore zone of Sylvan Lake, September 2004. Values represent mean and SE for Birchcliff (BC), Town of Sylvan Lake (TSL), Half Moon Bay (HB) and Sylvan Lake Natural Area (SLNA), and single measurements at Norglenwold (NORG), Jarvis Bay (JB) and Sunbreaker Cove (SBC)	A-58
Figure A-37	Mean ($\pm$ SE) concentrations of total phosphorus (TP) at deepwater sampling sites in Sylvan Lake, September 2004. Values represent averages of depth profiles at sites SLA, SLB and SLC and the single euphotic zone composite sample collected at SLD.....	A-59

Figure A-38	Mean ($\pm$ SE) concentrations of dissolved phosphorus (DP) at deepwater sampling sites in Sylvan Lake, September 2004. Values represent averages of depth profiles at sites SLA, SLB and SLC and the single euphotic zone composite sample collected at SLD.....	A-59
Figure A-39	Concentrations of Total Kjeldahl Nitrogen (TKN) in the nearshore zone of Sylvan Lake, September 2004. Values represent mean and SE for Birchcliff (BC), Town of Sylvan Lake (TSL), Half Moon Bay (HB) and Sylvan Lake Natural Area (SLNA), and single measurements at Norglenwold (NORG), Jarvis Bay (JB) and Sunbreaker Cove (SBC)	A-60
Figure A-40	Mean ($\pm$ SE) concentrations of Total Kjeldahl Nitrogen (TKN) at deepwater sampling sites in Sylvan Lake, September 2004. Values represent averages of depth profiles at sites SLA, SLB and SLC and the single euphotic zone composite sample collected at SLD	A-60
Figure A-41	Concentrations of ammonia in the nearshore zone of Sylvan Lake, September 2004. Values represent mean and SE for Birchcliff (BC), Town of Sylvan Lake (TSL), Half Moon Bay (HB) and Sylvan Lake Natural Area (SLNA), and single measurements at Norglenwold (NORG), Jarvis Bay (JB) and Sunbreaker Cove (SBC).....	A-62
Figure A-42	Mean ($\pm$ SE) concentrations of ammonia at deepwater sampling sites in Sylvan Lake, September 2004. Values represent averages of depth profiles at sites SLA, SLB and SLC and the single euphotic zone composite sample collected at SLD	A-62
Figure A-43	Specific conductance in the nearshore zone of Sylvan Lake, September 2004. Values represent mean and SE for Birchcliff (BC), Town of Sylvan Lake (TSL), Half Moon Bay (HB) and Sylvan Lake Natural Area (SLNA), and single measurements at Norglenwold (NORG), Jarvis Bay (JB) and Sunbreaker Cove (SBC).....	A-63
Figure A-44	Mean ($\pm$ SE) specific conductance at deepwater sampling sites in Sylvan Lake, September 2004. Values represent averages of depth profiles at sites SLA, SLB and SLC and the single euphotic zone composite sample collected at SLD.....	A-63
Figure A-45	Magnesium concentrations in the nearshore zone of Sylvan Lake, September 2004. Values represent mean and SE for Birchcliff (BC), Town of Sylvan Lake (TSL), Half Moon Bay (HB) and Sylvan Lake Natural Area (SLNA), and single measurements at Norglenwold (NORG), Jarvis Bay (JB) and Sunbreaker Cove (SBC).....	A-64
Figure A-46	Mean ($\pm$ SE) concentrations of magnesium at deepwater sampling sites in Sylvan Lake, September 2004. Values represent averages of depth profiles at sites SLA, SLB and SLC and the single euphotic zone composite sample collected at SLD	A-64
Figure A-47	Calcium concentrations in the nearshore zone of Sylvan Lake, September 2004. Values represent mean and SE for Birchcliff (BC), Town of Sylvan Lake (TSL), Half Moon Bay (HB) and Sylvan Lake Natural Area (SLNA), and single measurements at Norglenwold (NORG), Jarvis Bay (JB) and Sunbreaker Cove (SBC).....	A-65

Figure A-48	Mean ($\pm$ SE) concentrations of calcium at deepwater sampling sites in Sylvan Lake, September 2004. Values represent averages of depth profiles at sites SLA, SLB and SLC and the single euphotic zone composite sample collected at SLD	A-65
Figure A-49	Sodium concentrations in the nearshore zone of Sylvan Lake, September 2004. Values represent mean and SE for Birchcliff (BC), Town of Sylvan Lake (TSL), Half Moon Bay (HB) and Sylvan Lake Natural Area (SLNA), and single measurements at Norglenwold (NORG), Jarvis Bay (JB) and Sunbreaker Cove (SBC).....	A-66
Figure A-50	Mean ($\pm$ SE) concentrations of sodium at deepwater sampling sites in Sylvan Lake, September 2004. Values represent averages of depth profiles at sites SLA, SLB and SLC and the single euphotic zone composite sample collected at SLD	A-66
Figure A-51	Bicarbonate concentrations in the nearshore zone of Sylvan Lake, September 2004. Values represent mean and SE for Birchcliff (BC), Town of Sylvan Lake (TSL), Half Moon Bay (HB) and Sylvan Lake Natural Area (SLNA), and single measurements at Norglenwold (NORG), Jarvis Bay (JB) and Sunbreaker Cove (SBC).....	A-67
Figure A-52	Mean ($\pm$ SE) concentrations of bicarbonate at deepwater sampling sites in Sylvan Lake, September 2004. Values represent averages of depth profiles at sites SLA, SLB and SLC and the single euphotic zone composite sample collected at SLD	A-67
Figure A-53	Secchi disk depth, total depth, and depth of the euphotic zone in the nearshore zone of Sylvan Lake, September 2004. Values represent mean and SE for Birchcliff (BC), Town of Sylvan Lake (TSL), Half Moon Bay (HB) and Sylvan Lake Natural Area (SLNA), and single measurements at Norglenwold (NORG), Jarvis Bay (JB) and Sunbreaker Cove (SBC)	A-68
Figure A-54	Concentrations of chlorophyll <i>a</i> in the nearshore zone of Sylvan Lake, September 2004. Values represent mean and SE for Birchcliff (BC), Town of Sylvan Lake (TSL), Half Moon Bay (HB) and Sylvan Lake Natural Area (SLNA), and single measurements at Norglenwold (NORG), Jarvis Bay (JB) and Sunbreaker Cove (SBC).....	A-70
Figure A-55	Total phosphorus (TP) concentrations in Sylvan Lake tributaries and the lake outflow	A-70
Figure A-56	Dissolved phosphorus (DP) concentrations in Sylvan Lake tributaries and the lake outflow.....	A-71
Figure A-57	Total nitrogen (TN) concentrations in Sylvan Lake tributaries and the lake outflow	A-71
Figure A-58	Dissolved inorganic nitrogen (DIN) concentrations in Sylvan Lake tributaries and the lake outflow.....	A-72
Figure A-59	Total suspended solid (TSS) concentrations in Sylvan Lake tributaries and the lake outflow.....	A-72
Figure A-60	Total fecal coliform levels in Sylvan Lake tributaries and the lake outflow	A-73
Figure A-61	Total <i>E. coli</i> Levels in Sylvan Lake Tributaries and the Lake Outflow	A-73
Figure A-62	Mean % composition of sediments collected from nearshore and offshore areas in Sylvan Lake	A-81

Figure A-63	Total organic carbon (%) in sediments collected from nearshore and offshore areas in Sylvan Lake (mean+/-SE)	A-81
Figure A-64	Moisture Content (%) in sediments collected from nearshore and offshore areas in Sylvan Lake (mean+/-SE)	A-82
Figure A-65	Total phosphorus (TP; µg/g dry wt) in sediments collected from nearshore and offshore areas in Sylvan Lake (mean+/-SE)	A-82
Figure A-66	Total nitrogen (TN; %) in sediments collected from nearshore and offshore areas in Sylvan Lake (mean+/-SE)	A-83
Figure A-67	Percent composition of five horizons from a sediment core taken offshore from the Town of Sylvan Lake	A-83
Figure A-68	Percent total organic carbon (TOC) of five horizons from a sediment core taken offshore from the Town of Sylvan Lake	A-84
Figure A-69	Total phosphorus (TP), phosphorus sorption capacity (PSC) and phosphorus sorption index (PSI) of five horizons from a sediment core taken offshore from the Town of Sylvan Lake	A-84
Figure A-70	Percent total nitrogen (TN) of five horizons from a sediment core taken offshore from the Town of Sylvan Lake.....	A-85
Figure A-71	Phosphorus sorption capacity (PSC; µg/g dry wt) in sediments collected from nearshore and offshore areas in Sylvan Lake (mean+/-SE).....	A-85
Figure A-72	Phosphorus sorption index (PSI; L/Kg) in sediments collected from nearshore and offshore areas in Sylvan Lake (mean+/-SE).....	A-86
Figure A-73	Relative abundance of major phytoplankton groups in Sylvan Lake in 1973 and 1974. Values are estimates based on data presented in Grant (1976).....	A-92
Figure A-74	Relative abundance of major phytoplankton groups collected in Sylvan Lake in July and August 1976, and September 2004. Samples collected in 1976 were collected at 1 m depth (A) and 10 m depth (B). The single sampled collected in 2004 was a composite sample of the euphotic zone. Abundance was based on number of cells/mL	A-93
Figure A-75	Abundance of major phytoplankton groups collected in Sylvan Lake in July and August 1976, and September 2004. Samples collected in 1976 were collected at 1 m depth (A) and 10 m depth (B). The single sampled collected in 2004 was a composite sample of the euphotic zone.....	A-94
Figure A-76	Relative abundance of major phytoplankton groups collected in a composite sample of the euphotic zone of Sylvan Lake on September 06, 2004. Relative abundance is presented based on the number of cells/mL and as a biomass (mg/m ³)	A-95
Figure A-77	Linear regressions between (A) chlorophyll <i>a</i> and total phosphorus (TP); and (B) chlorophyll <i>a</i> and TKN in Sylvan Lake. Data based on historical record provided by AENV. p=0.05.....	A-98
Figure A-78	Trophic status of Alberta lakes based on total phosphorus measured from May–September, 1980–2003. Figure provided by AENV (2004).....	A-103
Figure A-79	Trophic status of Alberta lakes based on chlorophyll <i>a</i> measured from May–September, 1980–2003. Figure provided by Alberta Environment (2004).....	A-104

Figure A-80	Water level of Sylvan Lake from 1956 to 2000. Red line indicates mean. Data provided by AENV	A-107
Figure A-81	Bathymetric Map of Sylvan Lake	A-109
Figure A-82	Sylvan Lake Drainage Basin.....	A-111
Figure A-83	Precipitation at Red Deer, Alberta, 1956-2000.....	A-114
Figure A-84	Annual Total Precipitation on Sylvan Lake, 1956-2000	A-115
Figure A-85	Annual total evaporation from Sylvan Lake, 1956-2000.....	A-117
Figure A-86	Stage Discharge Rating Curve for the Sylvan Lake Outlet	A-118
Figure A-87	Annual Total Surface Outflow from Sylvan Lake, 1956-2000.....	A-119
Figure A-88	Annual total surface water inflow to Sylvan Lake, 1956-2000	A-122
Figure A-89	Land Cover Classes within the Sylvan Lake Watershed	A-147

Abbreviations

%.....	percent
<.....	less than
>.....	greater than
~.....	approximately
°C.....	degrees Celsius
µg/g.....	microgram per gram
µg/kg.....	microgram per kilogram
µg/L.....	microgram per Litre
AB.....	Alberta
AENV.....	Alberta Environment
AES.....	Atmosphere Environment Service
ALMS.....	Alberta Lake Management Society
ANOVA.....	technique used to analyze variance
ASL.....	above sea level
AXYS.....	AXYS Environmental Consulting Ltd.
BC.....	British Columbia
CaCO ₃	calcium carbonate
CCME.....	Canadian Council of Ministers of the Environment
CFU.....	colony forming units
cm.....	centimetre
DIN.....	dissolved inorganic nitrogen
DL.....	detection limit
DO.....	dissolved oxygen
DP.....	dissolved phosphorus
<i>E. coli</i>	<i>Escherichia coli</i>
e.g.....	for example
i.e.....	<i>id est</i> (that is)
et al.....	<i>et alii</i> (and others)
FWMC.....	flow-weighted mean concentration
GIS.....	Groundwater Information System
km.....	kilometres
L/kg.....	Litres per kilogram
LEL.....	lowest effect level
m.....	metre
m ³ /d.....	metres cubed per day
m ³ /s.....	metres cubed per second
MAC.....	maximum acceptable concentration
mg/L.....	milligram per Litre
mL.....	milliLitre
mm.....	millimetre
mV.....	milliVolt
N.....	nitrogen
no.....	number
NO ₃	nitrate
OECD.....	Organization for Economic Co-operation and Development
P.....	phosphorus
pers. comm.....	personal communication

PFRA	Prairie Farm Rehabilitation Agency
pH	the measurement of a substance's acidity or alkalinity
PSC	phosphorus sorption capacity
PSI	phosphorus sorption index
redox	oxidation-reduction potential
SEL	severe effect level
sp.	species
SQG	sediment quality guideline
TDS	total dissolved solids
TKN	total kjeldahl nitrogen
TN	total nitrogen
TOC	total organic carbon
TP	total phosphorus
TSS	total suspended solids
USEPA	United States Environmental Protection Agency
vs.	versus
x	times

Appendix A Detailed Water Quality Assessment and Watershed Management Considerations

A.1 Review of Water Quality and Limnological Conditions of Sylvan Lake

The following sections provide discussion of data on water quality, sediment quality, and phytoplankton in Sylvan Lake and its tributaries. An overview of Sylvan Lake and its watershed are shown in Figure A-1. The emphasis of this review was evaluation of nutrients and related variables, in order to assist in the development of lake management plans. Data were compiled from all available sources of information including historical studies. In addition, as a component of this study, Sylvan Lake was sampled in September 2004 to evaluate water and sediment quality and phytoplankton species composition. Detailed methods and raw data derived from this study are presented in Appendix C. The components of this study are summarized below.

Available data were summarized and analysed for evidence of temporal changes and spatial differences (where applicable), and the nutrient status of Sylvan Lake was assessed based on this information. Additionally, comparisons were made to results of other similar studies especially those of other Alberta lakes. In particular, conditions in Sylvan Lake were compared to two other nearby lakes (Pine Lake and Gull Lake) that are located in the same regional drainage basin. The following sections provide a summary of water quality (Section A.2.1), sediment quality (Section A.2.2), and phytoplankton community composition (Section A.2.3) data and conditions in Sylvan Lake, based on the sources of information indicated below.

A.1.1 Background and Description of Water Quality and Sediment Quality Variables

A.1.1.1 Water Quality

Water Clarity: Total Suspended Solids (TSS), Secchi Disk depth and Turbidity

Water clarity can be described using measures of Secchi disk depth, TSS, or turbidity. Secchi disk depth is the depth at which a black and white disk is no longer visible when lowered into the water column. TSS and turbidity are indicators of the scattering of light by suspended particles in water. Turbidity and total suspended solids can affect the suitability of water used for drinking and recreation, aquatic life, and affect the aesthetic quality of aquatic ecosystems.

At very high concentrations, TSS can threaten aquatic life, reduce fish growth rates, modify fish movements, affect fish egg and larval development, impair fish foraging and predation behaviour, reduce the abundance of fish diet items, affect reproduction and the immune systems of aquatic biota, and harm benthic habitats. At lower concentrations, suspended sediment can influence aquatic ecosystems by reducing light penetration into the water column, thereby limiting the growth of plants and algae, and may affect behaviour of aquatic life (e.g., predation success of fish).

Dissolved Oxygen (DO)

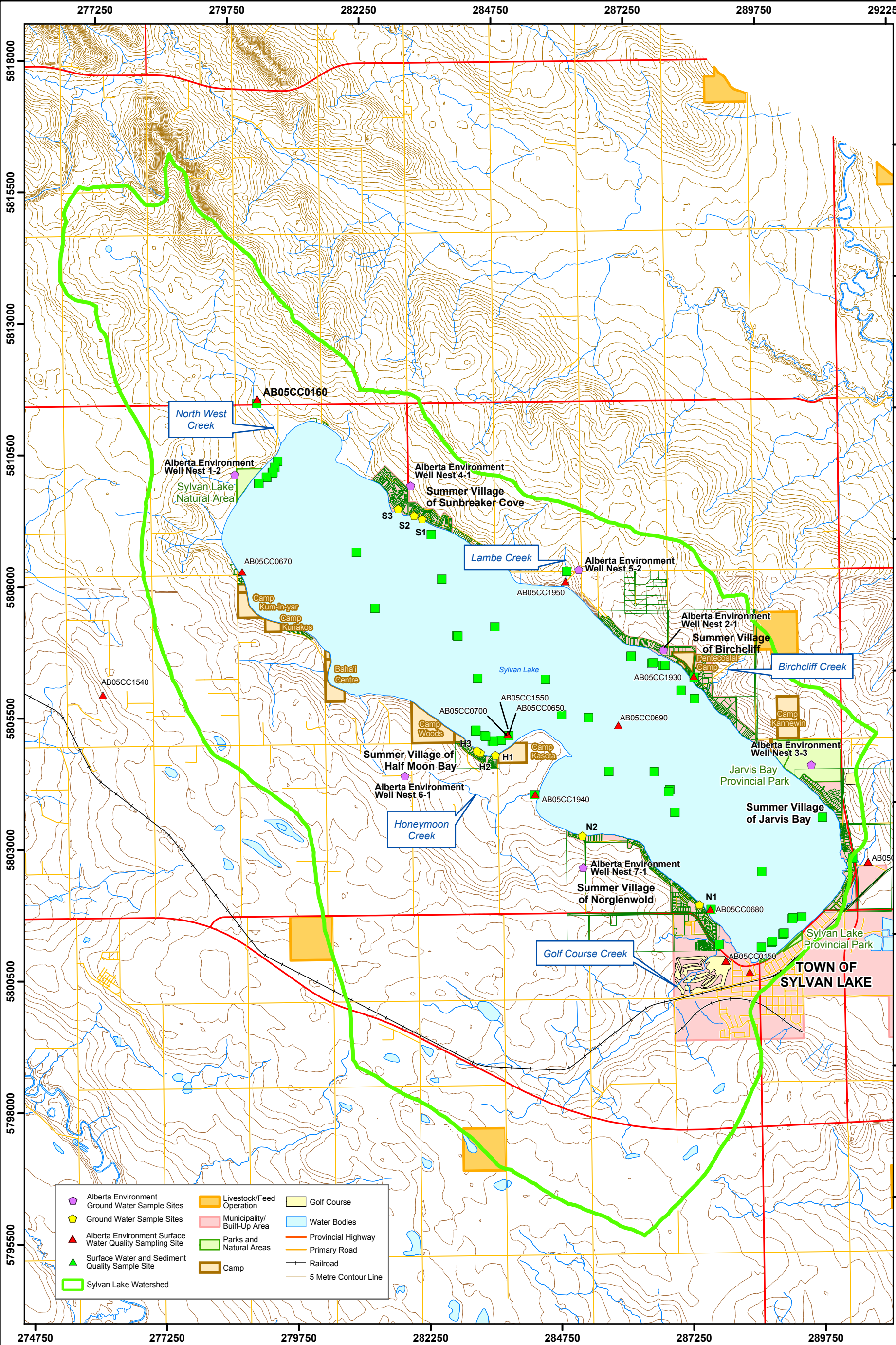
Dissolved oxygen is essential for the survival of most aquatic biota. It is consumed by aquatic organisms including, animals, plants, algae, and bacteria in the water column and sediments. Re-aeration (i.e., input of oxygen from the atmosphere) and photosynthesis by plants and algae supply dissolved oxygen to aquatic systems. Dissolved oxygen concentrations are affected by water temperature; water can hold more oxygen at lower temperatures. DO is often expressed as a percent saturation which is a measure of the amount of dissolved oxygen in the water, relative to its total capacity to hold DO at a given temperature. When a lake stratifies, DO in the water column tends to vary with depth; typically decreasing with increasing depth. In the open-water or ice-cover seasons, DO may decrease with depth and may become depleted at the bottom (i.e., hypolimnetic oxygen depletion). This occurrence may be harmful to aquatic life, particularly to those biota associated with or living in or on the sediments. Fish eggs deposited on substrates at the bottom of lakes and rivers can be adversely affected by low dissolved oxygen conditions.

Nutrients

Nitrogen and phosphorus are the principle plant and algal nutrients. In aquatic ecosystems, they support the growth of aquatic plants, benthic algae (i.e., periphyton), and algae in the water column (phytoplankton). Sources of nutrients in surface waters include the breakdown of organic matter, excretion by organisms, wastewater discharges, erosion and runoff from nutrient-rich soils, agricultural activities (e.g., fertilizer use), and atmospheric deposition. Nutrients are not toxic at the concentrations normally found in surface waters. However, nutrient enrichment (i.e., eutrophication) can stimulate excessive growth of plants and algae, which can subsequently lead to the degradation of aquatic habitat through physical changes (e.g., excessive plant or algal growth), and through changes to water quality (reduced dissolved oxygen at night, reduced water clarity due to, algae and possible production of toxins by some forms of algae). Stimulation of plant or algal growth by nutrient enrichment in individual water bodies also depends on several other factors that potentially limit plant or algal growth, such as water clarity, temperature, flushing rates, turbulence, velocities, solar radiation, and grazing by zooplankton (i.e., microscopic animals that consume algae).

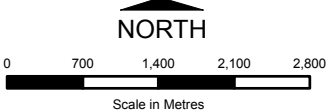
Nitrogen exists in several forms in surface waters: ammonia, nitrate/nitrite, and organic nitrogen. The nitrogen cycle consists of the mineralization of organic nitrogen to ammonia and subsequent 'nitrification' (i.e., breakdown) of ammonia to nitrite and nitrate. The latter process consumes oxygen and where ammonia concentrations are high, can lead to critical depletion of DO in aquatic systems. Dissolved ammonia, nitrite, and nitrate, which are often collectively referred to as dissolved inorganic nitrogen (DIN), are taken up by plants and algae and so are essential nutrients. However, ammonia and nitrate may be toxic to aquatic life at sufficiently high concentrations.

Phosphorus exists in organic and inorganic forms in surface waters. Plants and algae take up inorganic phosphorus and release organic phosphorus through decomposition. Until recently, it has generally been accepted that phosphorus is most often the limiting nutrient for plant and algal growth in lakes. However, more recent research and monitoring have indicated that nitrogen may be the limiting nutrient in many systems. In particular, recent studies have indicated that nitrogen is frequently limiting in Canadian prairie ecosystems.



SYLVAN LAKE WATER QUALITY STUDY

Sylvan Lake Watershed and Surrounding Area



Acknowledgements:
Original Drawing by AXYS Environmental Consulting Ltd.

PREPARED BY			
DRAFT DATE	25/01/2005	SCALE	1:70,000
REVISION DATE	27/06/2005	PROJECT	POGDS 1250
DRAWN	CHECKED	APPROVED	VOL
CS	DC	DB	
			FIGURE NO. A-1

pH

The pH of water indicates the acidity of the system, and is influenced by nutrients, organic acids, metals, gases, algae (i.e., photosynthesis), solar radiation (i.e., temperature), and particulates (CCME 1999). Changes in pH can influence the chemical state of important plant nutrients such as phosphate, ammonia, iron, and trace metals (Horne and Goldman 1994). Fairly wide ranges of pH in surface waters are suitable for aquatic life and wildlife. pH may directly threaten aquatic biota (i.e., highly acidic or alkaline conditions) or may be indirectly harmful to aquatic life (e.g., increase toxicity of ammonia and metals). Reductions of pH may mobilize metals bound in sediments (i.e., release metals to water) and may alter the physico-chemical form of metals in aquatic systems. pH may be altered by flooding of soils, decomposition of organic matter, and photosynthesis.

Hardness

Hardness, a measure of the concentration of calcium carbonate in water, affects the accumulation and toxicity of numerous metals to aquatic biota (i.e., metals are less toxic to aquatic life in hard water). Hardness is a reflection of the type of soil minerals and bedrock in the local environment, as well as the hydrological characteristics of the area (e.g., length of time water is in contact with bedrock). In general, soft water occurs in watersheds characterized by igneous rock, whereas hard water occurs in systems draining through carbonate rock (Williamson and Ralley 1993).

Alkalinity

Alkalinity is a measure of the water's acid neutralizing capacity, which is largely dependent upon the concentration of hydroxides, bicarbonates, and carbonates in the water. It is generally a reflection of the local geology and bicarbonates being leached from the soil. Lakes with low-buffering capacity may be more susceptible to acidification due to flooding or acidic precipitation. High alkalinity may indicate high levels of primary production and nutrient inputs. The sensitivity of lakes to acidification is often categorized on the basis of total alkalinity. A common categorization is: lakes with a total alkalinity between 0 and 10 mg/L as CaCO_3 are deemed highly sensitive to acidification; lakes with a total alkalinity of 11 to 20 mg/L as CaCO_3 are deemed moderately sensitive to acidification; lakes with a total alkalinity between 21 and 40 mg/L as CaCO_3 are deemed to have low sensitivity to acidification; and, lakes with a total alkalinity in excess of 40 mg/L as CaCO_3 are deemed to have very low sensitivity to acidification (Palmer and Trew 1987).

Total Dissolved Solids (TDS) and Conductivity

Total dissolved solids and conductivity are measures of the amount of minerals and organic matter dissolved in water, reflecting both natural conditions such as local geology, and anthropogenic activities that increase these substances in water (e.g., mining effluents, agricultural runoff). TDS may affect the quality of water for human use (i.e., taste, scaling, corrosion, and laxative effects).

Bacteria

Pathogenic bacteria (fecal coliform bacteria) can be spread through the release of untreated human and livestock wastes into surface waters. Fecal coliform bacteria are

commonly used as indicators of bacterial contamination. However, coliform bacteria may also be introduced to aquatic ecosystems from wildlife. *Escherichia coli* (i.e., *E. coli*) is a species of bacteria that is a direct indicator of contamination by warm-blooded animals.

Major Ions and Trace Elements

Major ions, metals, and metalloids (i.e., trace elements) are typically present in surface waters and sediments. They are introduced to surface waters through erosion and weathering of soils and rock and atmospheric deposition. Whereas high levels may occur naturally in some waterbodies, they may become elevated due to various anthropogenic activities including, acidification (e.g., acid rain), agricultural activities, mining and smelting, combustion of fossil fuels, or the release of municipal and industrial effluents. Plants and animals need low levels of many trace elements but at sufficient concentrations, metals (such as nickel, cadmium, and mercury) can be harmful to fish, wildlife, and humans. In aquatic ecosystems, metals may bioaccumulate in aquatic biota via both exposure to metals in water and via ingestion of food containing metals.

Oxidation-Reduction Potential (redox)

Oxidation-reduction potential (redox) describes the potential required for electrons to flow from one compound or element to another. It is used to describe the state of oxidation of water. The relevance of redox potential in water bodies is its effect on the flux of substances such as phosphorus between sediments and water. Low redox potentials near the bottom of water bodies may lead to the release of phosphorus to the overlying water column. This effect may be of significance with respect to nutrient enrichment, as it can affect internal loading of nutrients.

Chlorophyll a

Chlorophyll *a* is a pigment that is commonly used indicator of algal biomass. Because algal biomass is dependent upon a number of factors other than nutrients alone, chlorophyll *a* is commonly monitored in aquatic ecosystems to determine the amount of algae. It can also be used as an indicator of the trophic status of water bodies.

A.1.1.2 Sediment Quality

Sediment Composition and Moisture Content

Sediment composition refers to the relative proportion of sediment particle types (sand, silt, clay) present in a sediment sample, expressed as percentages. The method by which the composition is determined is termed 'particle size analysis' and it is the standard method by which the composition of sediments is categorized. The composition of the sediment is important in determining the ability of the sediment to adsorb and incorporate nutrients and contaminants from the overlying water. For example, clay has a very high capacity to adsorb or remove phosphorus from the overlying water compared to either silt or sand. Sand has the lowest adsorption capacity and silt is intermediate. The moisture content of sediments refers to the ability to retain water (porosity). Sand is very porous and so it has the lowest moisture content; clay has the highest moisture content, and silt is intermediate.

Sediment Phosphorus and Nitrogen

Phosphorus and nitrogen adsorbed and incorporated into sediments are referred to as sediment phosphorus and nitrogen. Phosphorus and nitrogen associated with sediments are generally not available for uptake by biota (e.g., microbes, plants, invertebrates). Phosphorus and nitrogen can under certain conditions, be released into the overlying water in forms that are available for uptake by biota.

Sediment Phosphorus Sorption Capacity

The sediment phosphorus sorption capacity is the ability of sediment to accumulate increasing quantities of phosphorus from the water column. Sediments close to saturation have low phosphorus sorption capacities as they have a low capacity to adsorb additional phosphorus from the overlying water.

A.1.2 Approach and Methods

A summary of the overall approach and methods employed is given here but the reader is referred to Appendices B and C for a detailed description of the approach taken and the methods employed.

A.1.2.1 Lake Water Quality, Sediment Quality, and Limnology

To address the objectives of this study regarding conditions of Sylvan Lake, available historical data on water quality, sediment quality, and limnology in Sylvan Lake were compiled and evaluated. Additionally, a field sampling program was conducted in September 2004 to:

- provide information on the spatial variability of water quality in the lake;
- evaluate conditions in nearshore areas;
- to update and digitize lake bathymetry;
- evaluate sediment quality in deep and nearshore areas of the lake; and,
- evaluate potential historical changes in sediment quality through collection of a sediment core.

Additionally, water quality of inflowing tributary streams was examined to assist in the determination of the sources and loads of nutrients to Sylvan Lake. Data collected by Alberta Environment (AENV), as well as samples collected in September 2004, were evaluated.

A.1.2.2 Water Balance

A water balance for Sylvan Lake was constructed in which the surface and groundwater inflows, lake evaporation, precipitation, and surface and groundwater outflows, were estimated using available hydrological and climatological data, in conjunction with information on lake morphology and drainage basin area. The water balance represented a 45-year period (1956-2000). The model was not extended to 2003 due to the lack of published evaporation rates beyond 2000. The basic formula used to construct the water balance was:

Change in lake storage = Total inflows (water entering the lake) - total outflows (water leaving the lake).

Elements of the water balance were then used in the derivation of a nutrient balance for the period of 1983-2000.

A.1.2.3 Nutrient Balance

Phosphorus and nitrogen levels and consequently the trophic status of Sylvan Lake are dependent upon the balance between external and internal nutrient inputs into the lake, and nutrient outputs (export) out of the lake. Inputs into the lake, defined as phosphorus and nitrogen loads, are derived from surface inflow, septic field effluent inflow, groundwater inflow, atmospheric deposition, and internal loading from phosphorus enriched sediments. Phosphorus and nitrogen are potentially exported from the lake via surface and groundwater outflows. The levels of phosphorus and nitrogen retained by the lake were calculated by subtracting the total nutrient loads exported from the lake (outputs), from the sum of the nutrient inputs into the lake and any internal loading from the sediments. The resultant nutrient loading represents the nutrient load retained in the lake (i.e., nutrient retention).

Because the majority of water quality monitoring activities in Sylvan Lake began in 1983, the nutrient balance was constructed for the period of 1983-2000 (further extension of the balance beyond 2000 was not possible owing to gaps in the data required for the water balance).

A.1.2.4 Lake Mass Balance Model

To assist in determining the potential sensitivity of Sylvan Lake to increased nutrient loading, a mass balance water quality model was constructed using the BATHTUB (Version 6.1) model. The model is generally used to evaluate eutrophication in lakes and reservoirs and an earlier version of this model was recently used by AENV to evaluate the proposed mitigation activities in Pine Lake, AB (Sosiak 1997).

A.1.3 Data Sources

A.1.3.1 Historical Data

There are a number of sources of data describing recent and historical water quality and limnological conditions of Sylvan Lake. Alberta Environment (AENV) regularly monitored Sylvan Lake beginning in 1983. More recent studies (2000, 2001 and 2003) were conducted by the Alberta Lake Management Society (ALMS). Reports produced as a result of these routine monitoring activities include: Mitchell (1996, 1999); and McEachern (2000, 2003).

Other sources of historical information include several short-term studies conducted over the last several decades in which water quality and limnology of Sylvan Lake were evaluated. These studies include:

- A water quality and phytoplankton study of Sylvan Lake conducted in 1973 and 1974 (Grant 1976);
- A water quality and phytoplankton study of Sylvan Lake conducted in the summer of 1976 (Jones et al. 1976);
- A study of bacteria in nearshore areas and storm sewer outfalls and ditches near the Town of Sylvan Lake (Mitchell 1988); and,

- *In situ* measurements collected near the Sylvan Lake Natural Area, in support of proposed development applications (Carson and Allan 2001, 2002).

Additionally, Mitchell and Prepas (1990) provide an overview of the physical, chemical, and biological conditions of Sylvan Lake in the Atlas of Alberta lakes.

A.1.3.2 September 2004 Study

As a component of this study, a water and sediment quality sampling program was conducted in September 2004 to provide further information on the current nutrient conditions in Sylvan Lake. The main objective of this program was to examine the nutrient status of the lake. Additionally, a bathymetric survey was conducted in September 2004 to update and digitize the historical bathymetric map of Sylvan Lake that was originally generated in 1961 (see Section A.4.2).

The water quality sampling program consisted of collecting samples of surface water from four offshore areas and seven nearshore areas (Figure A-2). The offshore sites were sampled to characterize the deeper water zone, as indicated in Figure A-2. Samples were collected from several depths at three sites and a composite sample was collected from the euphotic zone (i.e., the depth where light penetrates). The location of, and collection methods employed for, the latter site were consistent with the methods employed by AENV in their monitoring program of Sylvan Lake. Additionally, samples were collected from seven nearshore areas adjacent to the following areas:

- Town of Sylvan Lake
- Summer Village of Half Moon Bay
- Sylvan Lake Natural Area
- Summer Village of Birchcliff
- Summer Village of Jarvis Bay
- Summer Village of Sunbreaker Cove
- Summer Village of Norglenwold

Two tributary streams, Golf Course Creek and Northwest Creek, were flowing at the time of the water quality sampling program. Samples of surface water were collected from these creeks for analysis. Discharge was measured to facilitate computation of nutrient loads. Water quality variables examined in the study included nutrients (phosphorus, nitrogen), dissolved oxygen (DO), pH, conductivity, temperature, major ions, and bacteria.

The composite sample collected from the deepwater area of Sylvan Lake was also analysed for phytoplankton species composition and biomass.

Sediments were also collected from the four deepwater locations and at four of the nearshore areas (Sylvan Lake Natural Area, Town of Sylvan Lake, Summer Village of Half Moon Bay, and Summer Village of Birchcliff). Samples were analysed for nutrients, phosphorus sorption capacity (PSC), and supporting variables (i.e., particle size and organic matter).

Detailed methodologies and results of this study are presented in Appendix C. A summary of sampling conducted in Sylvan Lake and its tributaries in September 2004 is provided in Table A-1.

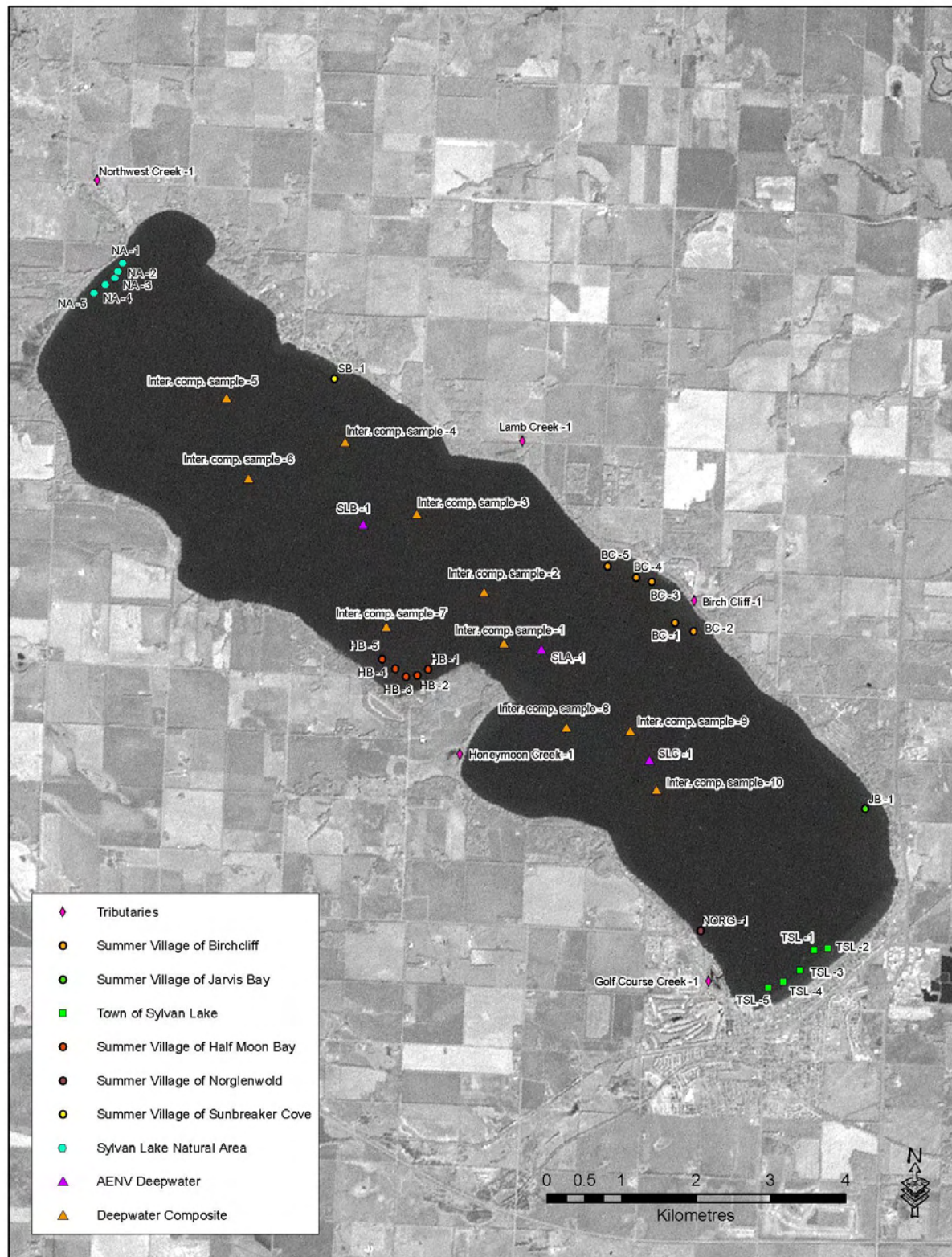


Figure A-2 Sylvan Lake Water and Sediment Quality Sampling Sites, September 2004

Table A-1 Summary of Water Quality, Sediment Quality, and Limnological Sampling Conducted in Sylvan Lake and its Tributaries in September 2004

Location	Site ID	Water Quality	Sediment Quality	Limnology
Deep Sites				
Sylvan Lake - 18 m	SLA	Depth profiles	No samples taken	Depth profiles of <i>in situ</i> parameters
Sylvan Lake - 16 m	SLB	Depth profiles	1 composite sample (5 grab samples)	Depth profiles of <i>in situ</i> parameters
Sylvan Lake - 14 m	SLC	Depth profiles	1 composite sample (5 grab samples)	Depth profiles of <i>in situ</i> parameters
Sylvan Lake composite	SLD	Composite of 10 samples of euphotic zone	No samples taken	Composite sample of euphotic zone for algal taxonomy and biomass; <i>in situ</i> parameters measured at 1 m
Sylvan Lake - 7 m	SLE	No samples taken	1 sediment core taken	No samples taken
Nearshore Sites				
Town of Sylvan Lake	TSL	Replicate grab samples (n = 5)	1 composite sample (5 grab samples)	<i>In situ</i> parameters measured at surface, mid-depth, and bottom
Summer Village of Norglenwold	NORG	Single grab sample (n = 1)	No samples taken	<i>In situ</i> parameters measured at surface, mid-depth, and bottom
Summer Village of Birchcliff	BC	Replicate grab samples (n = 5)	1 composite sample (5 grab samples)	<i>In situ</i> parameters measured at surface, mid-depth, and bottom
Summer Village of Half Moon Bay	HB	Replicate grab samples (n = 5)	1 composite sample (5 grab samples)	<i>In situ</i> parameters measured at surface, mid-depth, and bottom
Summer Village of Jarvis Bay	JB	Single grab sample (n = 1)	No samples taken	<i>In situ</i> parameters measured at surface, mid-depth, and bottom
Summer Village of Sunbreaker Cove	SBC	Single grab sample (n = 1)	No samples taken	<i>In situ</i> parameters measured at surface, mid-depth, and bottom
Sylvan Lake Natural Area	SLNA	Replicate grab samples (n = 5)	1 composite sample (5 grab samples)	<i>In situ</i> parameters measured at surface, mid-depth, and bottom
Tributary Streams				
Golf Course Creek	GCC	Single grab sample (n = 1)	No samples taken	<i>In situ</i> parameters measured
Northwest Creek	NWC	Single grab sample (n = 1)	No samples taken	<i>In situ</i> parameters measured

A.1.4 Data Analysis

Historical water quality data provided by AENV were compiled and statistically summarized to assist in data interpretation. Parameters that may vary over the open-water season (including nutrients, Secchi Depth, chlorophyll *a*) were averaged for each open-water season (defined as May-September) to facilitate inter-annual comparisons. Data used for all historical statistical summaries were restricted to results of composite samples; depth profile data were evaluated separately. Where duplicate samples were collected for a given sampling event, an average of those values was derived for data analysis purposes. When more than one measurement was collected in the same month in a given year, these values were averaged to derive a single value per month for statistical analysis.

All of the annual data were averaged to obtain a single value for key variables. This methodology is consistent with that employed by AENV for determination of lake nutrient status and for comparison between lakes. Values that were reported below analytical detection limits (DL) were assigned values equal to one half of the DL for the purposes of statistical analysis. Routine variables that do not vary seasonally (such as major ions and alkalinity) were averaged using all available data. Water quality data collected in the earliest studies (Grant 1976; Jones et al. 1976) were not included in the summaries of historical data due to inconsistencies between analytical methods. Historical data were not evaluated statistically for changes over time, as visual examination of the data did not indicate trends. In addition, Mitchell (1988, 1996) indicated that water quality has not deteriorated over the years. For illustrative purposes, detailed seasonal profiles of key variables are presented for the open-water seasons of 1996 and 2000 as more samples were collected during these years.

The only known phytoplankton community composition data, other than those obtained from the present study, for Sylvan Lake were derived from studies conducted in the 1970's (Grant 1976; Jones et al. 1976). Raw data that were summarized in Grant (1976) could not be located. However, an attempt was made to estimate phytoplankton relative abundance from a figure provided in Grant (1976). Raw data presented in Jones et al. (1976) were summarized and presented as figures for the purposes of this study.

Where data were sufficient, statistical analyses were conducted on water quality and sediment quality variables measured in Sylvan Lake in September 2004. Nearshore water and sediment quality data were evaluated for spatial differences using a one-way ANOVA and Tukey's multiple comparison test.

A.2 Results and Discussion

A.2.1 Water Quality Conditions

Over the last 20 years, water quality conditions have been measured primarily in the deeper areas of Sylvan Lake and largely through collection of composite samples from the euphotic zone of the lake, with periodic evaluations of deep water depth profiles. AENV has monitored Sylvan Lake approximately 4-5 times per open-water season in most years of study. Monitoring in winter has also been periodically conducted. This information is discussed in Section A.3.4.1.

Studies describing water quality conditions in nearshore areas of Sylvan Lake are more limited but are discussed in Section A.3.4.2. The latter includes the results of nearshore measurements collected as a component of the present study (as detailed in Appendix C).

Additionally, Alberta Environment has collected water quality and stream discharge data for a number of inflowing tributary streams as well as the outflow (when discharging) over the years. Tributary streams are ephemeral and the lake outflow discharges only in some years. This information, which provides valuable insight into the quality of water in these streams as well as measures of the nutrient contribution of surface runoff to the lake, is discussed in Section A.3.4.3.

A.2.1.1 Whole Lake Water Quality

Temperature, Dissolved Oxygen, Redox and Stratification

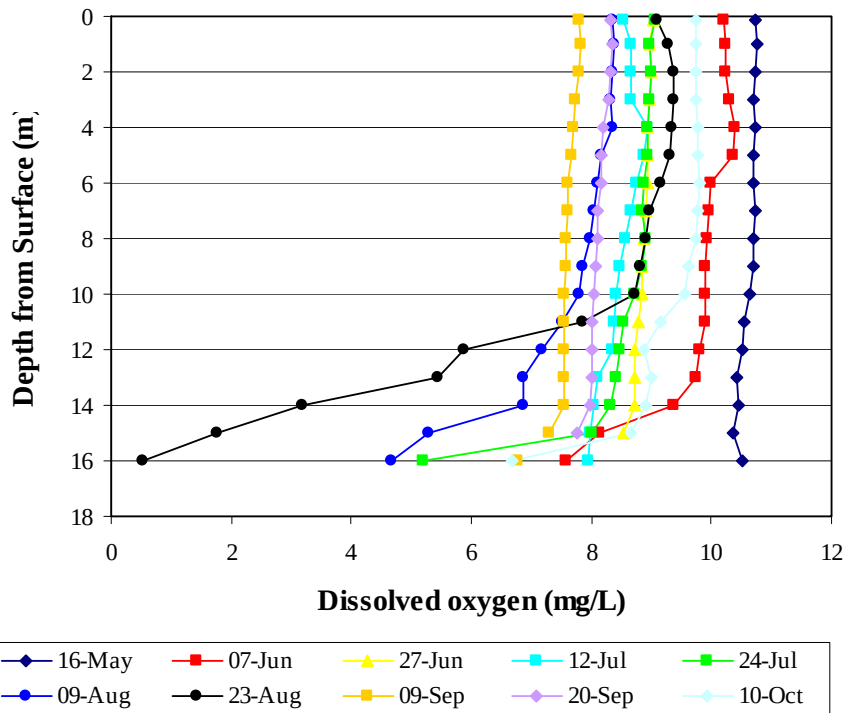
Temperature in Sylvan Lake varies from near zero in the winter months to upwards of 23°C in the late summer. Thermal stratification (i.e., abrupt changes in temperature with depth) has been recorded in the open-water season, typically being most pronounced in late summer. For example, the lake was weakly stratified in August 1996 (Figure A-3). Temperature stratification may also vary considerably from year to year (Figure A-4). Additionally, temperature typically increases with depth under ice cover in Sylvan Lake (Figure A-5).

Dissolved oxygen concentrations are relatively high in the euphotic zone of Sylvan Lake year round and typically range between 90 and 100% saturation. However, the concentration of dissolved oxygen varies seasonally, both over the open-water season and in winter, in accordance with changes in water temperature and to some extent, algal productivity and ice cover. In general, dissolved oxygen concentrations near the lake surface are approximately 9 to 10 mg/L in May and June and decrease thereafter to approximately 8 to 9 mg/L in late summer. An example of seasonal changes in DO over the open-water season is presented for 1996 in Figure A-3. Concentrations of DO near the lake surface are generally above AENV water quality guidelines for the protection of aquatic life (5.0 mg/L [1-day minimum] and 6.5 mg/L [7-day mean], AENV 1999).

Despite the high levels of oxygen observed near the lake surface, DO becomes depleted near the bottom in Sylvan Lake in both summer and winter. When the lake is thermally stratified, dissolved oxygen is not readily replenished as the bottom layer of water is cut off from oxygen in the air and from oxygen generated by photosynthesis. In 1996, near anoxic conditions were observed in late August near the sediment-water interface. Dissolved oxygen depletion at depth has been observed in most summers when monitoring has been conducted (Figure A-5). Similarly, dissolved oxygen depletion at depth has been observed for most winters, with substantive reductions occurring at depths below 10 m in most years (Figure A-5). Collectively, monitoring data indicate fairly regular development of hypoxic or anoxic conditions in deep portions of the lake in summer and again in winter under ice cover. At these times, dissolved oxygen in deep water is often below the AENV minimum dissolved oxygen guideline of 5.0 mg/L for the protection of aquatic life (AENV 1999).

The lake was not stratified in September 2004 (Figure A-6) and DO was above 8 mg/L at all deepwater sites. The lack of vertical differences and the absolute concentrations measured at this time are consistent with previous surveys of Sylvan Lake in mid- to late September. Typically, at this time of year the surface water cools, and stratification breaks down. This allows the entire water column to mix, and DO is replenished in the water at the bottom.

(A)



(B)

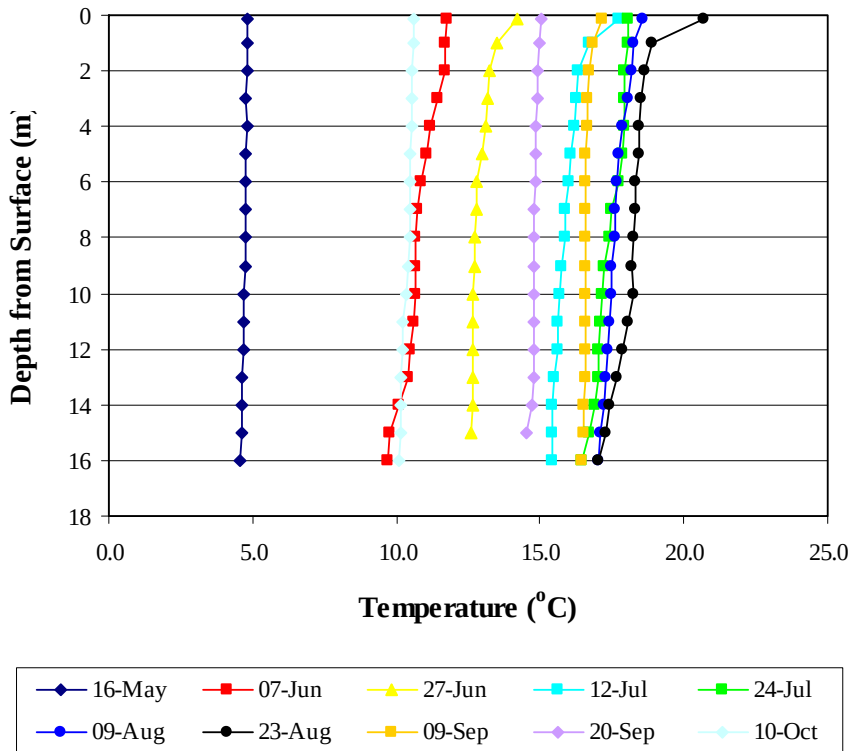
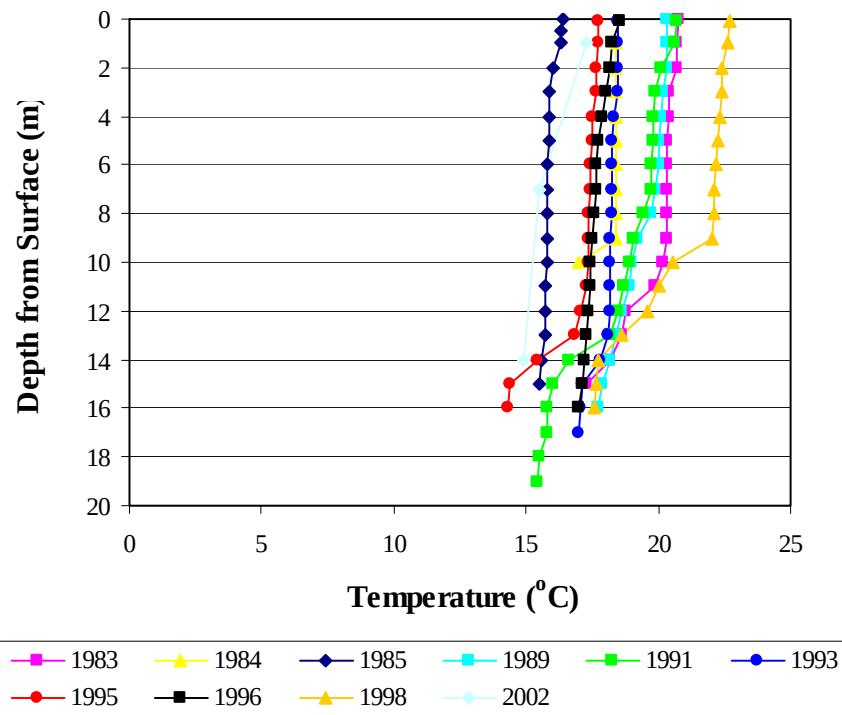


Figure A-3 Dissolved oxygen (A) and temperature (B) depth profiles measured at the AENV monitoring site AB05CC0650 in Sylvan Lake, open-water season, 1996

(A)



(B)

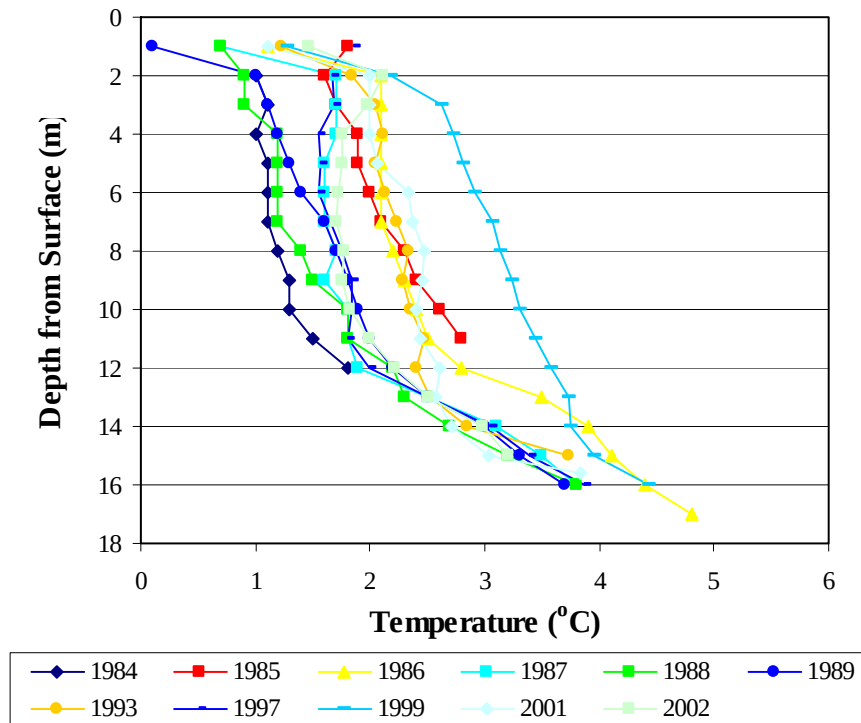
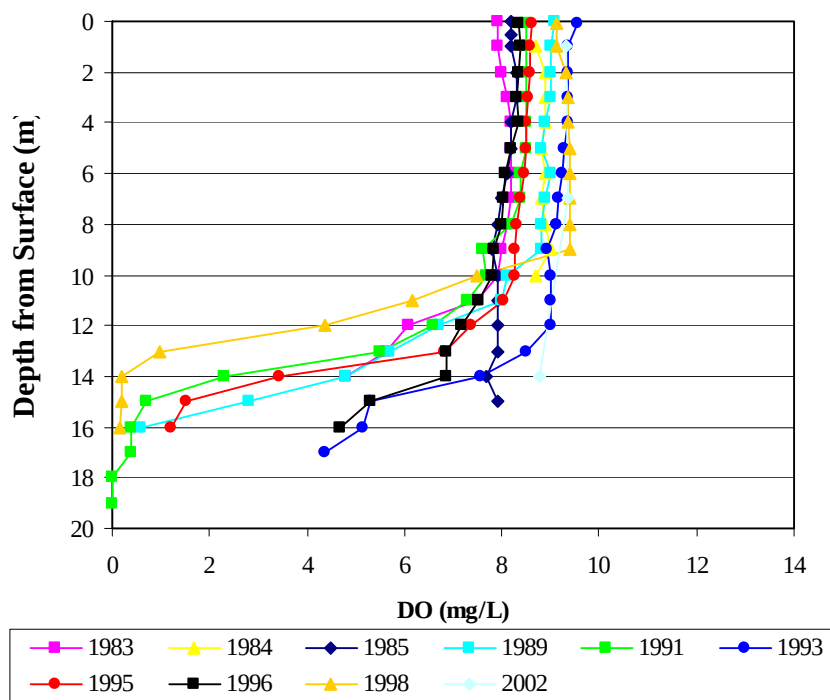


Figure A-4 Temperature depth profiles measured at the AENV monitoring site AB05CC0650 in Sylvan Lake: (A) profiles for the month of August; and (B) profiles in winter (January to March)

(A)



(B)

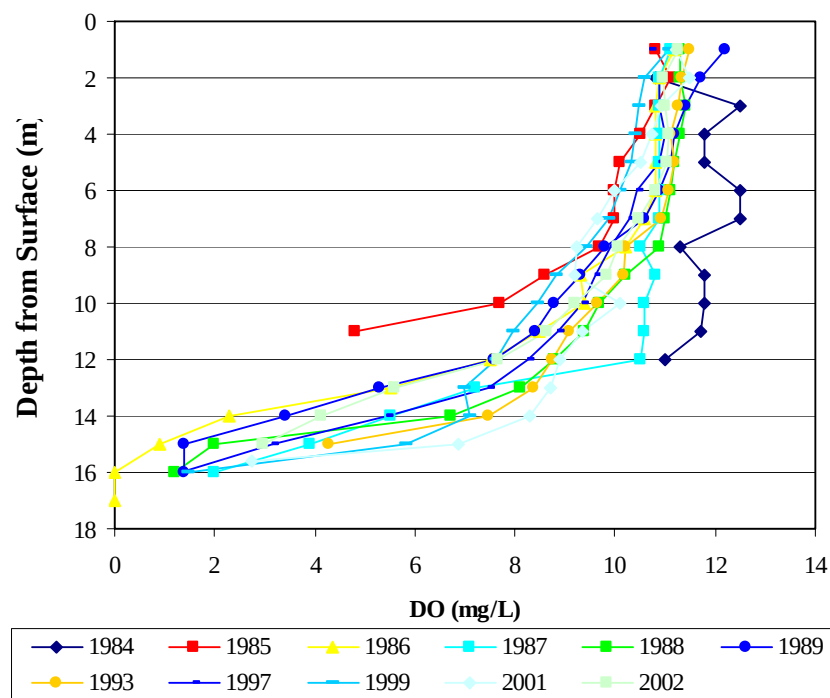


Figure A-5 Dissolved oxygen (DO) depth profiles measured at the AENV monitoring site AB05CC0650 in Sylvan Lake: (A) profiles for the month of August; and (B) profiles in winter (January to March)

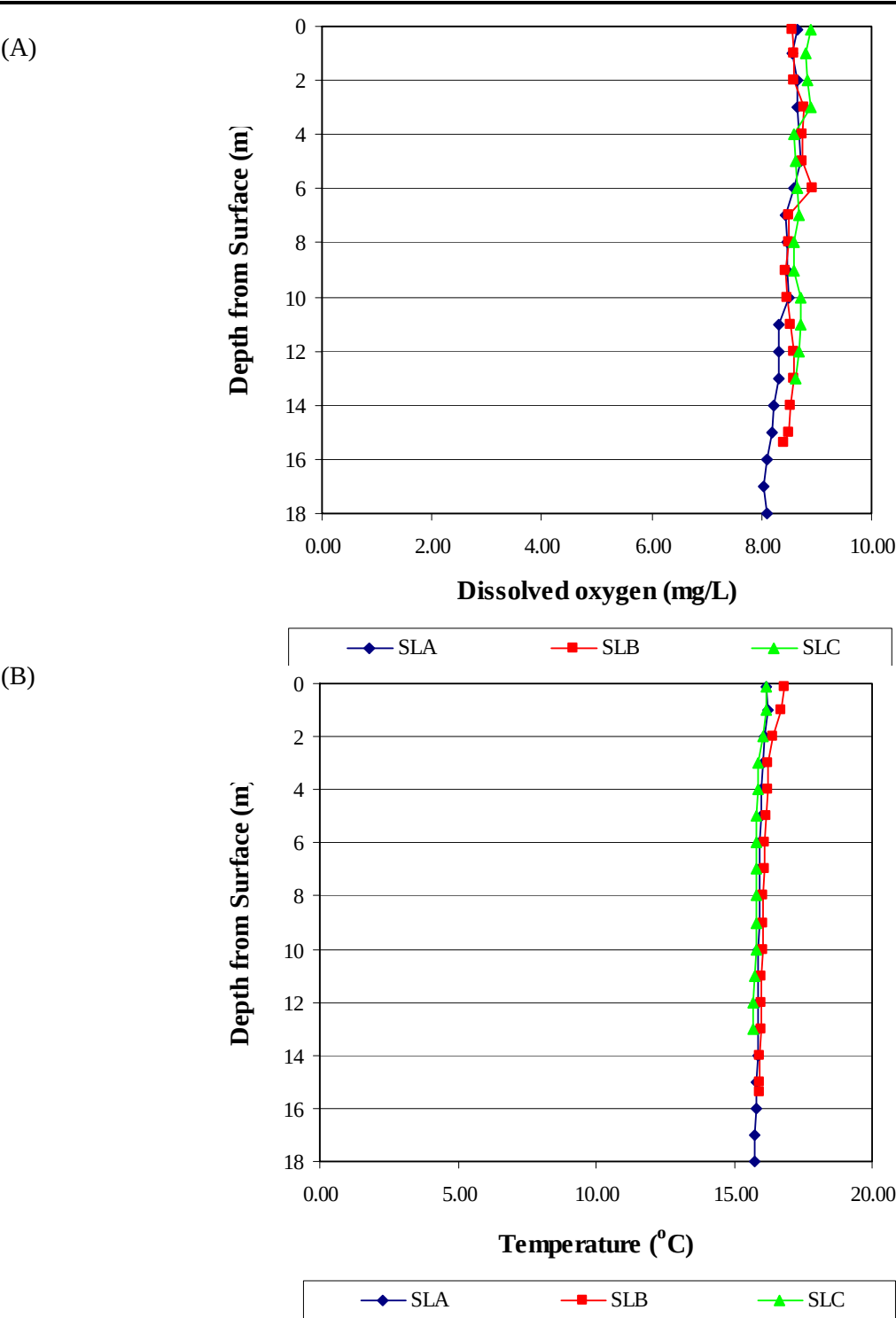


Figure A-6 Dissolved oxygen (A) and temperature (B) depth profiles measured at three deepwater sites in Sylvan Lake in September, 2004

Oxidation-reduction potential (i.e., “redox”) may affect the balance between sorption and release of a number of substances, including phosphorus, from the sediments. The critical threshold below which phosphorus that is normally bound in the sediments is released to the overlying water column (i.e., “internal loading”) is 200 mV (Kalff 2002). Very few measurements of redox conditions have been collected in Sylvan Lake. However, available data indicate that redox may vary substantively over the open-water season (Figure A-7) but that conditions near the sediment-water interface generally remain above 200 mV. For the available period of record, redox potential has dropped below 200 mV in August 1998 and February 1999 (Figure A-8). At these times, dissolved oxygen was also low (0.17 mg/L in August 1998 and 1.47 mg/L in February 1999) near the sediment water interface. Collectively, the limited data indicate that at least on some occasions, redox potential reaches levels that are conducive to internal loading of phosphorus. It should be noted that phosphorus release from sediments is a complex process that can be related to additional factors other than oxidation-reduction potential alone (Section A.3.5.1).

Redox potentials were fairly uniform across depth and between sites at the deepwater sampling sites examined in September 2004 (Figure A-9). However, the redox potential was near or slightly above 200 mV at this time.

pH, Alkalinity, and Hardness

Sylvan Lake is alkaline with a mean pH of 8.81 for the open-water season (1983-2003, Table A-2). Alkalinity is also high (i.e., greater than 100 mg/L) averaging 326 mg/L as CaCO₃ in the open-water season (Table A-2). Similarly, pH averaged approximately 8.9 and alkalinity averaged 326 to 328 mg/L from top to bottom in September 2004, all of which are consistent with historical data. Water in Sylvan Lake is also characterized as very hard (Mitchell and Prepas 1990).

Table A-2 Statistical Summaries of Major Ions and Related Variables in the Euphotic Zone of Sylvan Lake: 1983–2003¹

	Unit	Mean	Median	SD	SE	Minimum	Maximum	n
DIN:TP molar ratios	-	3.4	1.6	4.5	1.1	0.1	17.1	18
DIN:DP molar ratios	-	8.0	3.6	10.3	2.4	0.1	40.5	18
Specific conductance	(mg/L)	588	587	12	2	557	604	39
TDS	(mg/L)	337	337	10	2	303	356	35
Total hardness	(mg/L CaCO ₃)	195	195	9	1	175	213	40
pH	(mg/L)	8.81	8.81	0.12	0.02	8.34	9.00	42
Calcium	(mg/L)	17.3	17.2	1.2	0.2	13.0	20.0	39
Chloride	(mg/L)	1.8	1.9	0.7	0.1	0.5	3.0	39
Iron	(mg/L)	0.018	0.010	0.028	0.005	<0.01	0.130	31
Magnesium	(mg/L)	36.9	37.0	1.8	0.3	32.0	42.0	37
Potassium	(mg/L)	7.0	6.9	0.5	0.1	6.2	8.7	41
Silica	(mg/L)	2.2	1.7	1.4	0.2	<0.05	4.3	39
Fluoride	(mg/L)	0.14	0.13	0.02	0.00	0.10	0.21	33.00
Sodium	(mg/L)	65.3	65.0	2.9	0.5	58.6	73.0	41
Sulphate	(mg/L)	12.8	13.0	2.7	0.4	7.0	20.0	41
Total Alkalinity	(mg/L CaCO ₃)	326.3	326.4	10.1	1.6	277.3	342.0	42
Bicarbonate	(mg/L)	357	353	11	2	337	381	40
Carbonate	(mg/L)	23.0	23.0	3.9	0.6	10.3	31.0	41

Note: 1 For months where more than one measurement for a given parameter was collected, the mean of those values for that month was derived and used for the basis of the statistics shown above.

Source: Alberta Environment

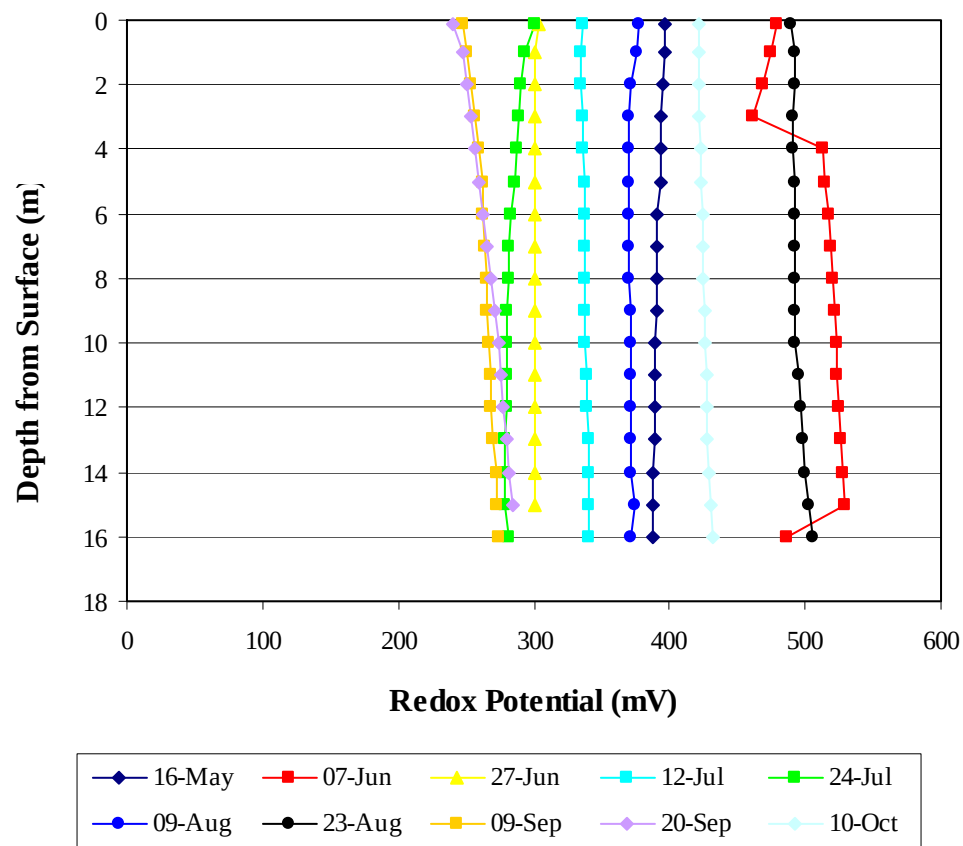


Figure A-7 Redox potential depth profiles at AENV monitoring site AB05CC0650 over the 1996 open-water season

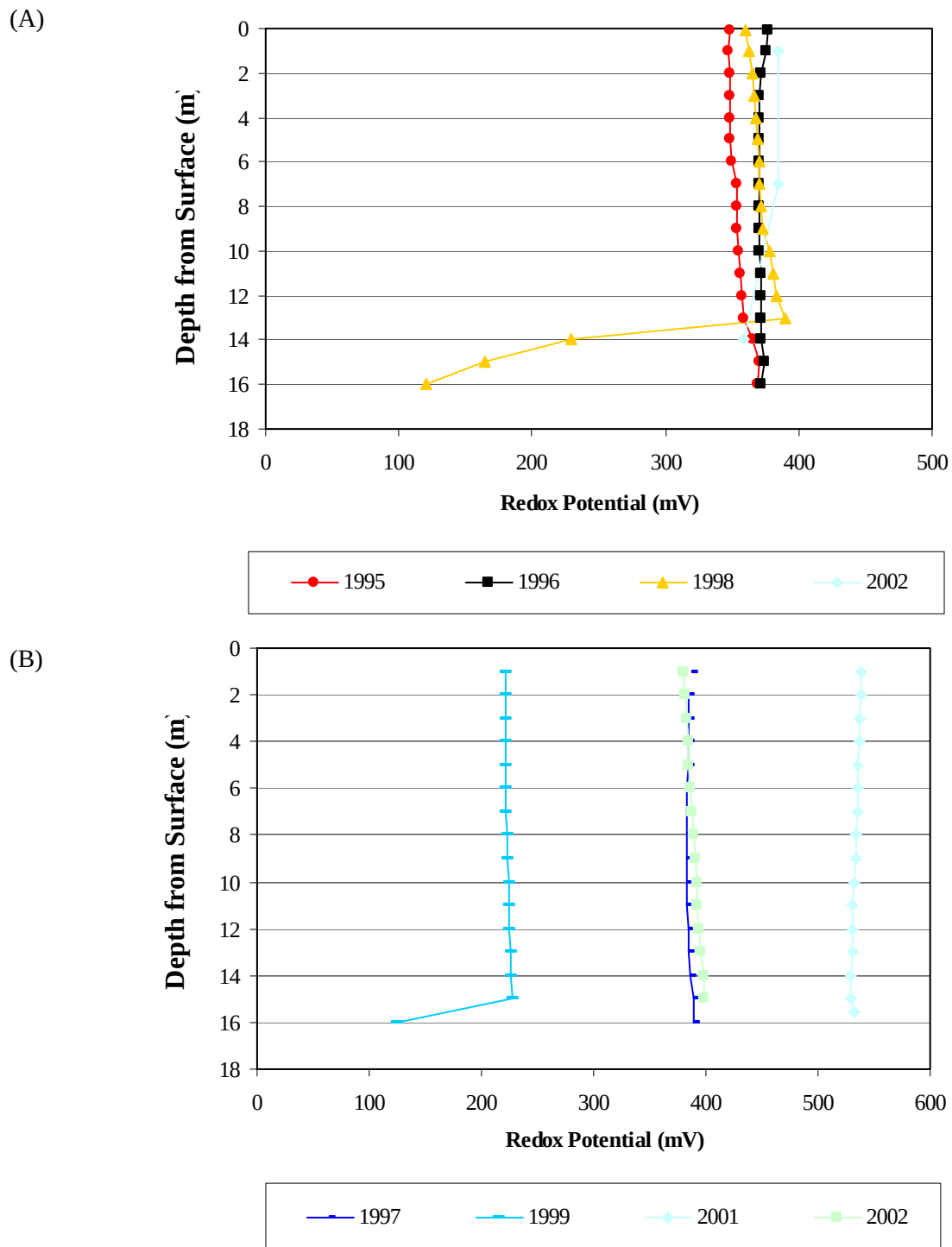


Figure A-8 Redox potential depth profiles measured at the AENV monitoring site AB05CC0650 in Sylvan Lake: (A) profiles for the month of August; and (B) profiles for the month of February

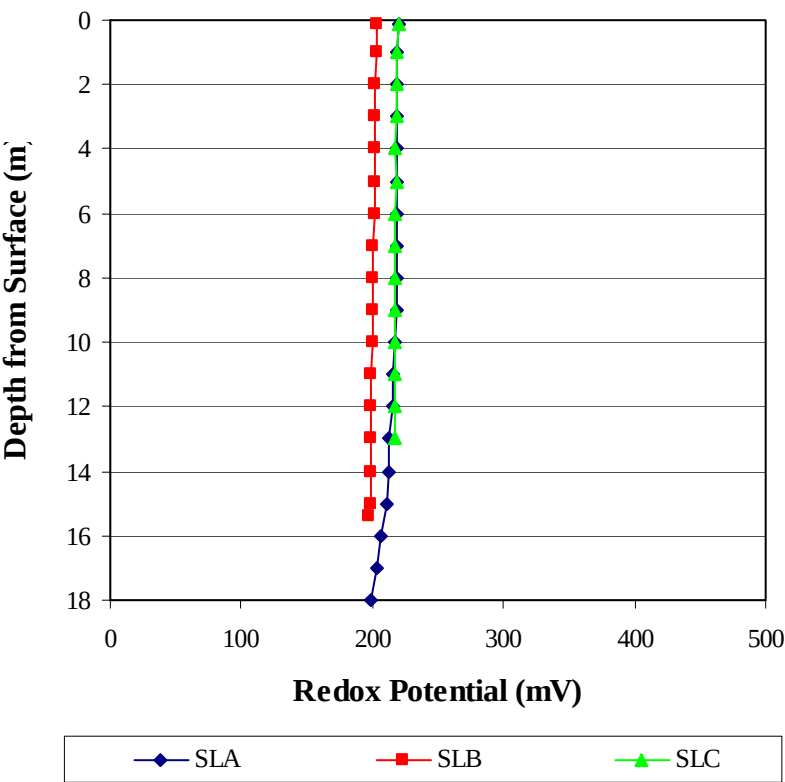


Figure A-9 Redox potential depth profiles measured at three deepwater sites in Sylvan Lake in September, 2004

pH varies only slightly between years (Figure A-10), ranging from an average of 8.67 to 8.94 for the open-water season. pH has been more variable between years under ice-cover conditions and was notably higher (pH >9) in February 1984 (Figure A-10). Some variation in pH has also been observed across the open-water season as well as with depth (Figure A-11). In 1996, the strongest vertical differences in pH observed across depth occurred in late August. In September 2004, pH was very similar across depth at all deep sampling sites (Figure A-12).

According to the classification scheme of Saffran and Trew (1996), on the basis of total alkalinity and pH, Sylvan Lake falls into the category of 'least sensitivity to acidification' (i.e., pH >7.5 and total alkalinity is >40 mg/L as CaCO₃).

Phosphorus

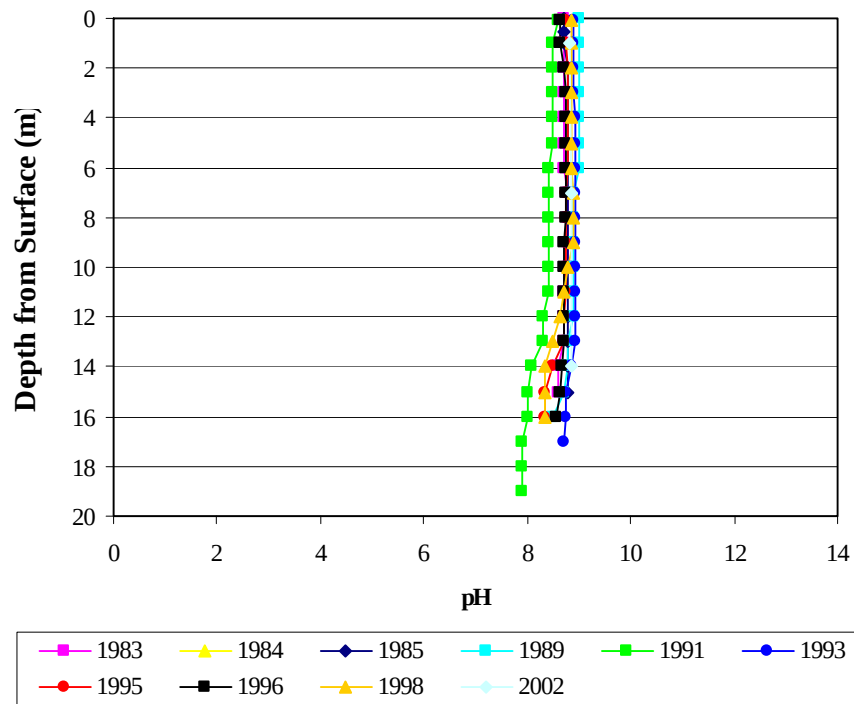
The mean concentration of total phosphorus (TP) in Sylvan Lake for the open-water season over the period of record (1983-2003) is 0.021 mg/L. Mean TP concentrations ranged from 0.014 mg/L in the open-water season of 1985 to 0.034 mg/L in the open-water season of 1992 (Figure A-13).

Overall, the historical data indicate fairly consistent TP concentrations over the period of record and there is no indication of gradual enrichment. Monthly mean TP concentrations in composite samples collected from the euphotic zone of Sylvan Lake from 1983 to 2002 (May-September) are presented in Figure A-14. With the exception of a single measurement of TP collected in May 1992 (0.07 mg/L), all concentrations were below the AENV water quality guideline of 0.05 mg/L (AENV 1999). A notably high concentration of TP (0.044 mg/L) occurred in late August 2001 in the euphotic zone, concurrent with an algal bloom (chlorophyll *a* = 32.4 µg/L) and a high Total Kjeldahl Nitrogen (TKN) concentration (1.5 mg/L).

In general, data indicate that concentrations of TP or dissolved phosphorus (DP) do not vary substantively across the open-water season within the euphotic zone (as a composite). Monthly median concentrations collected from May through September from 1983-2003 (with some years excluded¹) from the euphotic zone are presented in Figure A-15. Although no strong and consistent seasonal trends were evident, the median TP over the period of record was higher in September than other months. Measurements collected for TP in the open-water seasons of 1996 and 2000 are presented in Figures A-16 and A-17, respectively. The tendency for lower TP in the early months of the open-water season (i.e., May and June) relative to the rest of the season has been observed in other lakes in Alberta (Zhang and Prepas 1996), including Gull Lake (Mitchell and LeClair 2003) and Pine Lake (Sosiak and Trew 1996). It should be noted that DP data are limited and may not be sufficient to delineate seasonal trends.

¹ Monitoring was not conducted in all years from 1983-2003.

(A)



(B)

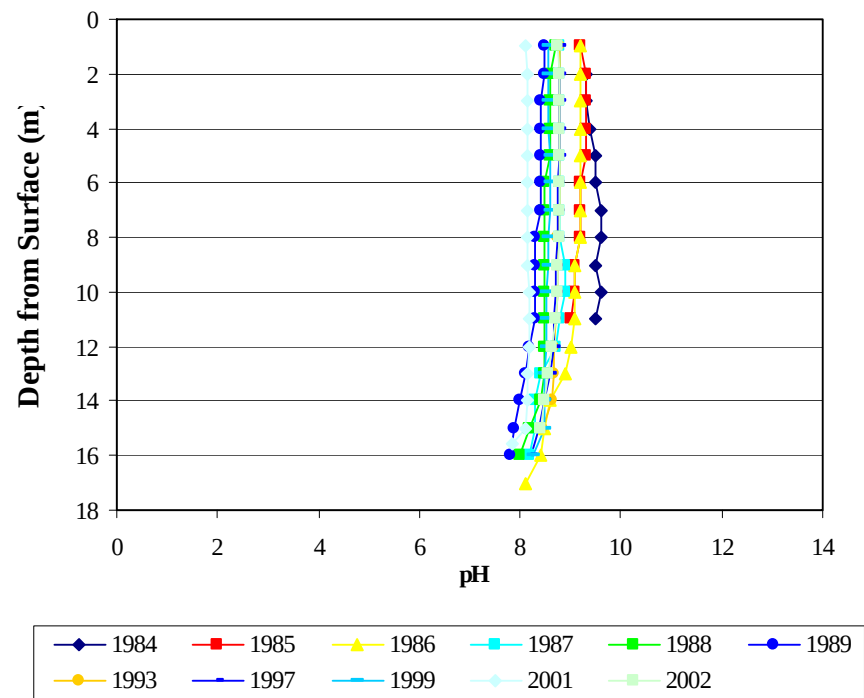


Figure A-10 pH depth profiles measured at the AENV monitoring site AB05CC0650 in Sylvan Lake: (A) profiles for the month of August; and (B) profiles in winter (January to March)

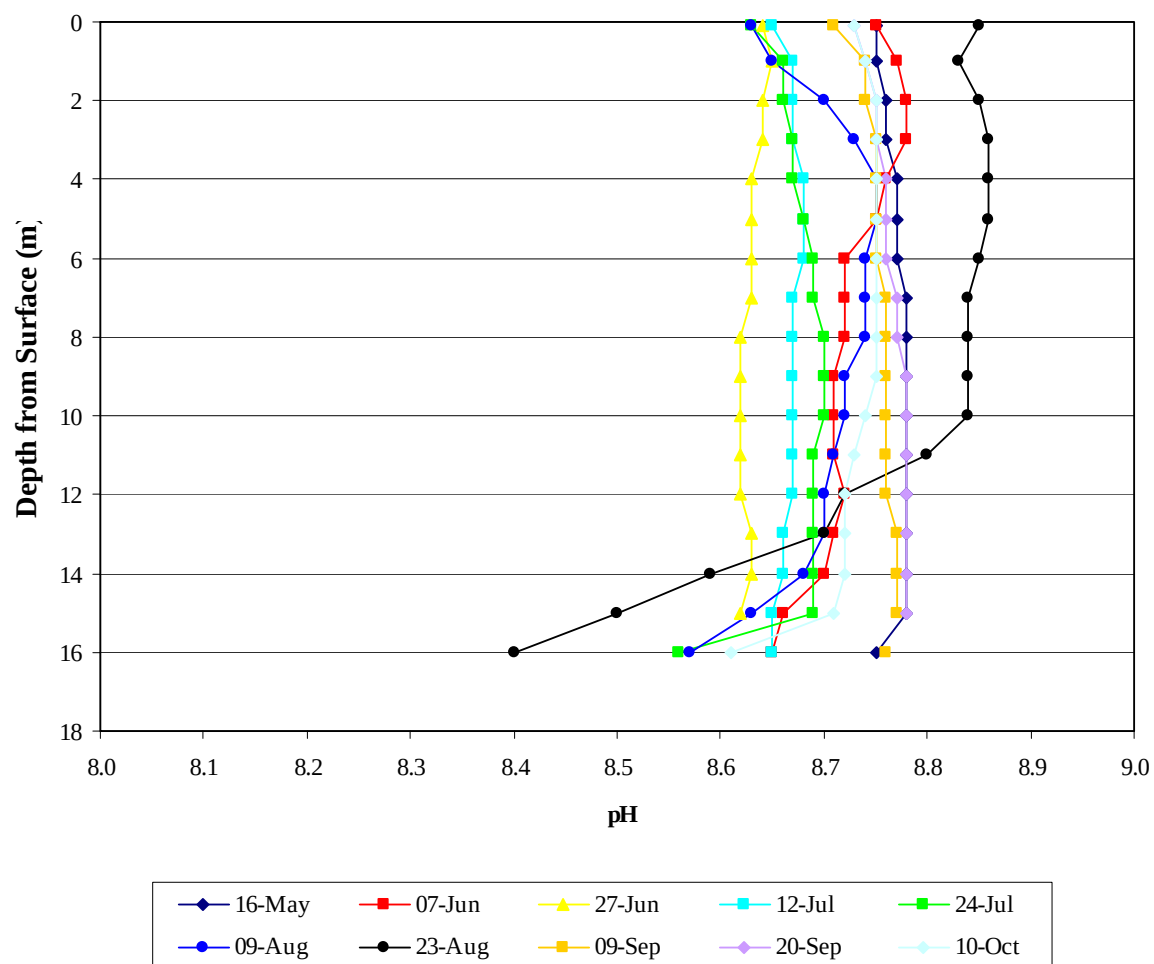


Figure A-11 pH depth profiles measured over the open-water season at AENV monitoring site AB05CC0650 in Sylvan Lake, 1996

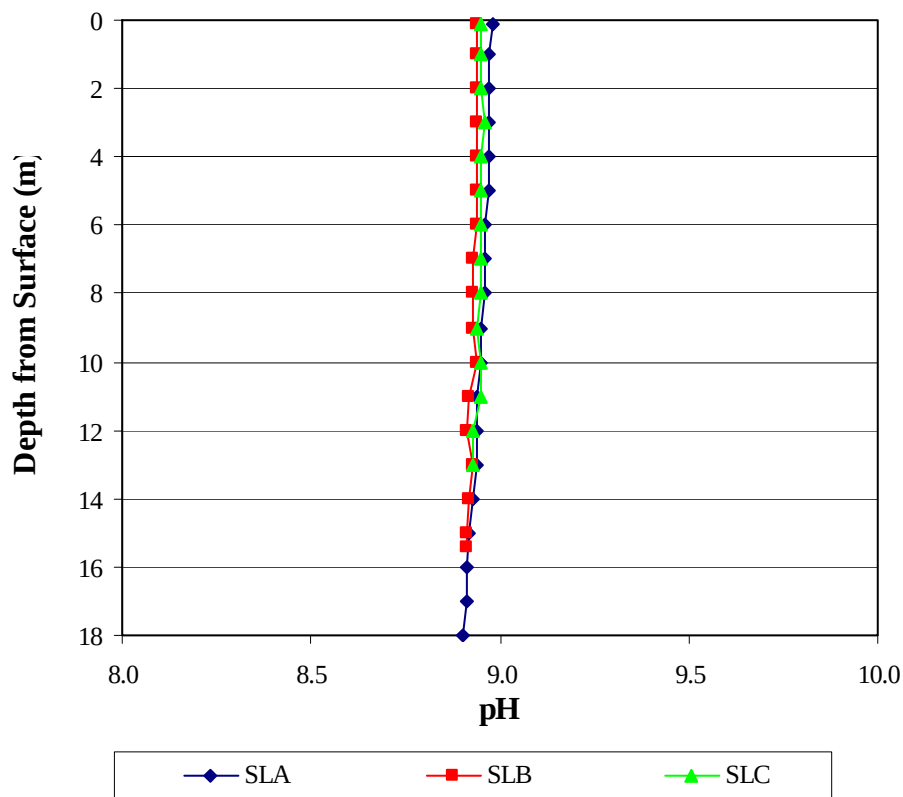


Figure A-12 pH depth profiles measured at three deepwater sites in Sylvan Lake in September, 2004

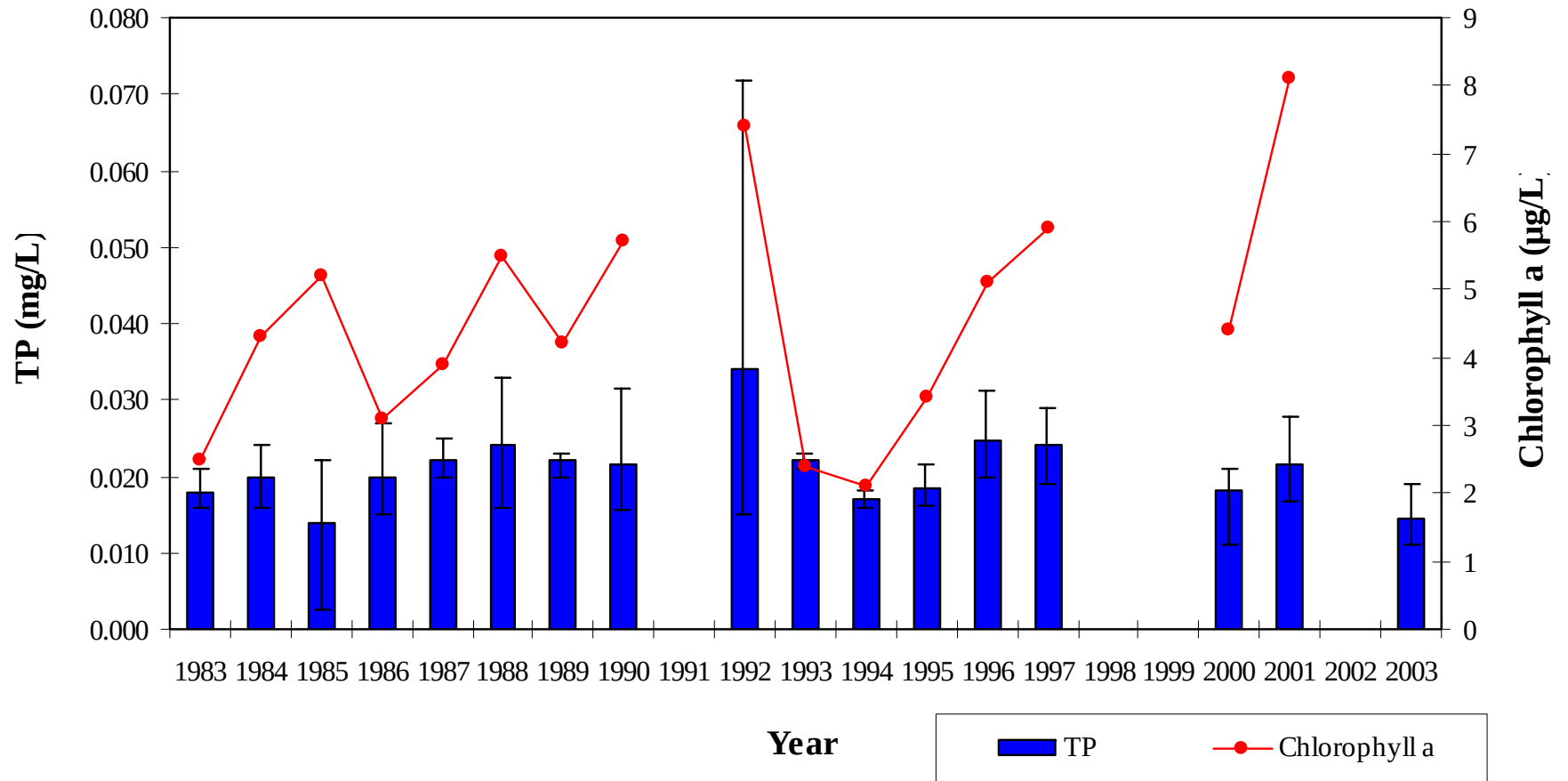


Figure A-13 Mean, minimum and maximum total phosphorus (TP) concentrations and mean chlorophyll a concentrations in composite samples from the euphotic zone of Sylvan Lake, 1983-2003

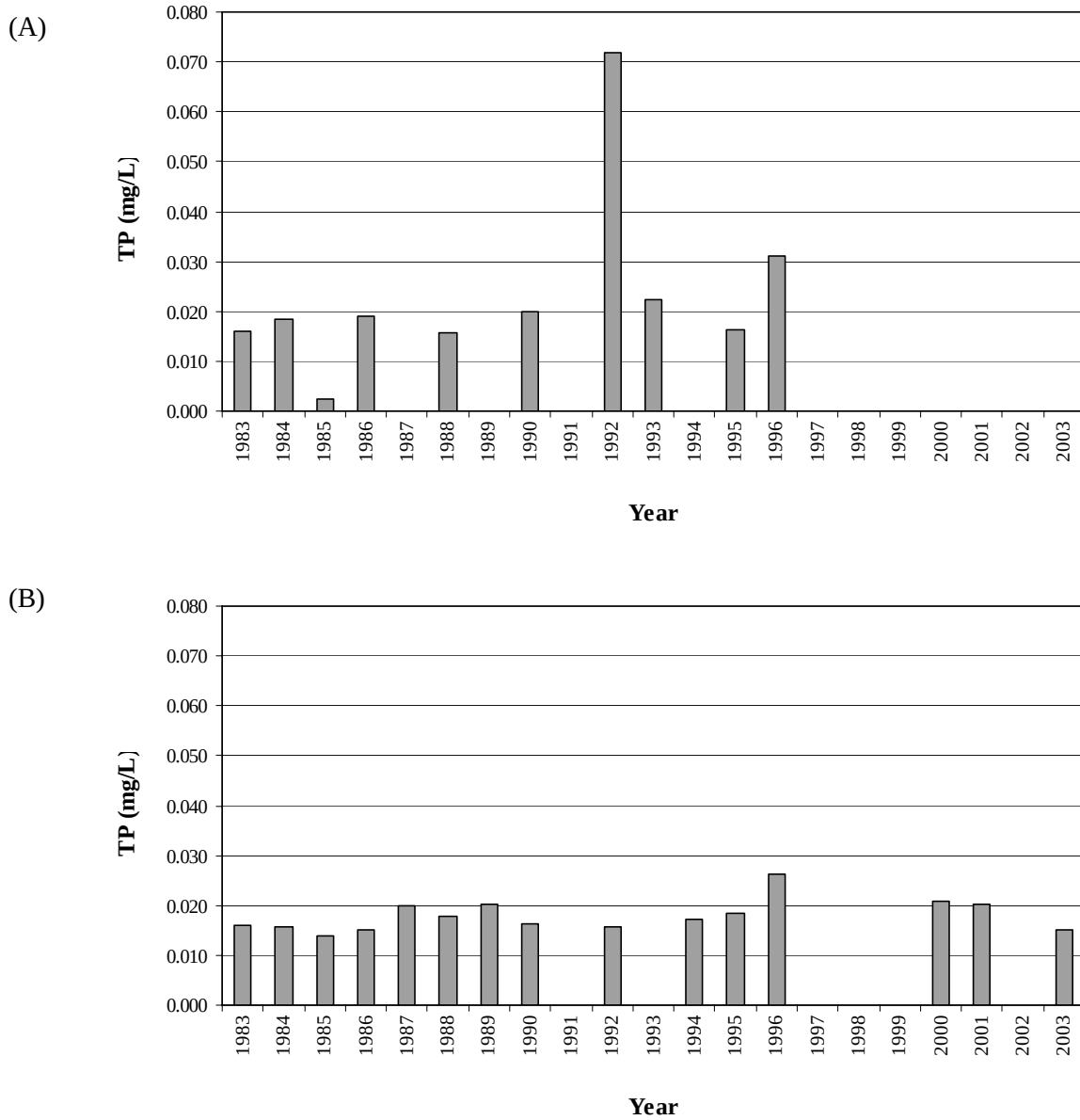


Figure A-14 Total phosphorus (TP) concentrations measured in composite samples collected from the euphotic zone of Sylvan Lake: (A) May; (B) June; (C) July; (D) August; and (E) September



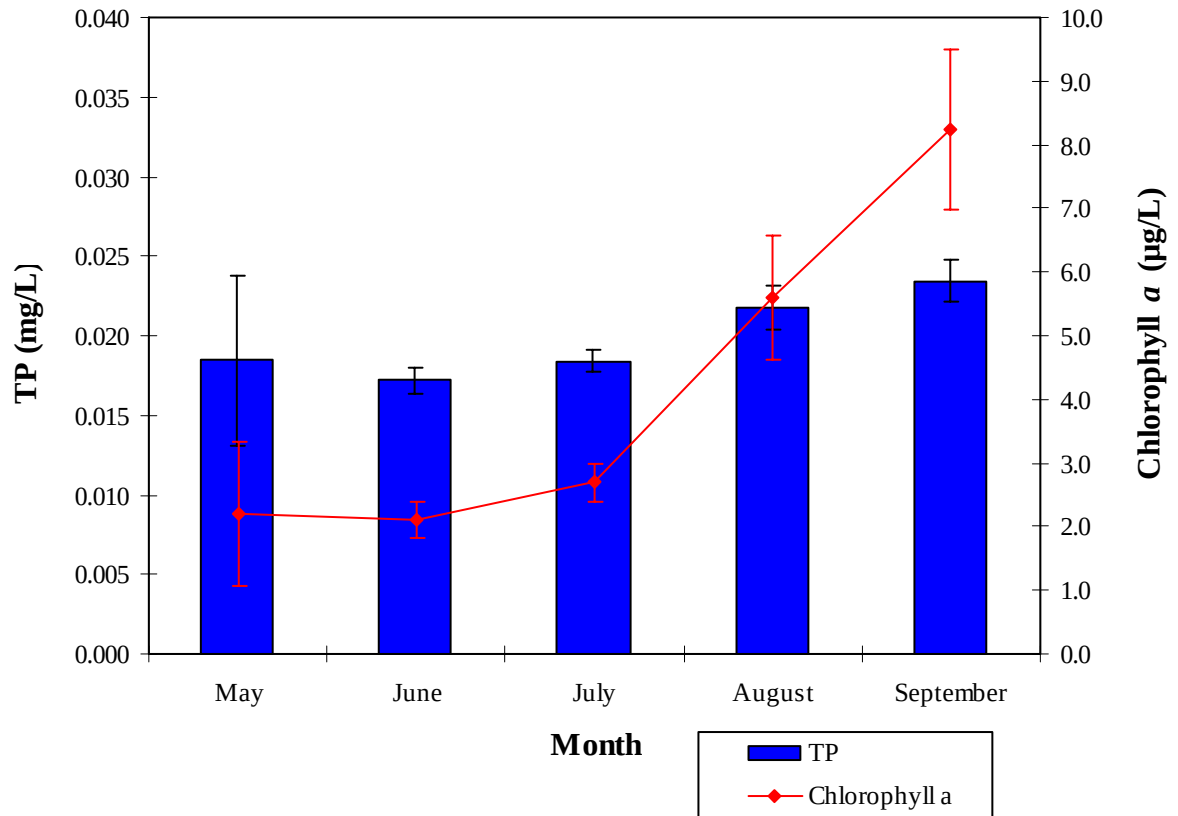


Figure A-15 Median $\pm$ SE concentrations of total phosphorus (TP) and chlorophyll a measured in the euphotic zone of Sylvan Lake between May and September, 1983-2003. Data provided by AENV

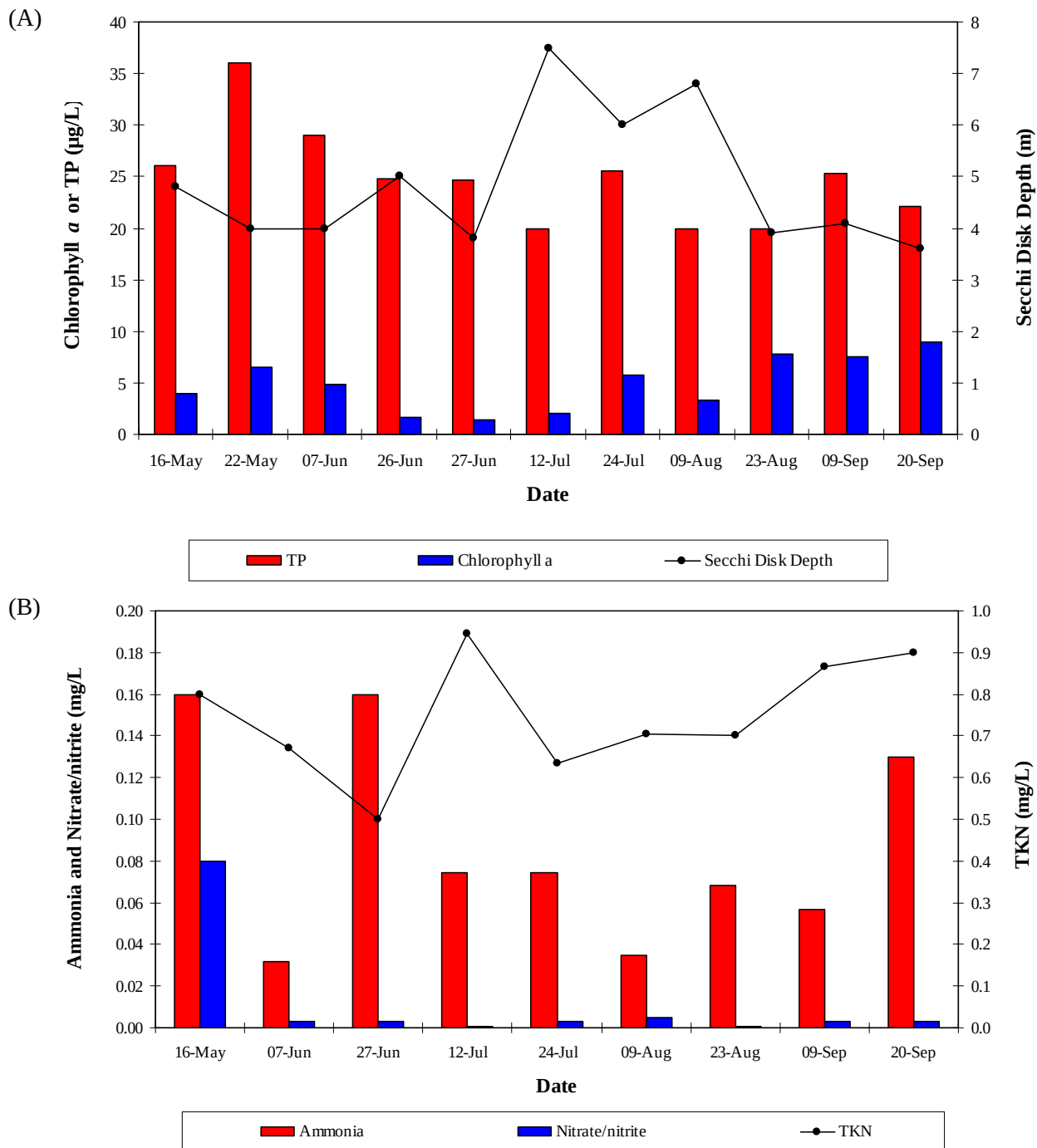


Figure A-16 Seasonal variation of: (A) total phosphorus (TP), chlorophyll a, and Secchi disk depth; and (B) Total Kjeldahl Nitrogen (TKN), ammonia, and nitrate/nitrite in the euphotic zone of Sylvan Lake during the open-water season of 1996

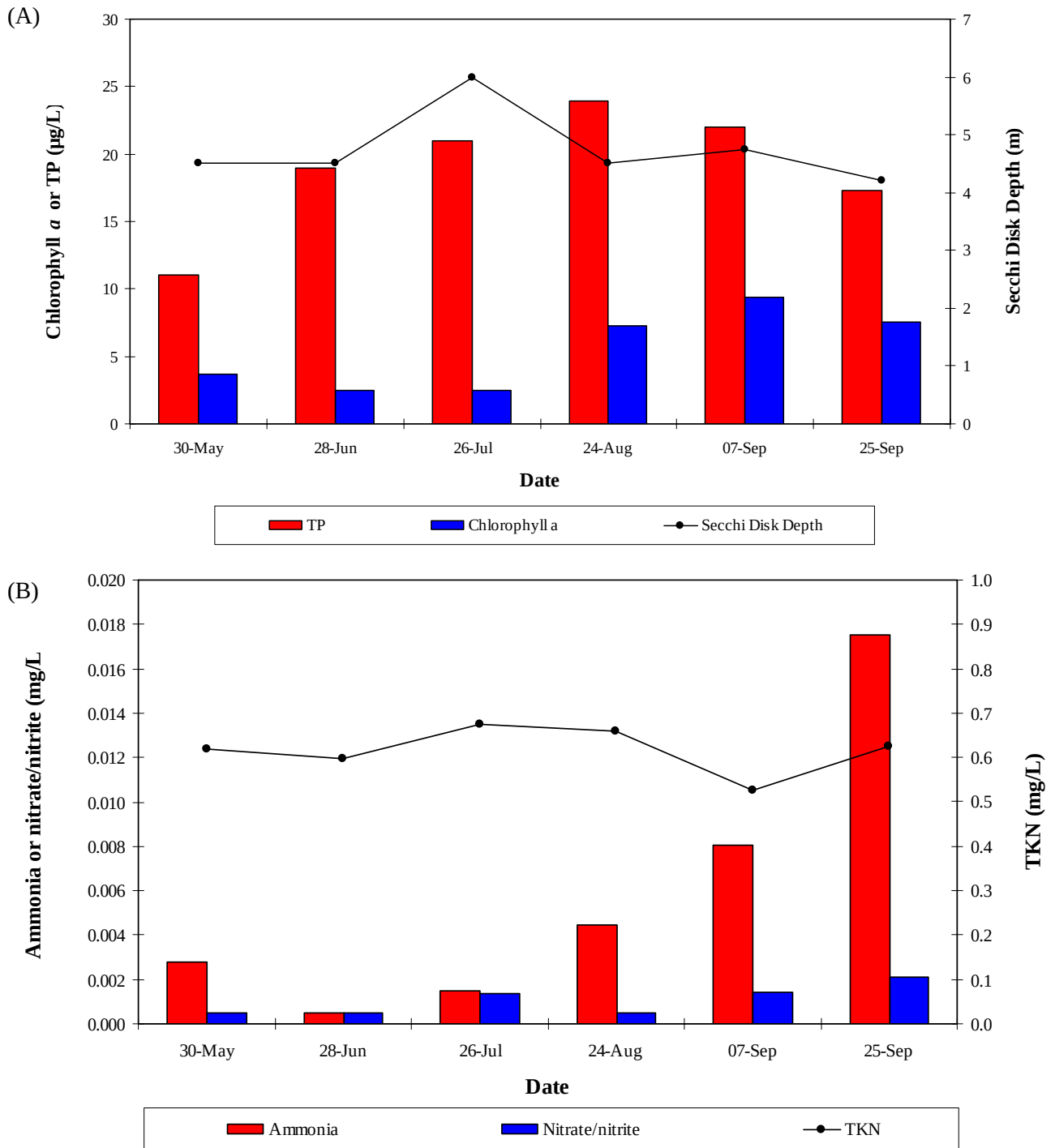


Figure A-17 Seasonal variation of: (A) total phosphorus (TP), chlorophyll a, and Secchi disk depth; and (B) Total Kjeldahl Nitrogen (TKN), ammonia, and nitrate/nitrite in the euphotic zone of Sylvan Lake during the open-water season of 2000

Depth profiles of TP or DP have only rarely been measured in the open-water season in Sylvan Lake (Figure A-18). The relatively constant TP concentrations in the euphotic zone over the open-water season indicate that settling and/or fluxes of phosphorus between the sediments and water column are not substantive enough to radically alter total concentrations in the euphotic zone. However, TP concentrations do exhibit vertical stratification at times in the deeper portions of the lake, which reflects the sediment flux of phosphorus that occurs under appropriate physico-chemical conditions at the interface. For example, profile data collected for TP and DP in 1996 indicate that both substances remained fairly uniform with depth in the open-water season except on August 23, when TP concentrations increased from 0.025 mg/L at 14 m to 0.091 mg/L at 16 m and concentrations of DP increased by nearly six-fold from 0.0106 mg/L to 0.0623 mg/L between 14 m and 16 m (Figure A-18). Vertical gradients in TP levels have been observed in other nearby lakes, including Pine Lake (Sosiak and Trew 1996). The more abundant depth profile data collected in winter indicate that levels of TP and DP frequently increase at depth under ice cover in Sylvan Lake (Figure A-19).

TP measured in the composite sample collected from the euphotic zone of Sylvan Lake in September 2004 (0.016 mg/L) was equal to the historical minimum value for September recorded for this lake. However, depth-averaged concentrations at other deep-water sites sampled in September 2004 (0.018-0.021 mg/L) were more consistent with, although lower than, the historical average for the euphotic zone in September (0.024 mg/L). Dissolved phosphorus concentrations in 2004 were similar to historical data for the month of September. TP was highest at 2 m in depth (Figure A-20).

The data indicate that there is no overt temporal increase in phosphorus in the lake, based on a twenty year period of record of composite samples. However, the period of record is reasonably short and the number of samples collected within the lake each year varies over that period of record. Small, more subtle changes in TP concentrations may not be discernible given the quantity of available data.

Nitrogen

Nitrogen, which may exist in inorganic forms including ammonia, nitrate, and nitrite, as well as in organic form, was not commonly measured in Sylvan Lake until recent years. Periodic measurements have been made of nitrate/nitrite, beginning in 1983, from the euphotic zone of the lake. In general, concentrations have been low and below analytical detection limits. All measurements collected over the period of record in the deepwater areas of Sylvan Lake were well below the CCME water quality guideline for the protection of aquatic life of 2.93 mg NO_3^- -N/L (equivalent to 13 mg/L of NO_3^- , CCME 1999). The highest measured concentration of nitrate/nitrite was 0.35 mg/L which occurred in July 1989. Concentrations of nitrate/nitrite did not exhibit any strong seasonal trends, as illustrated for the open-water seasons of 1996 and 2000 (Figures A-16 and A-17). Nitrate/nitrite was not detected in any surface water samples collected in Sylvan Lake in September 2004.

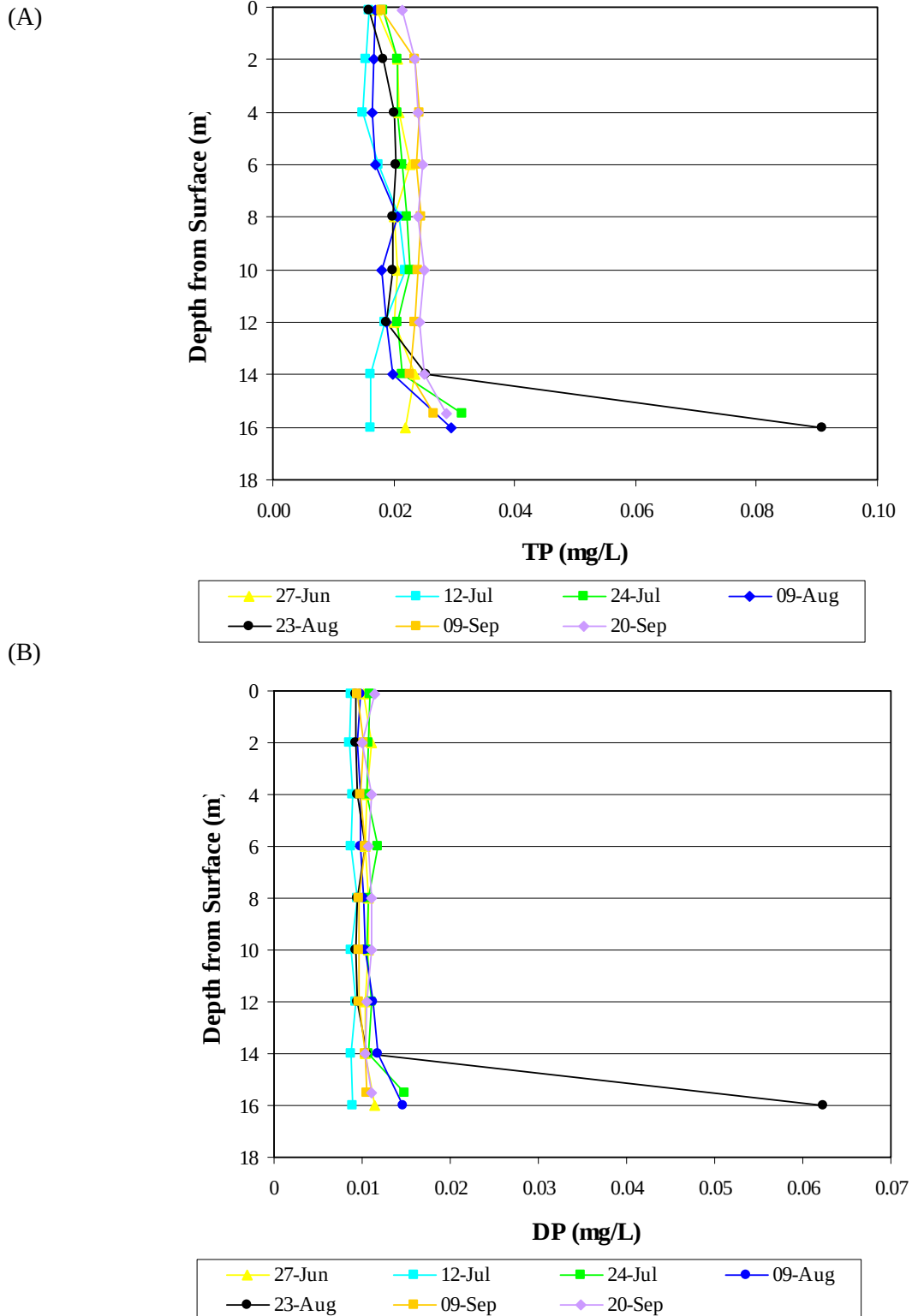
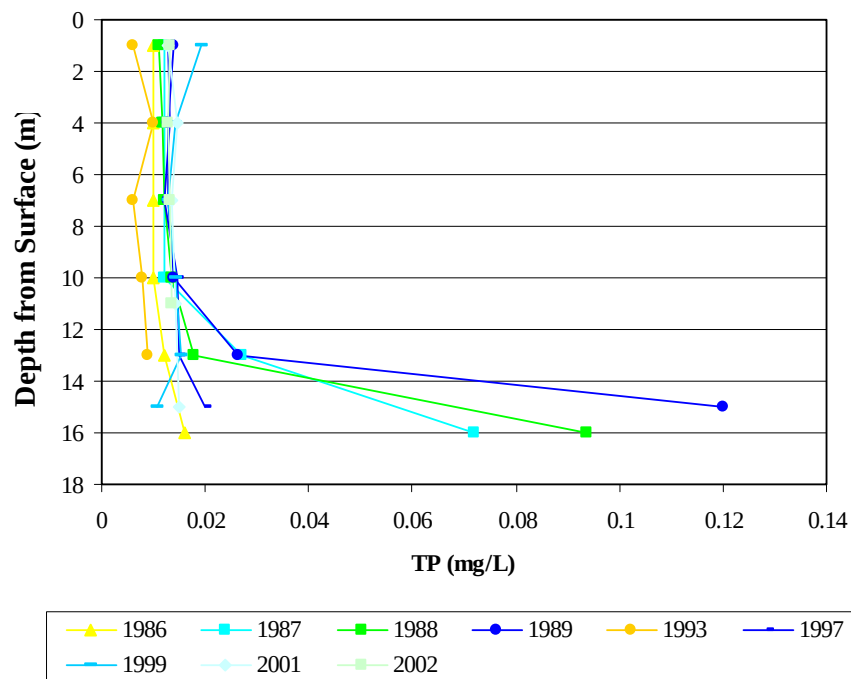


Figure A-18 Seasonal variations in phosphorus concentrations in samples from the euphotic zone of Sylvan Lake in 1996: (A) total phosphorus (TP); and (B) dissolved phosphorus (DP)

(A)



(B)

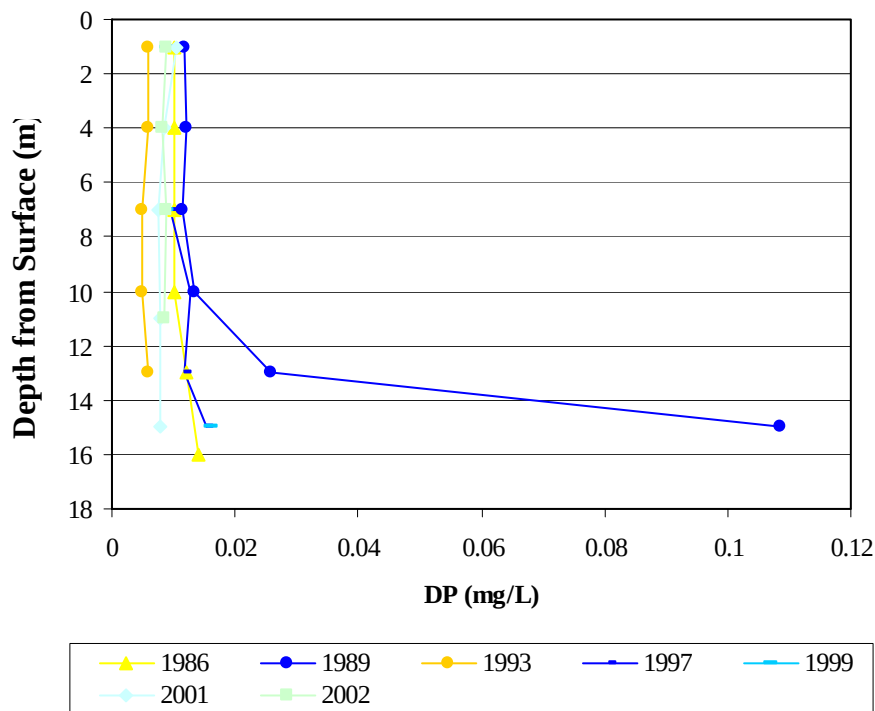


Figure A-19 Total phosphorus (TP) (A) and dissolved phosphorus (DP) (B) depth profiles measured in winter (January – March) in Sylvan Lake

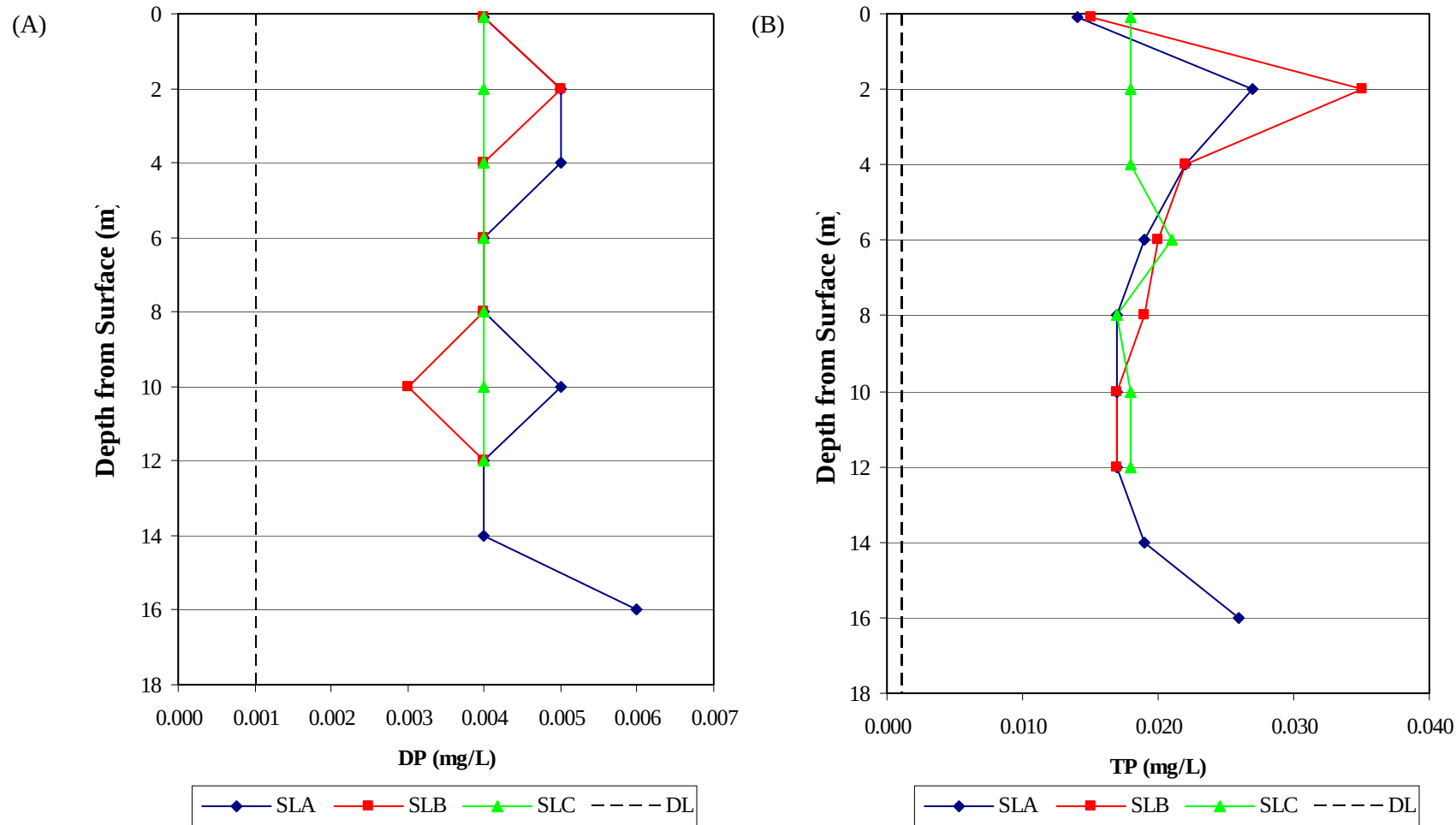


Figure A-20 Dissolved phosphorus (DP) (A) and total phosphorus (TP) (B) depth profiles measured in samples collected from sites on Sylvan Lake on September 06, 2004. Analytical detection limits (DL) are indicated by the dashed line

Fewer measurements have been collected for ammonia in Sylvan Lake over the period of record. Monitoring for ammonia began in 1995 and has been conducted fairly regularly since. Mean annual concentrations of ammonia have been less than 0.1 mg/L (and typically less than 0.01 mg/L) in the euphotic zone, with a maximum observed concentration of 0.160 mg/L on May 22, 1996. Ammonia toxicity varies with ambient pH and temperature but surface water temperature was not recorded for composite samples collected in Sylvan Lake. However, the highest concentration measured (0.16 mg/L) was associated with an ambient pH of 8.6 and water temperature at the deepest site in the lake measured approximately 5°C six days earlier (May 16, 1996). Therefore, assuming the ambient temperature was approximately 5 to 10°C on May 22, 1996, the CCME water quality guideline for the protection of aquatic life would have been approximately 0.502 mg/L (at 5°C) to 0.343 mg/L (at 10°C). Monitoring data indicate that ammonia concentrations that occur in the deepwater areas of Sylvan Lake are not toxic to aquatic life. However, winter depth profiles indicate that ammonia concentrations increase at greatest depth (Figure A-21).

Concentrations of ammonia measured in the deepwater areas of Sylvan Lake in September 2004 were within the recorded historical range and well below guidelines for the protection of aquatic life. Concentrations measured along depth profiles at three sites did not indicate any trend associated with depth (Figure A-22). No other data have been collected for ammonia at various depth intervals in the open-water season in Sylvan Lake. Conversely, there are considerable data delineating ammonia across depth in Sylvan Lake under ice. In winter, ammonia concentrations typically increase with depth (Figure A-21).

In general there is no strong indication of consistent seasonal variability in ammonia concentrations in the euphotic zone of Sylvan Lake (e.g., Figures A-16 and A-17). However, in at least some years ammonia concentrations rose gradually over the open-water season (Figure A-17).

Total Kjeldahl Nitrogen has been measured the least frequently of any nitrogen parameter in Sylvan Lake and data are inadequate to delineate temporal trends and seasonal variations. TKN has been measured periodically in samples collected in 1995, 1996, 2000, 2001, 2003, and in samples collected in September 2004 in conjunction with this study (Table A-3). In general, available data indicate that TKN values are moderate and do not fluctuate widely over the open-water season. TKN in Sylvan Lake is largely comprised of organic nitrogen, which dominates the nitrogen pool in the lake. Unlike the trend observed for nearby Pine Lake (Sosiak and Trew 1996), TKN does not notably increase over the open-water season in Sylvan Lake. However, it is cautioned that data are limited. The mean concentration for the open-water season is 0.7 mg/L although concentrations as high as approximately 1.5 mg/L have been recorded (August 31, 2001). There was no apparent relationship between TKN and water depth in September 2004 (Figure A-22).

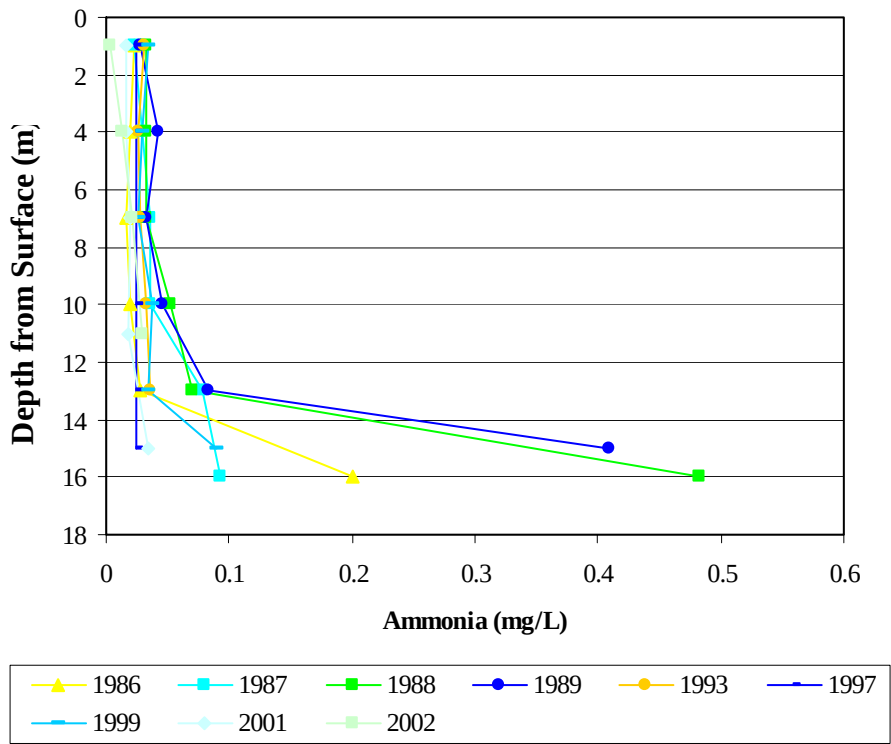


Figure A-21 Ammonia depth profiles measured in samples collected from Sylvan Lake in winter (January – March), 1986 to 2002

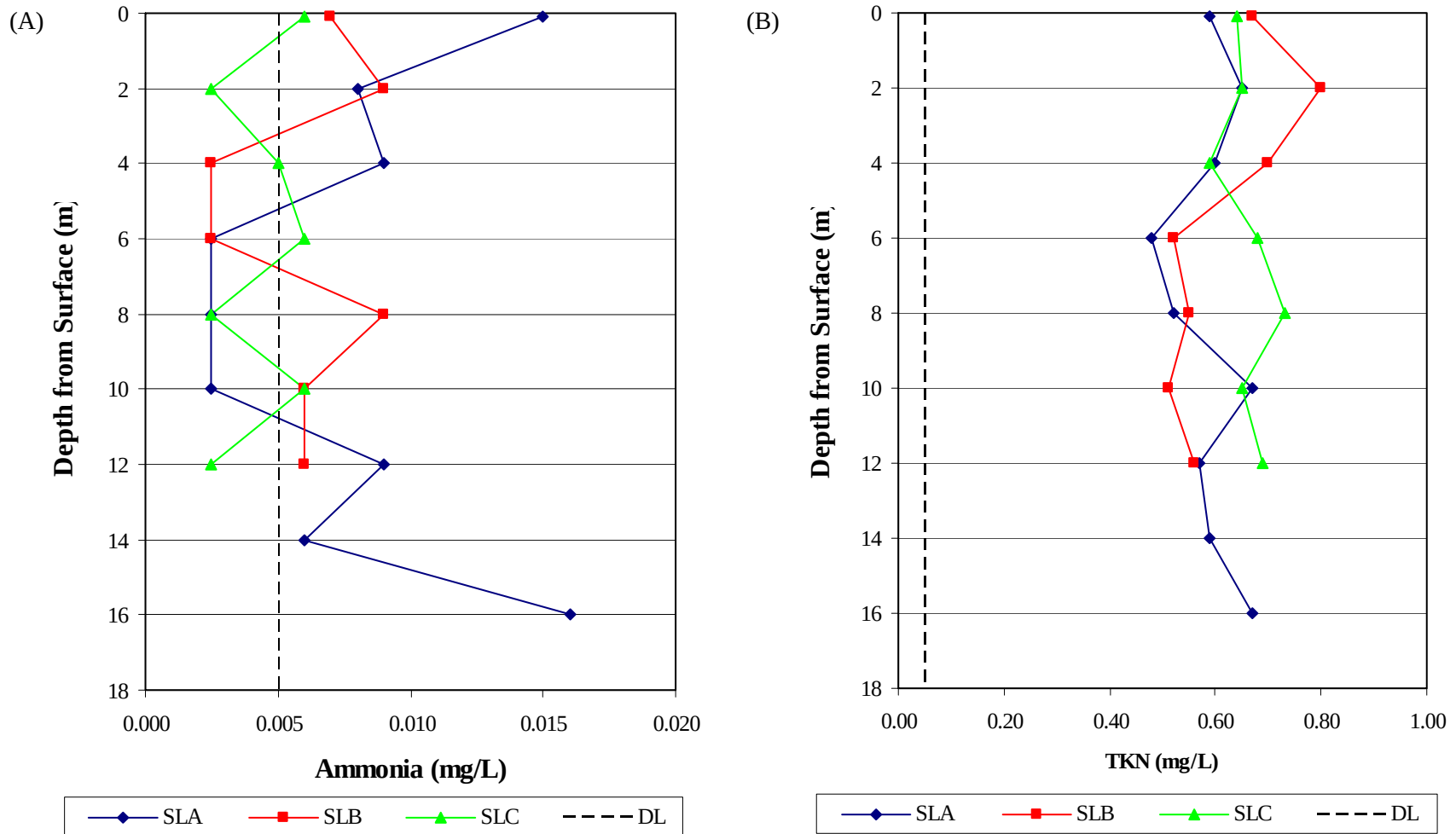


Figure A-22 Ammonia (A) and Total Kjeldahl Nitrogen (TKN) (B) depth profiles measured in samples collected from Sylvan Lake on September 06, 2004. Analytical detection limits (DL) are indicated by the dashed line

Table A-3 Summary statistics for TKN, nitrate/nitrite, and ammonia for the open-water seasons of 1983-2004 (Data from Alberta Environment)

Year	TKN (mg/L)					Dissolved Nitrate/nitrite (mg/L)					Ammonia (mg/L)				
	Mean	SE	Min	Max	n	Mean	SE	Min	Max	n	Mean	SE	Min	Max	n
1983	-	-	-	-	-	<0.05	-	-	-	1	-	-	-	-	-
1984	-	-	-	-	-	<0.05	-	-	-	2	-	-	-	-	-
1985	-	-	-	-	-	<0.05	-	-	-	1	-	-	-	-	-
1986	-	-	-	-	-	<0.05	-	-	-	3	-	-	-	-	-
1987	-	-	-	-	-	<0.02	-	-	-	2	-	-	-	-	-
1988	-	-	-	-	-	<0.02	-	-	-	2	-	-	-	-	-
1989	-	-	-	-	-	0.18	0.17	<0.01	0.35	2	-	-	-	-	-
1990	-	-	-	-	-	<0.02	-	-	-	3	-	-	-	-	-
1991	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1992	-	-	-	-	-	<0.005	-	-	-	2	-	-	-	-	-
1993	-	-	-	-	-	<0.005	-	-	-	3	-	-	-	-	-
1994	-	-	-	-	-	0.008	0	0.008	0.008	2	-	-	-	-	-
1995	0.66	-	-	-	1	<0.005	0.001	<0.005	0.001	3	0.007	-	-	-	1
1996	0.75	0.05	0.59	0.88	5	0.018	0.016	0.002	0.08	5	0.095	0.018	0.052	0.160	5
1997	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1998	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1999	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2000	0.625	0.019	0.576	0.675	5	0.001	0.0003	<0.001	0.002	5	0.004	0.002	<0.001	0.013	5
2001	0.824	0.002	0.487	1.212	3	0.002	0.001	<0.001	0.004	3	0.008	0.004	0.004	0.016	3
2002	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2003	0.61	0.01	0.59	0.65	4	<0.005	0.001	<0.005	0.005	4	0.008	0.002	0.005	0.012	4
2004 ¹	0.46	-	-	-	1	<0.006	-	-	-	1	0.008	-	-	-	
1983-2003	0.69	0.01	0.61	0.82	5	0.0218	0.0158	<0.005	0.18	16	0.0244	0.0035	0.004	0.10	5

Note: 1 Data collected in September 2004 in this study.

Because TKN has been measured relatively infrequently, comparison of historical nitrogen data to the AENV chronic water quality guideline for total nitrogen ([TN], 1.0 mg/L) is limited. However, available data (1995-2004) collected from the euphotic zone indicate that typically concentrations of TN are below 1.0 mg/L (averaging approximately 0.7 mg/L in the open-water season). A single measurement collected in August 2001 (1.5 mg/L) exceeded the guideline.

Levels of TKN (which approximate TN in Sylvan Lake) in Sylvan Lake are considerably lower than the mean levels reported for other nearby lakes; the mean open-water concentrations of TN in Pine and Gull lakes are 1.63 mg/L and 1.55 mg/L, respectively (Table A-4).

Table A-4 Comparison between water balances and trophic status of several Alberta lakes. Data for the Sylvan Lake water balance were derived from this study and refer to the average for the period of 1956-2000. Water quality data for Sylvan Lake were provided by AENV and refer to the averaging period of 1983-2002 (May–September)

Lake	Lake Area (km ²)	Drainage Basin Area (km ²) ¹	Trophic Status	TP (mg/L)	TN (mg/L)	Secchi Depth (m)	Chlorophyll a (µg/L)	Source
Sylvan Lake	41.75	109.25	Mesotrophic	0.021	0.72	4.8	4.6	This study and AENV
Gull Lake	80.6	206	Mesotrophic-eutrophic	0.0451	1.55	2.5	8.4	Mitchell and LeClair (2003)
Pine Lake	3.89	150	Eutrophic	0.072	1.63	2.8	18.7	Mitchell and Prepas (1990)

Note: 1 Excluding lake area.

Major Ions and Conductivity

In general, Sylvan Lake is characterized by a relatively low level of major ions and conductivity for central Alberta Lakes (Mitchell 1999). The dominant ions in Sylvan Lake are bicarbonate and to a lesser extent sodium and magnesium (Table A-2). Because bicarbonate is the dominant anion, Sylvan Lake is considered a bicarbonate-type lake. Mean concentrations of major ions measured in the euphotic zone of Sylvan Lake over the period of record fall within the ranges reported for freshwater Alberta lakes (Mitchell and Prepas 1990). However, means of sodium, potassium, carbonate, bicarbonate, and magnesium in Sylvan Lake exceeded the average for freshwater Alberta lakes (Table A-5). Conversely, mean calcium, chloride, and sulphate were lower than the average for freshwater Alberta lakes (Table A-5). The relative dominance of major ions

and the overall concentrations observed in Sylvan Lake are similar to the pattern observed in nearby Pine Lake (Sosiak and Trew 1996). Conversely, Gull Lake, which is considered to be slightly saline, is characterized by higher concentrations of major ions than either Sylvan or Pine Lake (Mitchell and LeClair 2003).

Table A-5 Mean (and range) concentrations of major ions in Alberta lakes (Mitchell and Prepas 1990)

Major Ions	Unit	Freshwater Lakes	Slightly Saline Lakes	Moderately Saline Lakes	Saline Lakes
Sodium	(mg/L)	20 (0.3-114)	113 (20-188)	379 (239-501)	7172 (1473-21,851)
Potassium	(mg/L)	5 (0.2-19)	29 (15-60)	34 (10-66)	166 (50-396)
Magnesium	(mg/L)	15 (4-44)	59 (41-98)	46 (19-55)	154 (107-206)
Calcium	(mg/L)	29 (7-59)	31 (8-76)	21 (9-31)	21 (14-28)
Chloride	(mg/L)	3 (0.1-20)	9 (2-17)	17 (10-30)	212 (99-459)
Sulphate	(mg/L)	24 (1-209)	209 (15-346)	395 (89-817)	7026 (2,413-16,530)
Bicarbonate	(mg/L)	178 (49-522)	415 (117-535)	647 (356-922)	2187 (571-5386)
Carbonate	(mg/L)	5 (0-31)	40 (0-70)	83 (25-138)	3291 (107-12,335)

Data collected in September 2004 from the euphotic zone and along depth profiles indicated that concentrations of major ions did not vary substantively across depth or between sites (Appendix C). Depth profiles for major ions have not been examined in previous studies in Sylvan Lake and it is not known if any of these parameters vary substantively with depth at other times of the year or in other years.

In Pine Lake, some major ions vary seasonally in accordance with major period of algal growth (Sosiak and Trew 1996). In fact, calcium carbonate precipitates in sufficient quantities in Pine Lake that the deposits have become referred to as Pine Lake “coral.” Data are generally too limited to facilitate an evaluation of seasonal variations in major ions in Sylvan Lake. In 1996, monitoring data indicate that major ions did not vary substantively over the open-water period.

Sylvan Lake has a relatively low concentration of dissolved salts, with total dissolved solids (TDS) averaging 337 mg/L and ranging between 303 and 356 mg/L in the euphotic zone over the period of record. Specific conductance remains fairly consistent over the seasons and years in Sylvan Lake (Figure A-23) and relationship to water depth is not evident. The mean specific conductance in the euphotic zone of the lake for the open-water season is 588 $\mu\text{S}/\text{cm}$. These levels are representative of “freshwater conditions” (i.e., TDS <500 mg/L) and are similar to the majority of Alberta lakes (Mitchell and Prepas 1990).

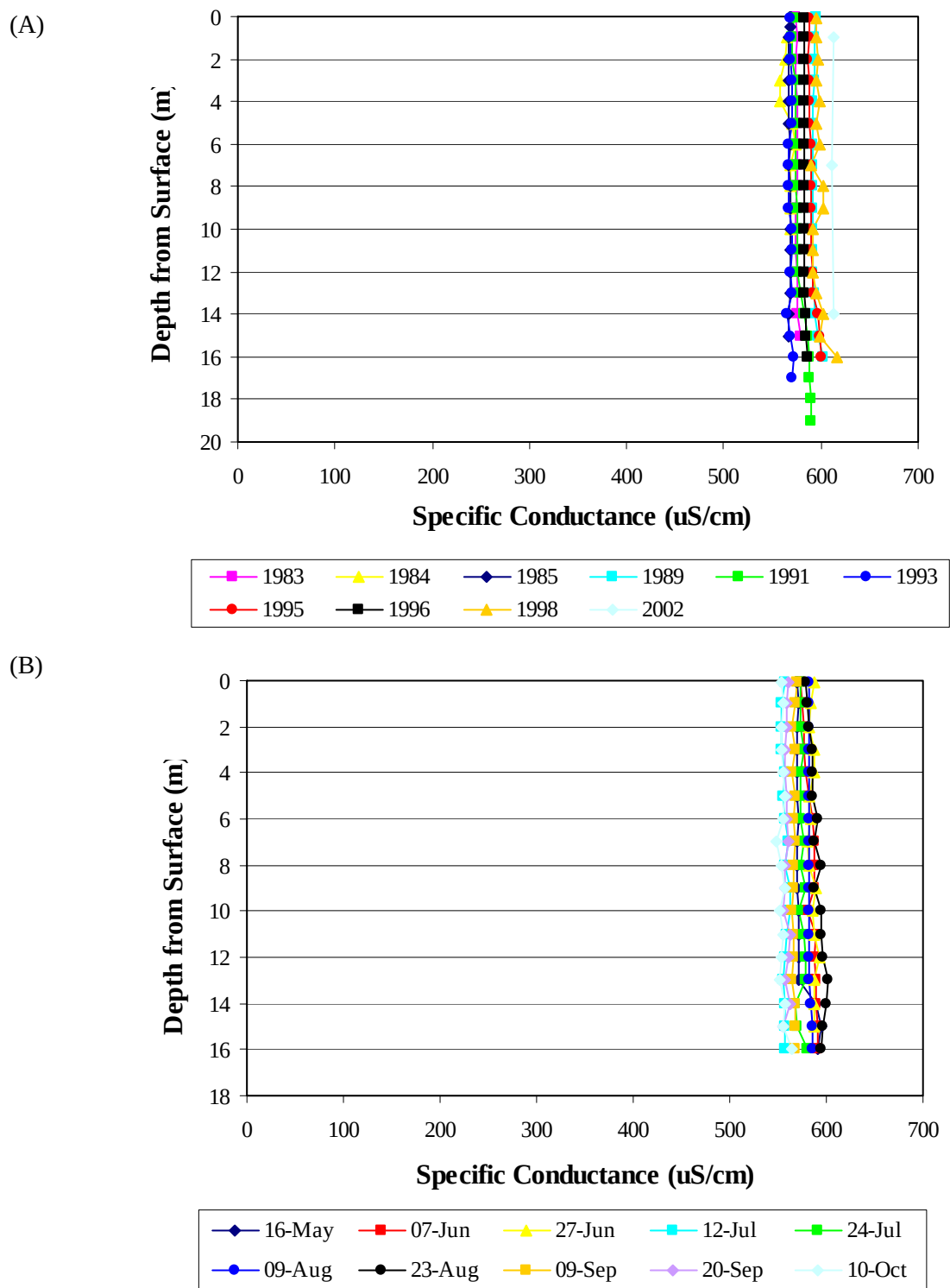


Figure A-23 Specific conductance measured in Sylvan Lake during: (A) August (1983-2002); and (B) the 1996 open-water season

Water Clarity

The water clarity of Sylvan Lake is high, as measured by Secchi disk depths, turbidity, or total suspended solids (TSS). Based on Secchi disk depth, which averaged 4.8 m for the open-water season (1983-2002), Sylvan Lake falls into the oligotrophic category for Alberta Lakes. Water clarity was also high in September 2004 (Secchi disk depths were generally >3 m).

There does not appear to be a strong relationship between Secchi disk depth and chlorophyll *a* concentrations (Figure A-24), as occurs in many Alberta Lakes (e.g., Gull Lake, Mitchell 1999). However, the historical data record indicates transparency is generally highest in July and somewhat lower in September (Figure A-25). As indicated by McEachern (2003), increases in Secchi depths in July 2003 were not related to algal biomass.

Similarly, TSS concentrations are very low in Sylvan Lake, averaging 2.3 mg/L over the period of record and ranging from 1 to 7 mg/L. TSS was 2 mg/L in the single composite sample analysed for September 2004.

Chlorophyll *a*

Chlorophyll *a*, an indicator of the amount of algae in the water column, is relatively low in Sylvan Lake, averaging 4.6 µg/L for the open-water season in the euphotic zone (1983-2003). Available data do not indicate that concentrations are increasing in the lake even though the maximum concentration observed in the lake occurred in 2001. Although the raw data could not be located, chlorophyll *a* concentrations measured in 1973 and 1974 reportedly averaged 4.4 µg/L and 4.1 µg/L, respectively (Mitchell 1999). This provides further evidence that chlorophyll *a* concentrations have not changed markedly over the last several decades.

Chlorophyll *a* generally increases over the open-water season in Sylvan Lake, reaching peak concentrations in September (Figures A-15 and A-26). This seasonal pattern of increasing biomass is typical of north temperate lakes. Levels measured in September 2004 were similar to historical levels for that month. The single measurement collected in the month of November in Sylvan Lake (1988), indicated that chlorophyll *a* remained high at least to the beginning of November (Figure A-27). In fact, in 1988, chlorophyll *a* peaked in November. Air temperatures were above average in the month of October and November, thus facilitating maintenance of algal populations into late fall.

Concentrations measured in winter in the euphotic zone (February 1983 and 1984 and March 1985) and surface samples collected along depth profiles in winter (February 1984, March 1986, January 1987, February 1988, March 1989, February 1997, February 1999) were generally near or below 1 µg/L, as expected in north temperate lakes that are under ice cover.

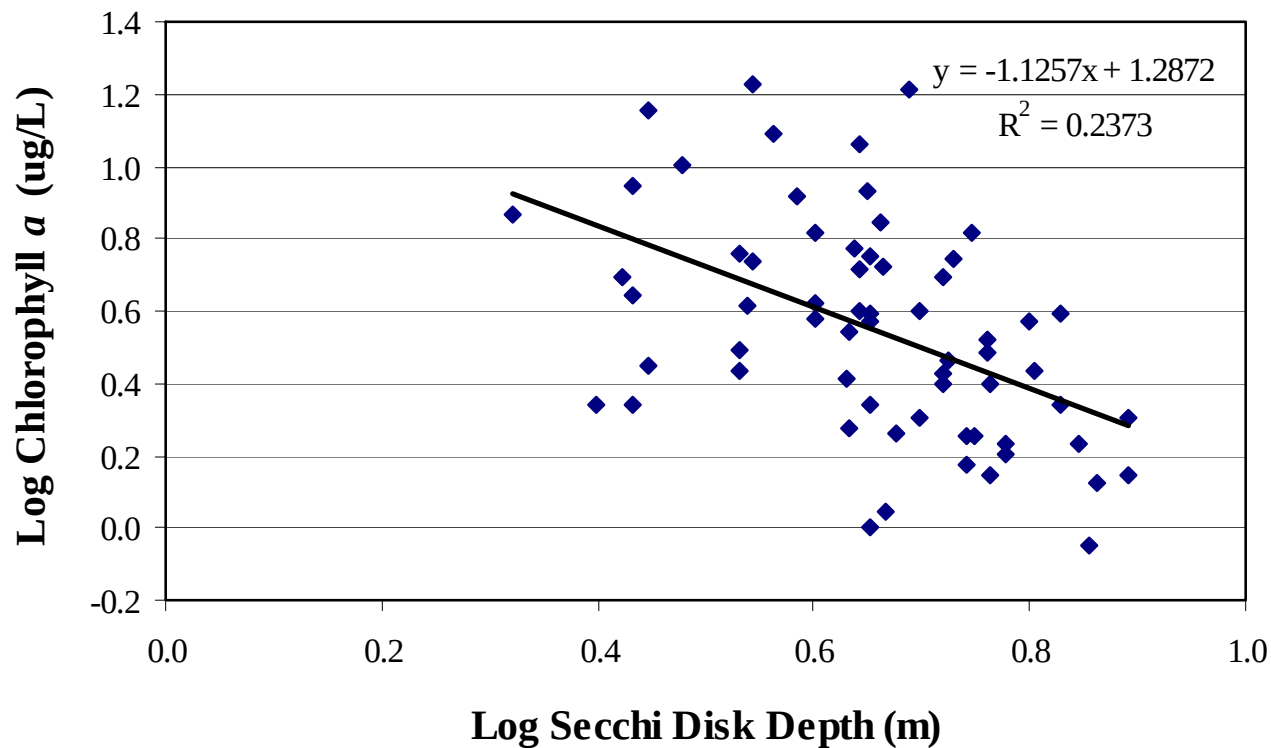


Figure A-24 Relationship between Secchi disk depth and chlorophyll *a* concentrations in the euphotic zone of Sylvan Lake, 1983-2003. $p=0.05$

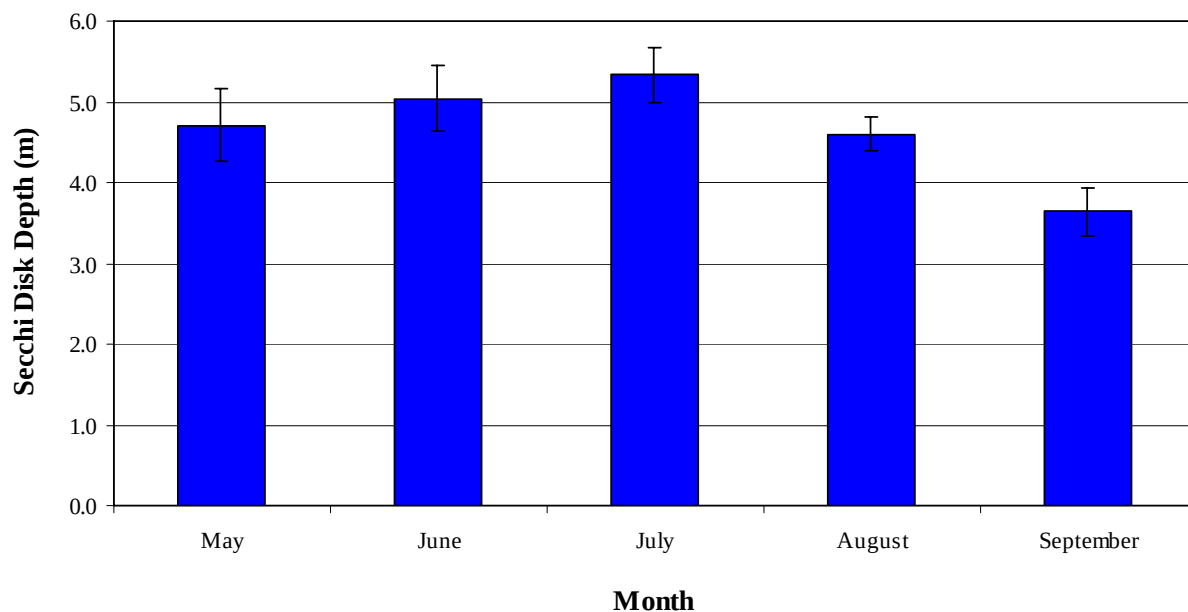


Figure A-25 Monthly mean (±SE) Secchi disk depths for the euphotic zone of Sylvan Lake between May and September, 1983-2003

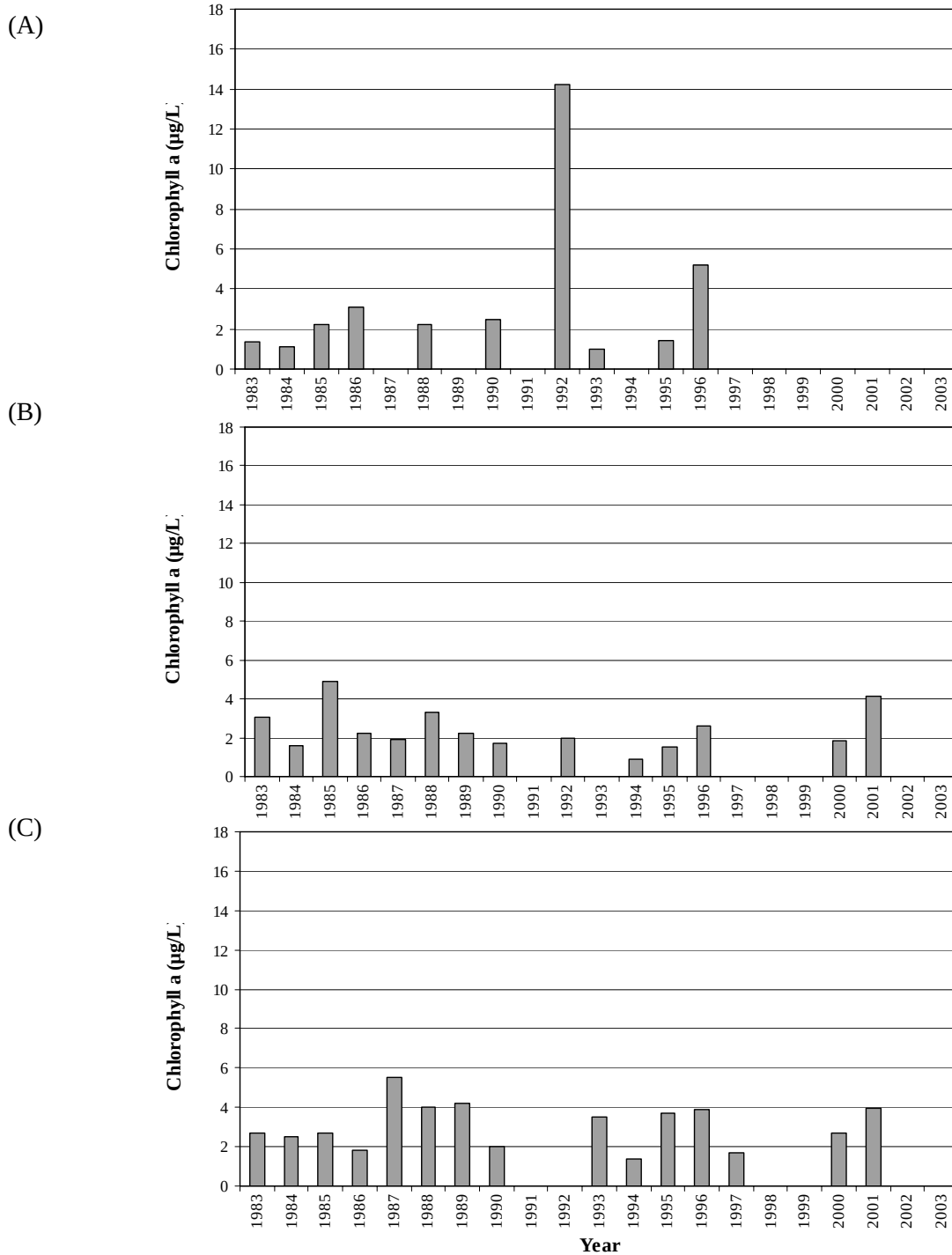


Figure A-26 Chlorophyll a concentrations measured in composite samples collected from the euphotic zone of Sylvan Lake: (A) May; (B) June; (C) July; (D) August; and (E) September

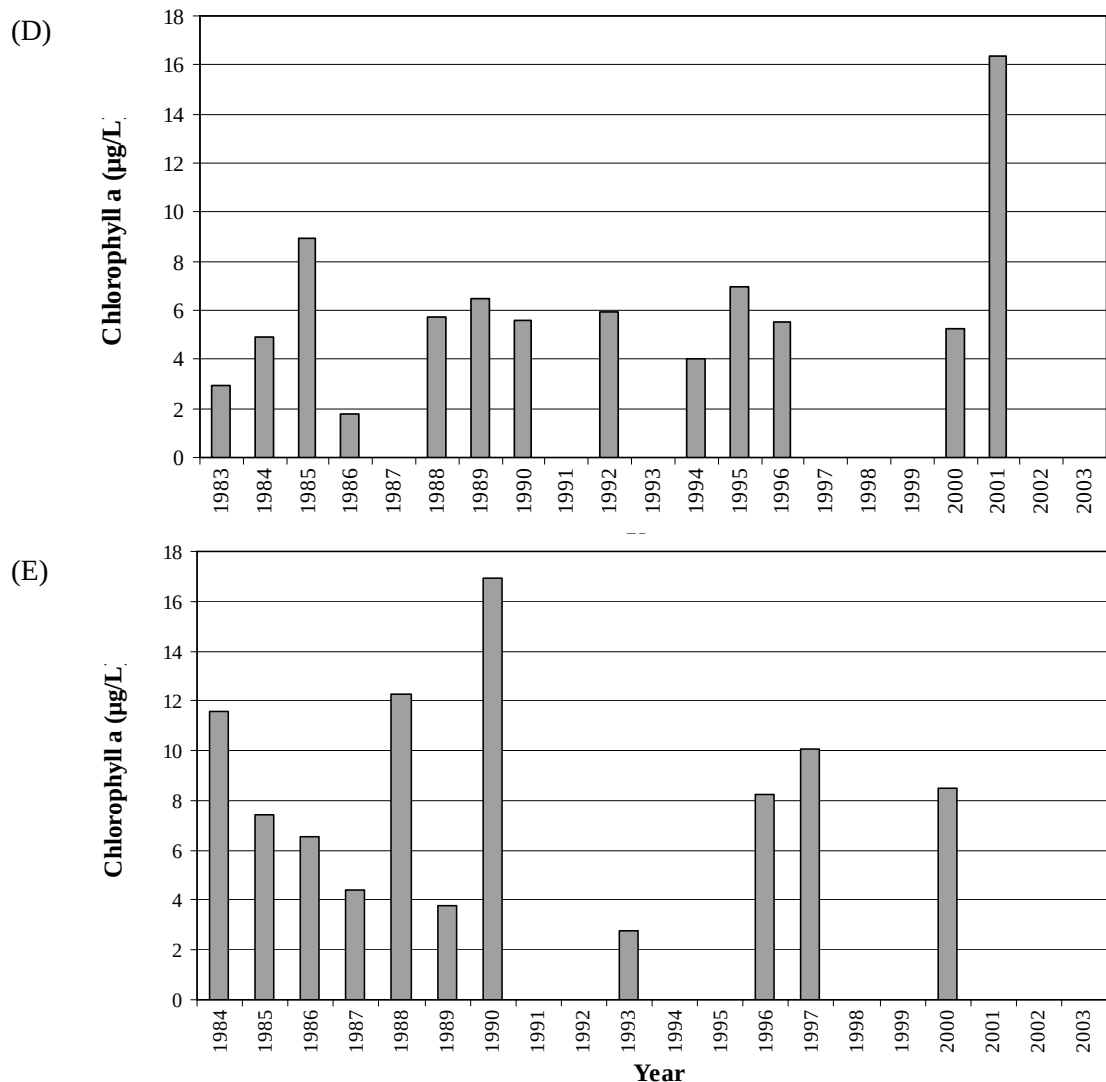


Figure A-26 Chlorophyll a concentrations measured in composite samples collected from the euphotic zone of Sylvan Lake: (A) May; (B) June; (C) July; (D) August; and (E) September (cont'd)

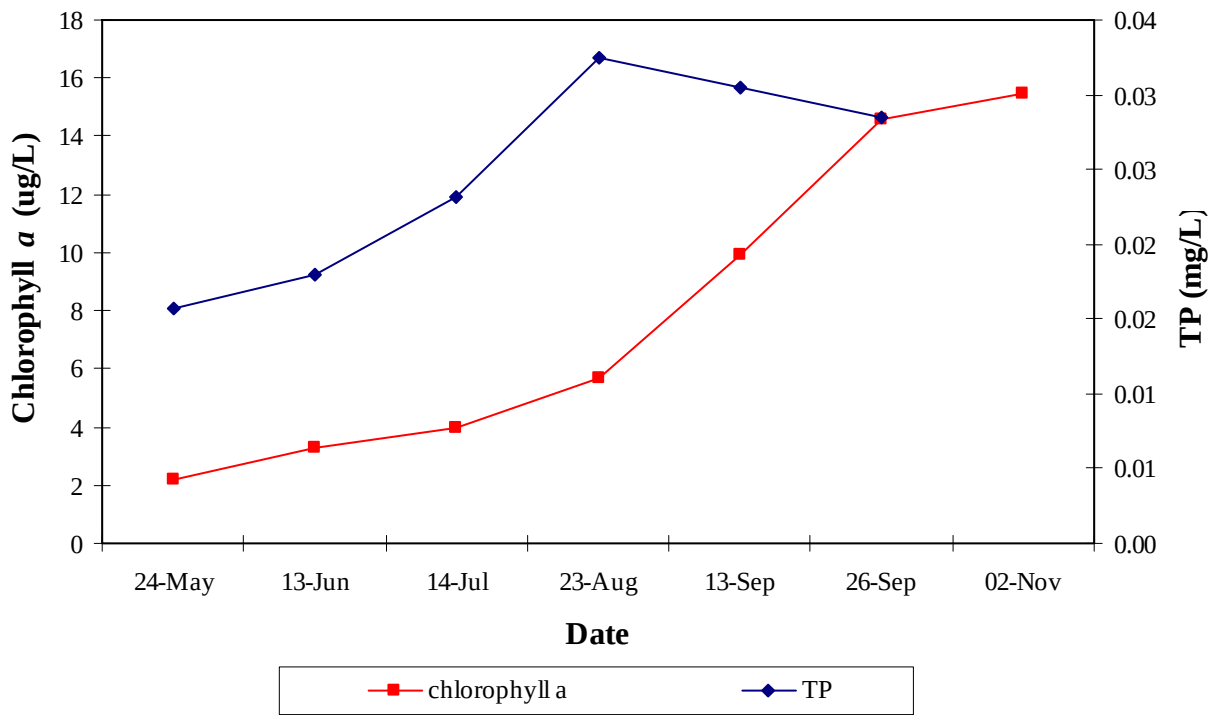


Figure A-27 Chlorophyll a and total phosphorus (TP) in the euphotic zone of Sylvan Lake during the 1988 open-water season

The highest mean chlorophyll *a* concentrations observed in Sylvan Lake for the open-water season occurred in 1992 (7.4 µg/L) and 2001 (8.1 µg/L, Figure A-28). However, in 1992, the seasonal variability of chlorophyll *a* concentrations differed from other years as the peak concentration occurred in May (Figure A-29). This peak corresponded to atypically high concentrations of TP and iron (the highest recorded) in the lake. Furthermore, since 1983, when monitoring of chlorophyll *a* was initiated, the highest recorded lake water level occurred in 1992 (see Section A.4). Collectively, these data may indicate that nutrient loading to the lake may have been particularly significant in that year. However, the sampling day in May 1992 was preceded by two atypically warm days (maximum daily temperatures of 23°C and 26°C) which may have also contributed to the development of algal biomass. The highest chlorophyll *a* concentrations observed in nearby eutrophic Pine Lake also occurred in 1992. In fact, concentrations were sufficiently high to classify Pine Lake as “hypereutrophic”. Spring breakup in 1992 was among the earliest recorded for Pine Lake, which was suggested to have contributed to the algal blooms that occurred during that open-water season (Sosiak and Trew 1996). Although spring breakup dates for Sylvan Lake are not available, it can be surmised that an earlier ice-off date may have also occurred in Sylvan Lake in 1992 as these two lakes are reasonably close and in the same river basin and ecoregion. Conversely, Gull Lake, which is of a more similar volume to Sylvan Lake did not experience maximum chlorophyll *a* concentrations in the 1992 (Mitchell and LeClair 2003).

The seasonal pattern of chlorophyll *a* was more typical in the open-water season of 2001, peaking at the end of August when the last sample was collected that year (Figure A-29). The highest recorded concentration of chlorophyll *a* in Sylvan Lake (32.4 µg/L) occurred on August 31, 2001. The month of August 2001 was warmer than average (mean temperature was 2.5°C above average and maximum temperature was 4.2°C above average), which would have contributed to the development of an algal bloom. The peak of chlorophyll *a* also coincided with a peak in TP.

A.2.1.2 Nearshore Water Quality

Overview

Water quality in the nearshore zone of Sylvan Lake has been studied less intensively than the deeper, offshore areas of the Lake. Data sources include:

- Historical bacteriological studies of nearshore areas adjacent to Half Moon Bay, Honeymoon Bay, Norglenwold, and the Town of Sylvan Lake and storm sewer ditches and outfalls in the Town of Sylvan Lake in 1988 (Mitchell 1988);
- Fisheries resource assessments for proposed Westend Landing and DeGroat developments adjacent to the Sylvan Lake Natural Area in 2000 (Carson and Allan 2001 and 2002); and,
- The field program conducted as a component of the current study in various nearshore areas in September 2004.

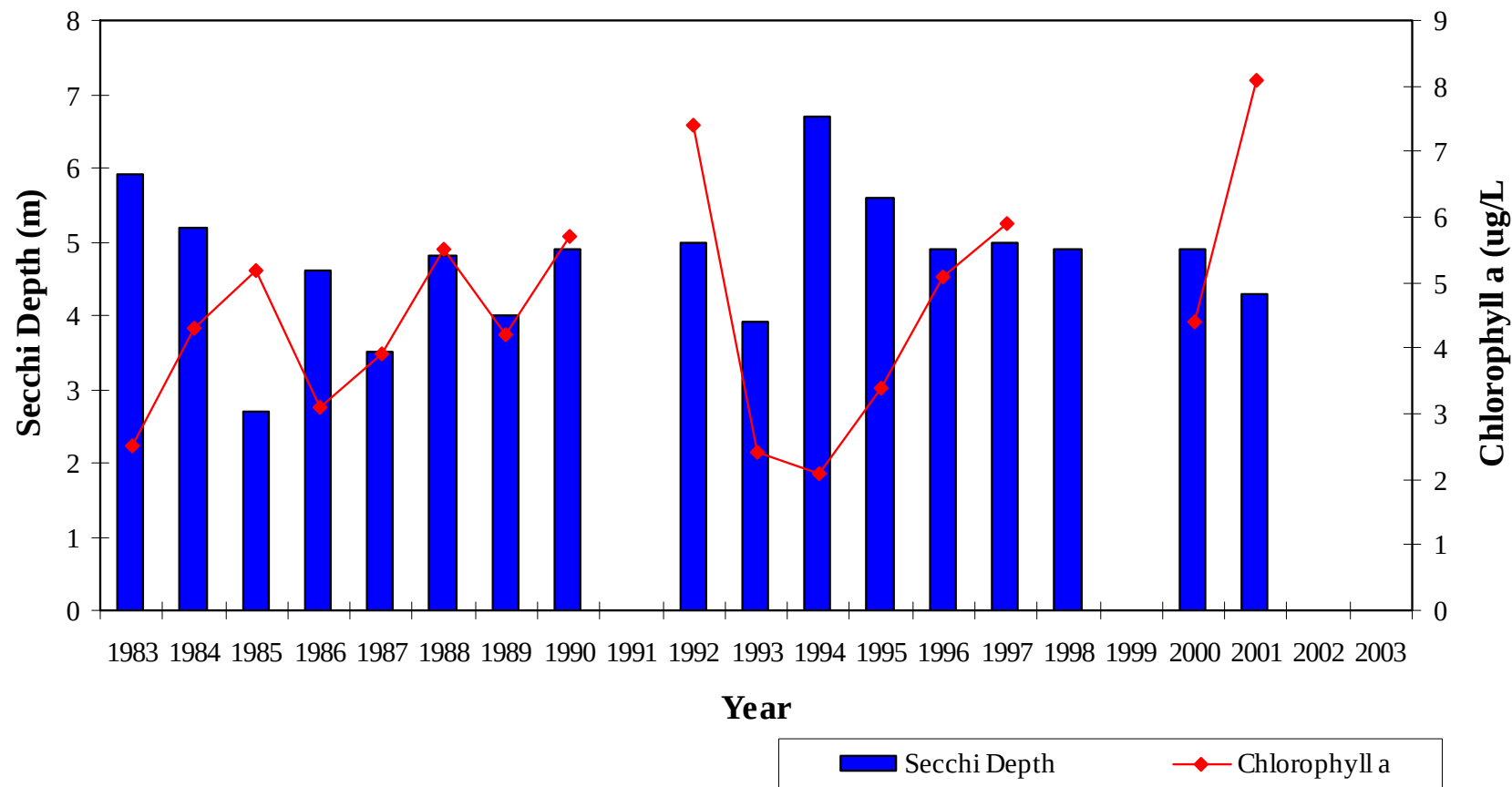


Figure A-28 Mean Secchi disk depths and chlorophyll a concentrations in the euphotic zone of Sylvan Lake, 1983–2003

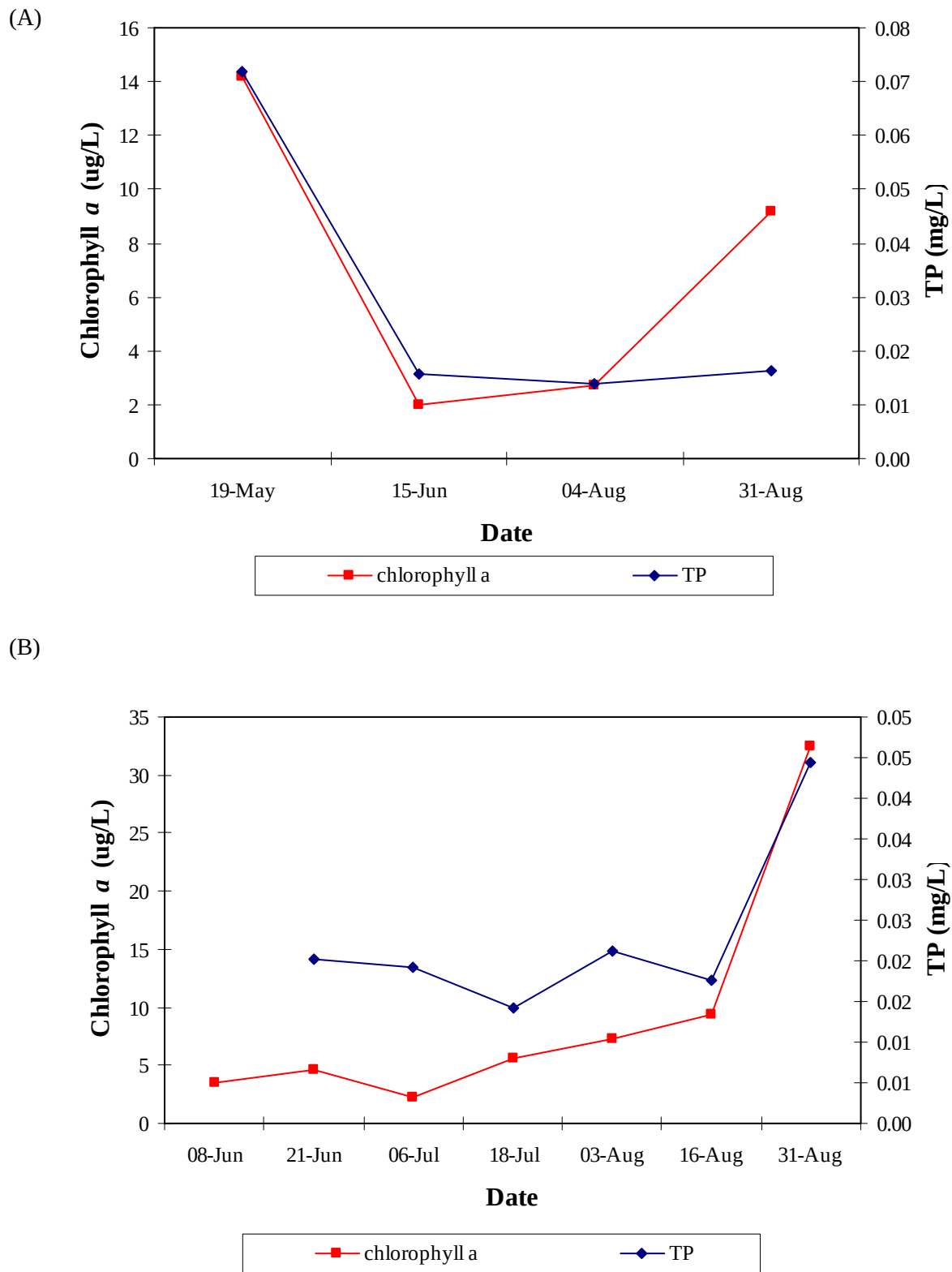


Figure A-29 Chlorophyll a and total phosphorus (TP) in the euphotic zone of Sylvan Lake during: (A) 1992; and (B) 2001

Bacteria

A bacteriological study conducted in the open-water season of 1988 found low levels of fecal coliform bacteria (within ranges considered to be background) in nearshore areas adjacent to the communities of Half Moon Bay, Honeymoon Bay, and Norglenwold (Mitchell 1988). Average concentrations at each sampling location were less than or equal to 13 CFU/100 mL and the maximum concentration measured anywhere was 64 CFU/100 mL (Table A-6). Similarly, bacteria levels were considered to be 'acceptable' adjacent to the beach at the Town of Sylvan Lake. However, concentrations were higher near the Town of Sylvan Lake than adjacent to other communities and it was concluded that the main source was stormwater drains adjacent to the beach.

Table A-6 Fecal coliform bacteria measured in the nearshore zone of Sylvan Lake, June 08- August 22, 1988. Samples were collected weekly (Mitchell 1989)

Site	Location	Range (CFU/100 mL)	Mean (CFU/100 mL)
Half Moon Bay	Floating dock	<4-48	7
	Striped boat canopy	<4-44	10
	Red life guard tower	<4-4	4
Honeymoon Bay	Beige mobile home	<4-16	6
	Railroad tie retaining wall	<4-12	5
	Red boat house	<4-8	5
	A-frame house	<4-4	4
Norglenwold	Boat house "ter col-lee"	<4-12	5
	Barn style cabin-brown roof	<4-8	4
	2-storey, brown boat house	<4-8	5
	Brown cottage with stairs	<4-16	5
	Norglenwold boat launch	<4-4	4
New Norglenwold	Long narrow pier at south	<4-8	5
	Horse stable	<4-24	6
	Creek mouth	4-36	10
	Marina entry	<4-64	13

Concentrations of *Escherichia coli* (*E. coli*) and fecal coliform bacteria measured in the nearshore areas adjacent to the Summer Villages of Jarvis Bay, Birchcliff, Norglenwold, Half Moon Bay, and Sunbreaker Cove, the Town of Sylvan Lake, and the Sylvan Lake Natural Area in September 2004 were low (Table A-7); all measurements were less than

10 CFU/100 mL. The Alberta recreational water quality guidelines refer to a geometric monthly mean of a minimum of five samples with a guideline of 200 *E. coli* or fecal coliforms/100 mL (AENV 1999). Although only single samples were taken and the results are not directly applicable to the recreational guidelines, all samples analysed for bacteria in Sylvan Lake were well below the guidelines. Collectively, there was no indication of a bacteriological issue in these areas, at that particular time. Similarly, *E. coli* and fecal coliform bacteria were not detected at most shallow groundwater quality monitoring locations (see Appendix B).

Table A-7 Means, ranges, and number of samples of fecal coliform bacteria and *E. coli* measured in nearshore areas of Sylvan Lake, September 06, 2004

		Town of Sylvan Lake	Summer Villages					Sylvan Lake Natural Area
			Norgenwold	Birchcliff	Half Moon Bay	Sunbreaker Cove	Jarvis Bay	
Fecal Coliform Bacteria (CFU/100 mL)								
	Mean	5	7	2	1	<1	1	1
	Range	4-6	-	<1-2	<1-2	-	-	<1-2
	n	3	1	3	3	1	1	3
E. coli (CFU/100 mL)								
	Mean	1	2	<1	<1	<1	<1	<1
	Range	1-1	-	<1-1	<1-1	-	-	<1-1
	n	3	1	3	3	1	1	3

For context, high levels of *E. coli* and fecal coliform bacteria were present in Golf Course Creek and Northwest Creek in September 2004 indicating that surface runoff is likely a more significant pathway for introduction of bacteria to Sylvan Lake than groundwater (Section A.3.4.3; Appendix B). Heavy rains experienced during the sampling program resulted in measurable discharges in these two creeks at that time. Despite the presence of significant concentrations of bacteria, no significant effect to nearshore surface water quality in the nearby areas of Sylvan Lake Natural Area (southwest of Northwest Creek) or the Town of Sylvan Lake (which is in the area of Golf Course Creek) was observed.

Dissolved Oxygen, pH, and Redox

pH levels in the nearshore zone were general higher than values measured across depths at deeper sampling locations in September 2004 (Figures A-30 and A-31); ranging from 9.03 at Jarvis Bay to a mean of 10.22 at Sunbreaker Cove and the Sylvan Lake Natural Area. pH values measured in the laboratory for this study were consistent and did not reveal spatial differences. Several measurements of pH collected in the nearshore area of Sylvan Lake near the Sylvan Lake Natural Area in the summer of 2000 indicated a pH in the nearshore areas of the lake (i.e., pH 8.2-8.8) similar to the historical record for the deepwater sampling locations (Table A-8, Carson and Allan 2001).

Table A-8 Water quality measured in situ in the open-water season of 2000, as presented in Carson and Allan 2001)

Area	Date	Temperature (°C)	Dissolved Oxygen (mg/L)	pH	Conductivity (µS/cm)
Nearshore area near Sylvan Lake Natural Area and the DeGroat Property	01-May-00	12	10.2	8.2	510
	17-May-00	10	11.9	8.2	510
	07-June-00	15	10.4	8.2	610
Sylvan Lake Marina	20-June-00	15	8.9	8.8	600
Marina Bay Marina	20-June-00	14	8.9	8.5	610

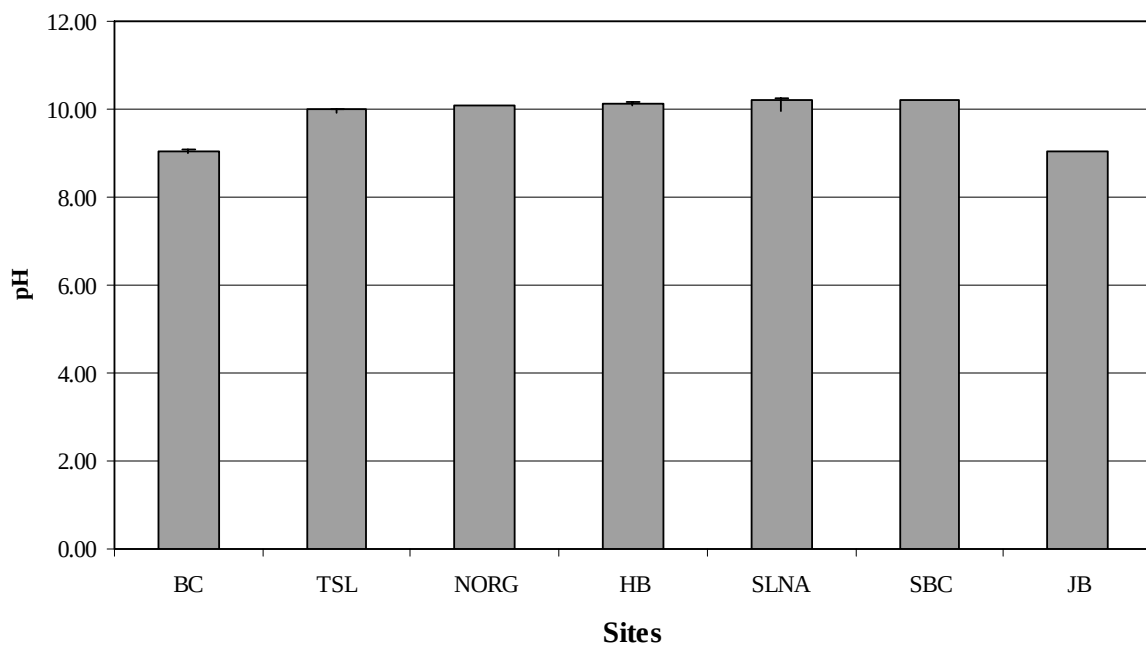


Figure A-30 pH in the nearshore zone of Sylvan Lake, September 2004. Values represent mean and SE for Birchcliff (BC), Town of Sylvan Lake (TSL), Half Moon Bay (HB) and Sylvan Lake Natural Area (SLNA), and single measurements at Norglenwold (NORG), Jarvis Bay (JB) and Sunbreaker Cove (SBC)

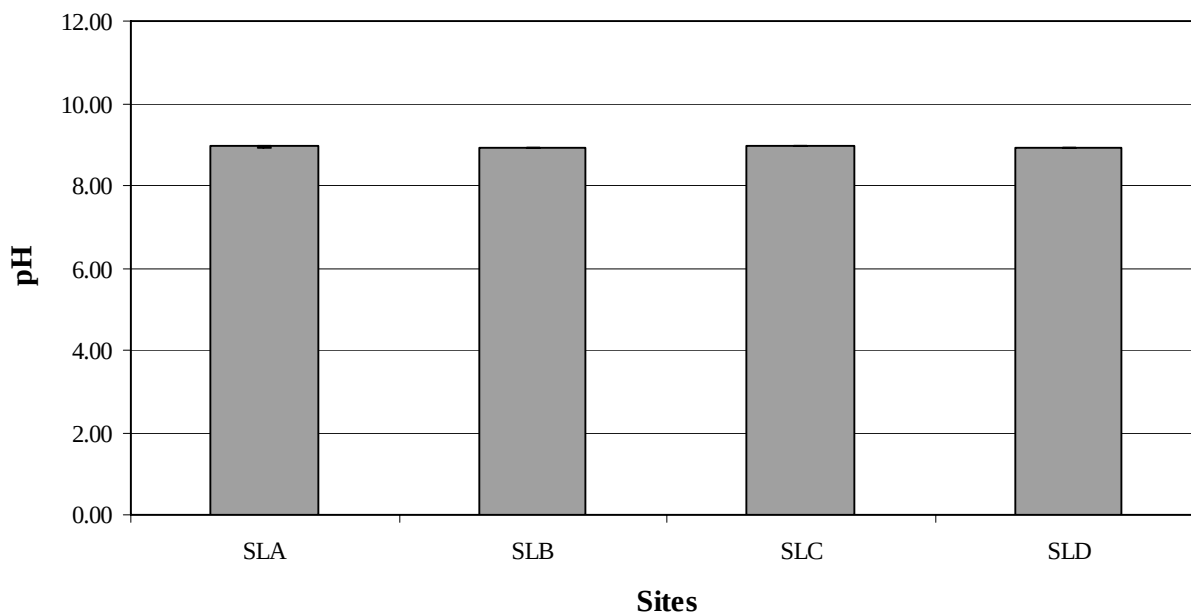


Figure A-31 Mean (±SE) pH at deepwater sampling sites in Sylvan Lake, September 2004. Values represent averages of depth profiles at sites SLA, SLB and SLC and the single euphotic zone composite sample collected at SLD

There are limited data available characterizing dissolved oxygen concentrations in the littoral areas of Sylvan Lake. In September 2004, DO was high in the nearshore areas, with concentrations in excess of 8 mg/L and saturation levels of greater than 80% (Figure A-32). Similarly, Carson and Allan (2001) reported high dissolved oxygen concentrations in the nearshore area of Sylvan Lake near the Sylvan Lake Natural Area (10.4-11.9 mg/L) and in two marina basins along the south shore of the lake (Sylvan Lake and Marina Bay marinas: 8.2 mg/L) in the summer of 2000. Available data indicate sufficient DO concentrations for the protection of aquatic life. However, due to the limited amount of data, it is possible that DO depletion may occur in nearshore areas in certain years, or times of years in association with algal blooms. Additionally, data are insufficient to characterize potential diurnal DO swings that can occur in productive environments (e.g., during algal blooms).

Redox potentials in the nearshore areas of Sylvan Lake in September 2004 were lower (all less than 100 mV) at the Town of Sylvan Lake, Norglenwold, Half Moon Bay, Sylvan Lake Natural Area, and Sunbreaker Cove relative to Jarvis Bay or Birchcliff or the deepwater sampling locations (where redox potential was at or above 200 mV, Figures A-33 and A-34). These data indicate that redox potential was conducive to the release of phosphorus from sediments at the time of the survey in September 2004. However, concentrations of TP were actually lower in the nearshore areas than at deep water locations.

Nutrients

The only known source of information regarding nutrients in the nearshore zone of Sylvan Lake is the study conducted in September 2004, as a component of this review. Concentrations of total and dissolved phosphorus in the nearshore area did not vary significantly between the Summer Villages of Birchcliff and Half Moon Bay, the Sylvan Lake Natural Area, or the Town of Sylvan Lake (Figures A-35 and A-36). TP, which ranged from 0.014 to 0.017 mg/L, was similar to but somewhat lower than the depth-averaged concentrations measured at deeper sites in the lake (Figure A-37). At the deep water sites, TP was higher in the first several metres of surface water relative to samples collected at greater depths and notably higher than concentrations observed in the nearshore zone. Conversely, dissolved phosphorus concentrations were fairly consistent at all sites evaluated in Sylvan Lake in September 2004 (Figures A-36 and A-38). No effects of loading from Golf Course or Northwest creeks to the nearshore zones adjacent to the Natural Area or the Town of Sylvan Lake were found; concentrations of TP and DP were notably higher (by approximately an order of magnitude) in the streams relative to the adjacent nearshore areas.

Similarly, TKN did not vary significantly between the nearshore zones of Birchcliff, Half Moon Bay, the Town of Sylvan Lake, or the Sylvan Lake Natural Area (Figure A-38). Concentrations were also similar to depth-averaged concentrations and levels observed in the first several meters at the deepwater sampling locations in September 2004 (Figure A-40). Although only a single sample was collected at Norglenwold, TKN was notably higher there relative to other nearshore areas and was the maximum concentration measured in the study. Due to the limited data (i.e., one sample) it is not possible to determine whether TKN is significantly different in the Norglenwold nearshore area.

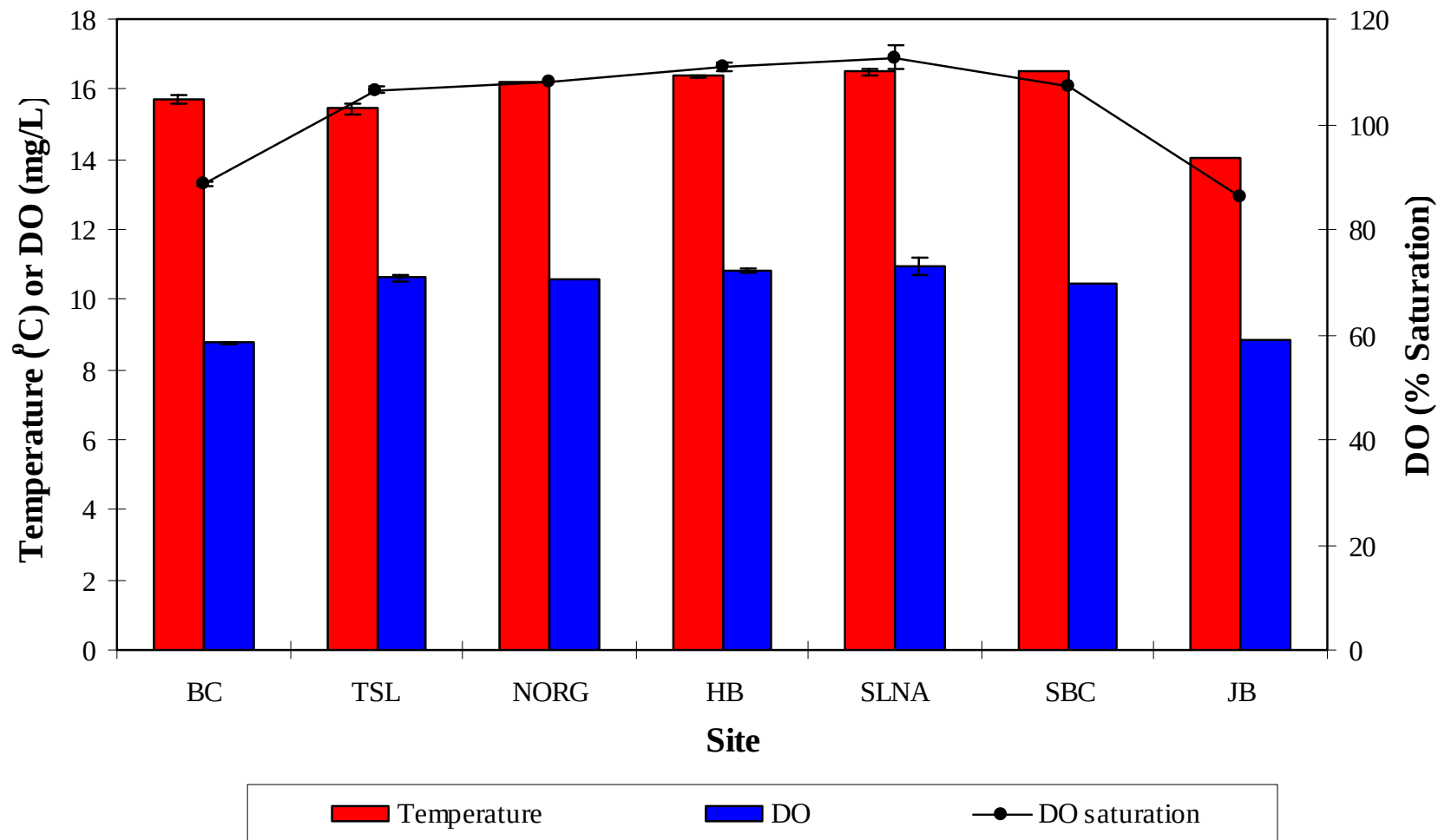
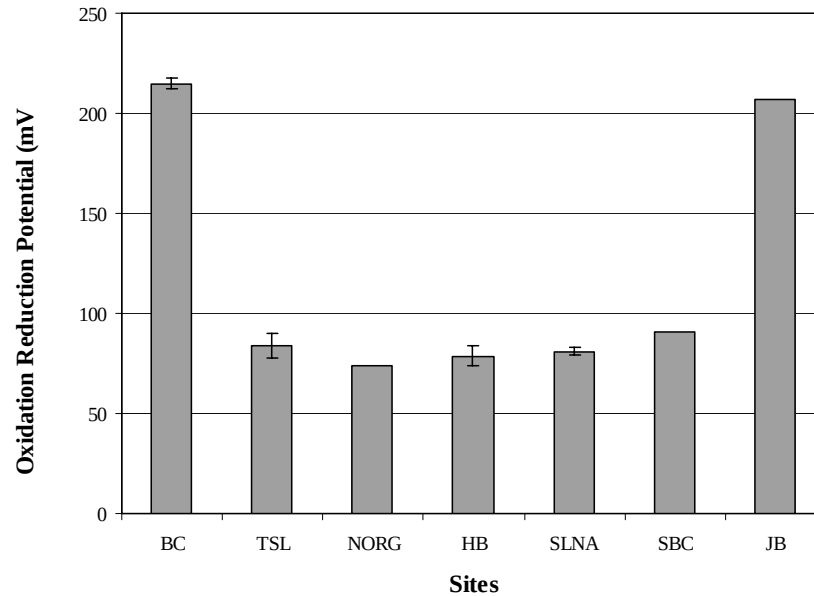
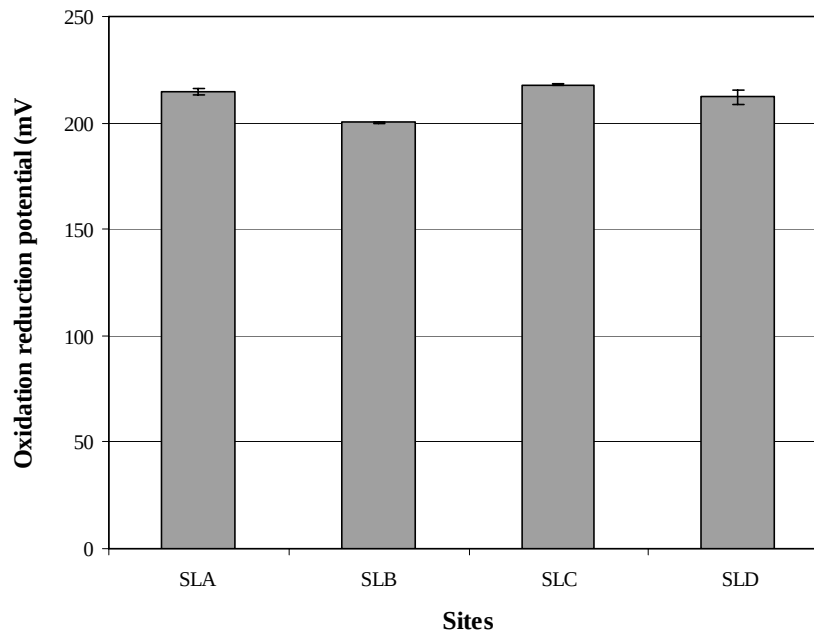


Figure A-32 Water temperature, dissolved oxygen (DO) concentrations and DO saturation levels in the nearshore zone of Sylvan Lake, September 2004. Values represent mean and SE for Birchcliff (BC), Town of Sylvan Lake (TSL), Half Moon Bay (HB) and Sylvan Lake Natural Area (SLNA), and single measurements at Norglenwold (NORG), Jarvis Bay (JB) and Sunbreaker Cove (SBC)

**Figure A-33**

Oxidation reduction potential in the nearshore zone of Sylvan Lake, September 2004. Values represent mean and SE for Birchcliff (BC), Town of Sylvan Lake (TSL), Half Moon Bay (HB) and Sylvan Lake Natural Area (SLNA), and single measurements at Norglenwold (NORG), Jarvis Bay (JB) and Sunbreaker Cove (SBC)

**Figure A-34**

Oxidation reduction potential at deepwater sampling sites in Sylvan Lake, September 2004. Values represent averages of depth profiles at sites SLA, SLB and SLC and the single euphotic zone composite sample collected at SLD

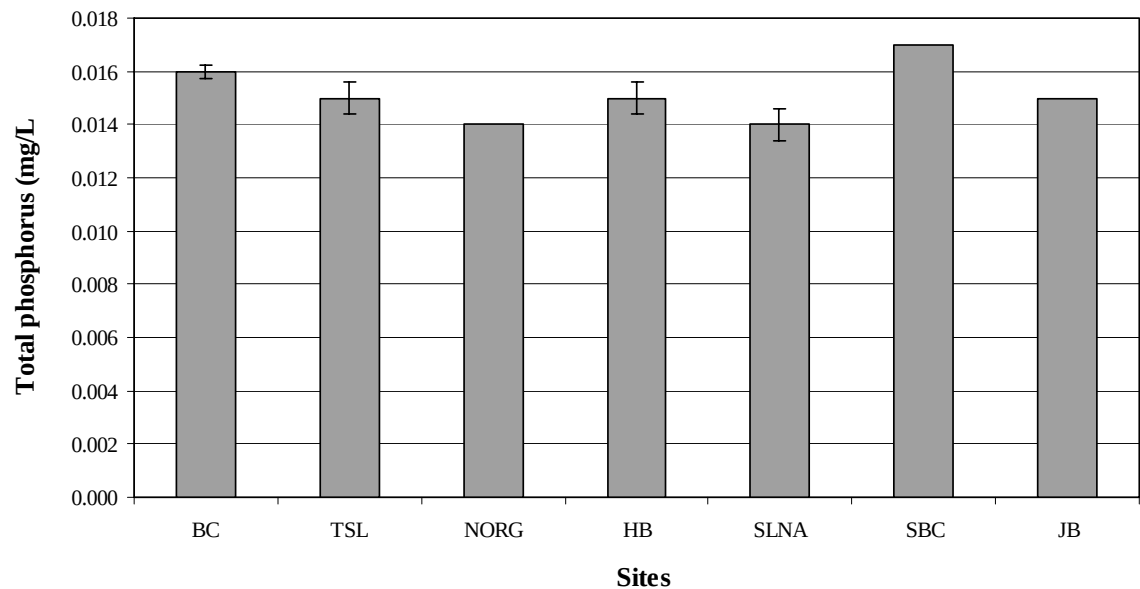


Figure A-35 Concentrations of total phosphorus (TP) in the nearshore zone of Sylvan Lake, September 2004. Values represent mean and SE for Birchcliff (BC), Town of Sylvan Lake (TSL), Half Moon Bay (HB) and Sylvan Lake Natural Area (SLNA), and single measurements at Norglenwold (NORG), Jarvis Bay (JB) and Sunbreaker Cove (SBC)

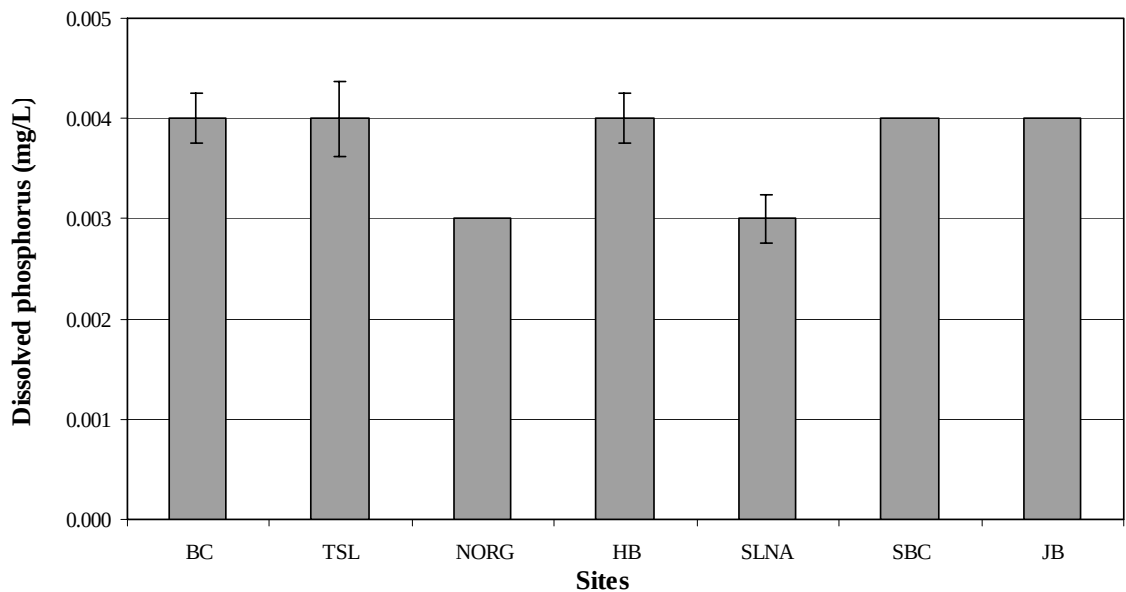


Figure A-36 Concentrations of dissolved phosphorus (DP) in the nearshore zone of Sylvan Lake, September 2004. Values represent mean and SE for Birchcliff (BC), Town of Sylvan Lake (TSL), Half Moon Bay (HB) and Sylvan Lake Natural Area (SLNA), and single measurements at Norglenwold (NORG), Jarvis Bay (JB) and Sunbreaker Cove (SBC)

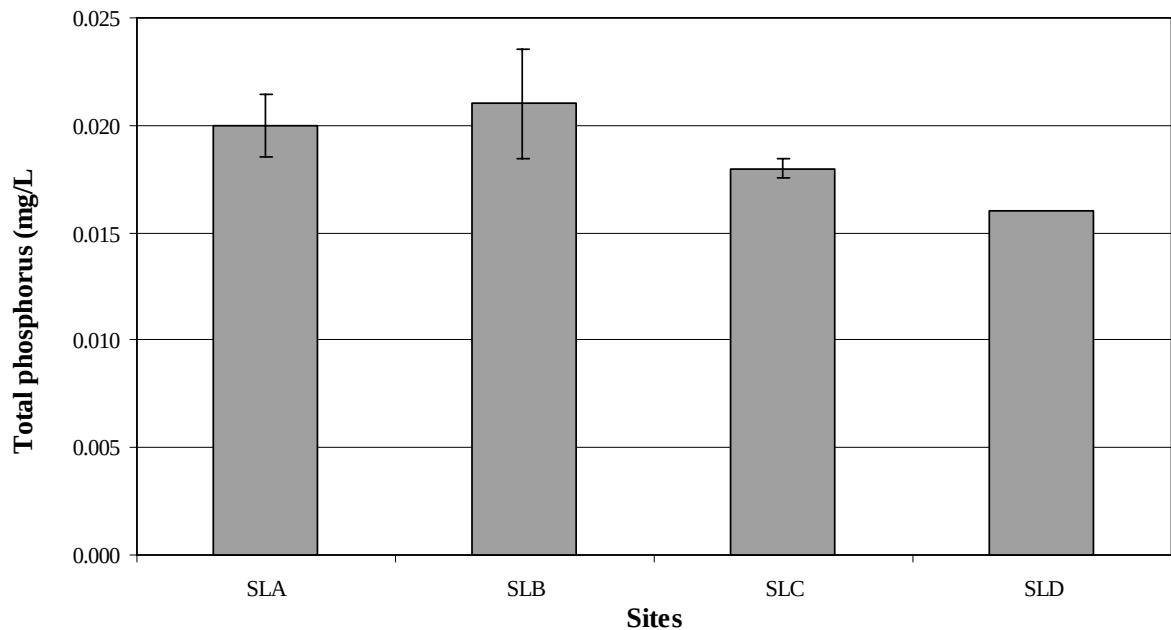


Figure A-37 Mean ($\pm$ SE) concentrations of total phosphorus (TP) at deepwater sampling sites in Sylvan Lake, September 2004. Values represent averages of depth profiles at sites SLA, SLB and SLC and the single euphotic zone composite sample collected at SLD

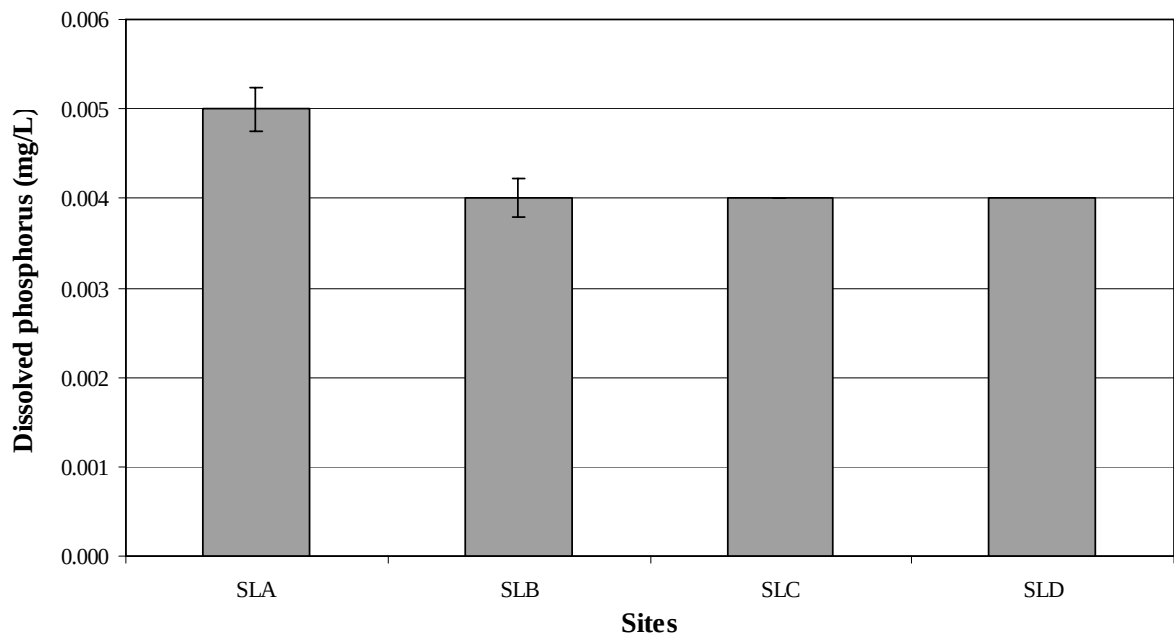


Figure A-38 Mean ($\pm$ SE) concentrations of dissolved phosphorus (DP) at deepwater sampling sites in Sylvan Lake, September 2004. Values represent averages of depth profiles at sites SLA, SLB and SLC and the single euphotic zone composite sample collected at SLD

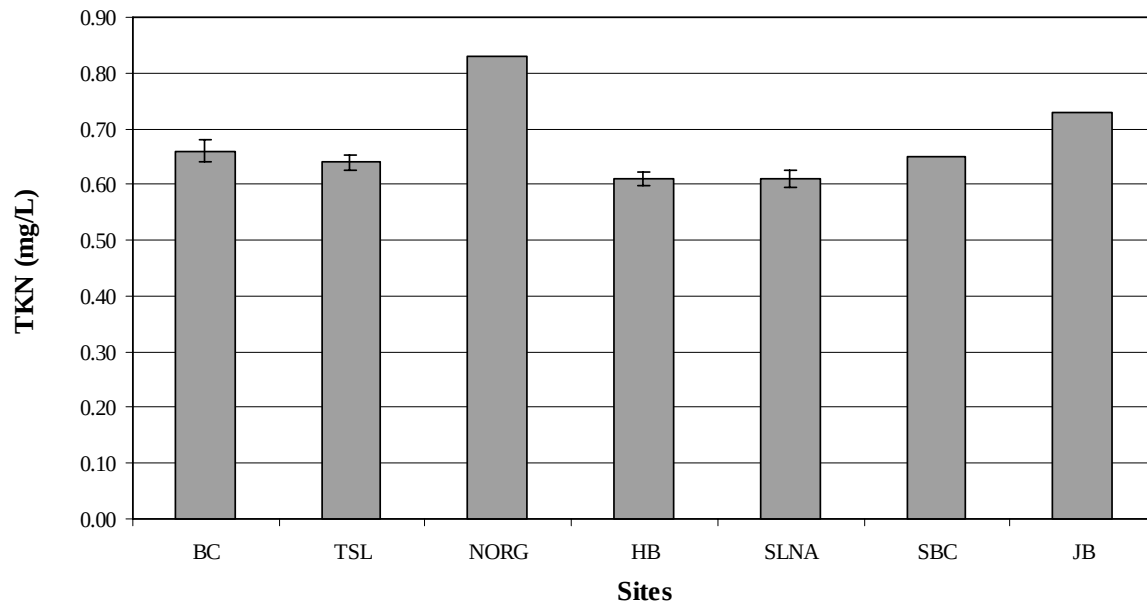


Figure A-39 Concentrations of Total Kjeldahl Nitrogen (TKN) in the nearshore zone of Sylvan Lake, September 2004. Values represent mean and SE for Birchcliff (BC), Town of Sylvan Lake (TSL), Half Moon Bay (HB) and Sylvan Lake Natural Area (SLNA), and single measurements at Norglenwold (NORG), Jarvis Bay (JB) and Sunbreaker Cove (SBC)

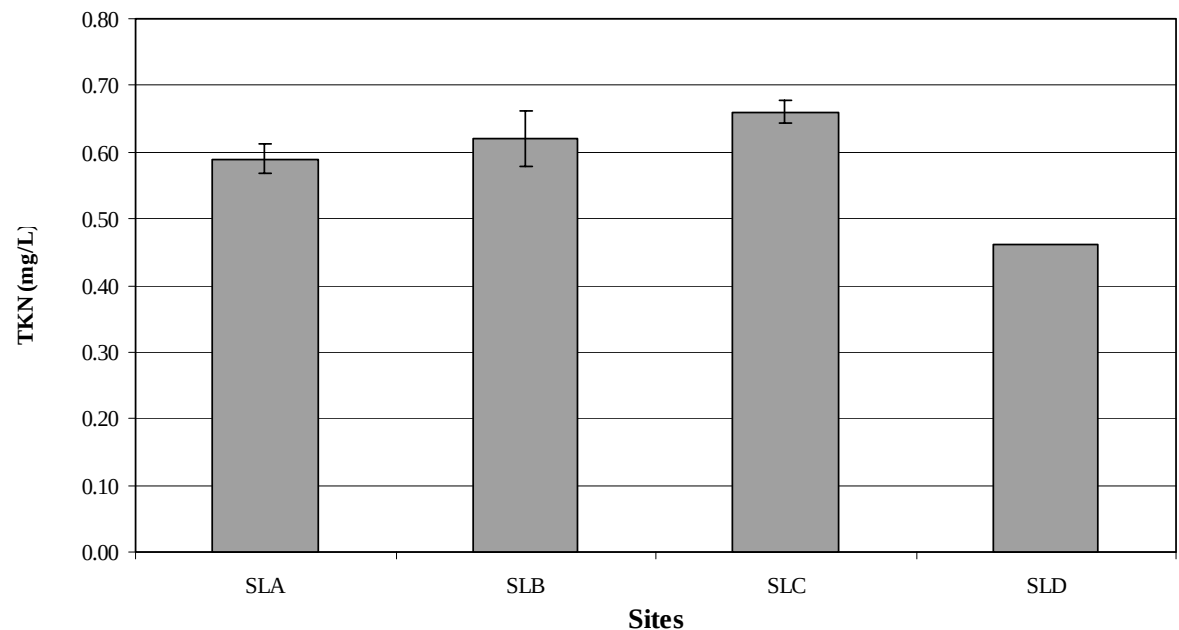


Figure A-40 Mean ($\pm$ SE) concentrations of Total Kjeldahl Nitrogen (TKN) at deepwater sampling sites in Sylvan Lake, September 2004. Values represent averages of depth profiles at sites SLA, SLB and SLC and the single euphotic zone composite sample collected at SLD

Ammonia concentrations varied between nearshore areas (Figure A-41); the mean concentration measured at Half Moon Bay was significantly higher than that measured at Birchcliff. Overall, concentrations measured in the nearshore areas were higher than the depth-averaged concentrations measured at deeper lake sites (Figure A-42). However, high concentrations (0.015 mg/L and 0.018 mg/L) of ammonia were measured near the surface at the deepest sampling site (SLA).

Nitrate/nitrite nitrogen was not detected in any samples collected in Sylvan Lake in September 2004. This occurred despite relatively high concentrations measured in one of the two tributary streams that were discharging at the time of the monitoring program; the concentration measured in Golf Course Creek was two orders of magnitude higher than the analytical detection limit and, therefore, all measurements obtained in the lake proper (Section A.3.4.3).

Major Ions, Conductivity, TDS

Levels of specific conductance in the nearshore areas of Sylvan Lake were generally consistent between areas and with the levels measured at the deeper sites (Figures A-43 and A-44). However, specific conductance was significantly higher in the nearshore area adjacent to the Summer Village of Birchcliff in September 2004. TDS concentrations were consistent between nearshore areas and relative to concentrations measured at deeper sites in Sylvan Lake in September 2004.

In general, the concentrations of major ions measured in the nearshore zone of Sylvan Lake in September 2004 were relatively similar and consistent with concentrations observed in the deeper area of the lake. The major exceptions to this generalization are concentrations of some major ions measured near the Sylvan Lake Natural Area, where some distinct differences relative to other littoral areas were observed. Magnesium, sodium, and calcium were all significantly lower near the Natural Area relative to the Summer Villages of Birchcliff and Half Moon Bay and the Town of Sylvan Lake (Figures A-45 to A-50). All were also lower than the depth-averaged concentrations observed in the deeper portion of Sylvan Lake at the same time.

Bicarbonate was higher in all nearshore areas, relative to the deeper sampling sites in Sylvan Lake in September 2004 (Figures A-51 and A-52). In addition, bicarbonate was notably lower near the Summer Villages of Birchcliff and Jarvis Bay, relative to other nearshore areas (although only one sample was collected at the latter site). Other conditions at Birchcliff and Jarvis Bay also varied from other nearshore areas; pH, dissolved oxygen, and total alkalinity were lower and fluoride and the oxidation reduction potential were higher at both Jarvis Bay and Birchcliff than the other nearshore areas.

Water Clarity

Secchi disk depth measured from the nearshore areas of Sylvan Lake are presented in Figure A-53. The depth of the euphotic zone, calculated from Secchi disk depths, extended well beyond the total depth at each site evaluated, indicating that light conditions were not limiting to algal growth. TSS concentrations measured at nearshore areas were low and ranged between 2 and 5 mg/L (see Appendix B).

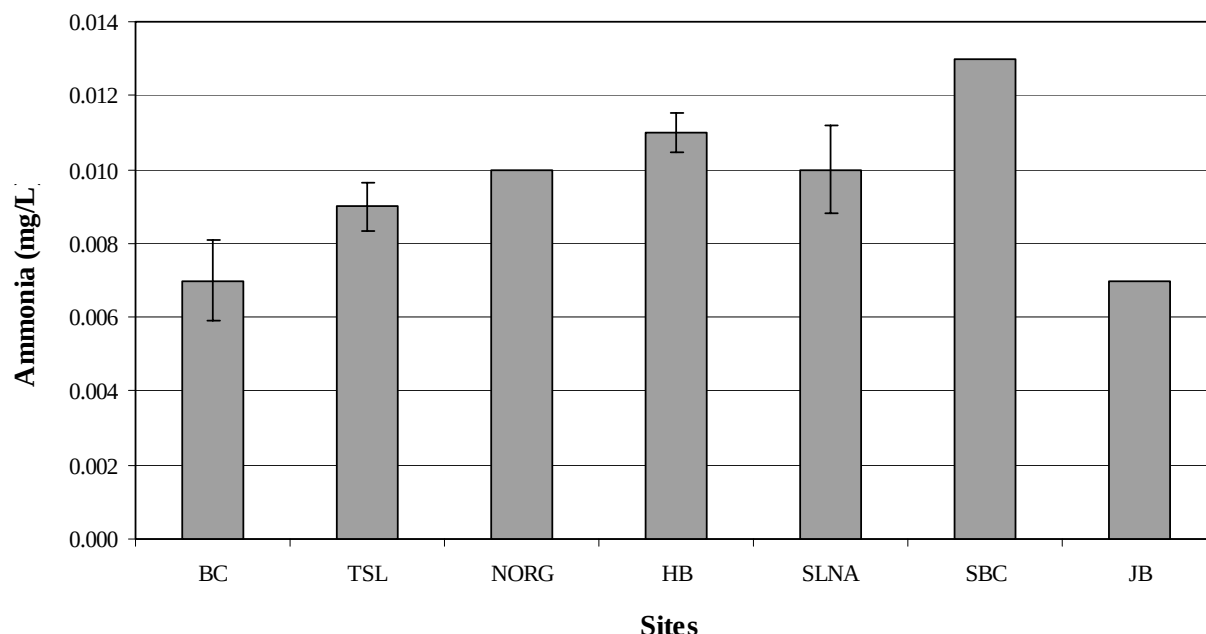


Figure A-41 Concentrations of ammonia in the nearshore zone of Sylvan Lake, September 2004. Values represent mean and SE for Birchcliff (BC), Town of Sylvan Lake (TSL), Half Moon Bay (HB) and Sylvan Lake Natural Area (SLNA), and single measurements at Norglenwold (NORG), Jarvis Bay (JB) and Sunbreaker Cove (SBC)

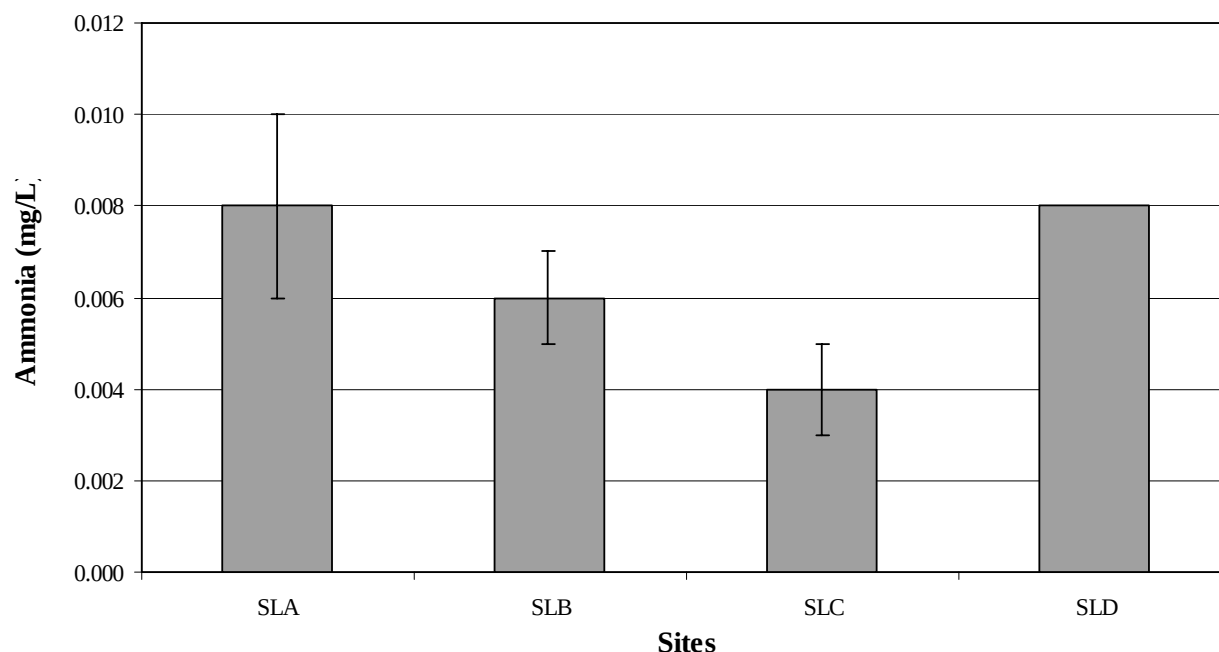


Figure A-42 Mean ($\pm$ SE) concentrations of ammonia at deepwater sampling sites in Sylvan Lake, September 2004. Values represent averages of depth profiles at sites SLA, SLB and SLC and the single euphotic zone composite sample collected at SLD

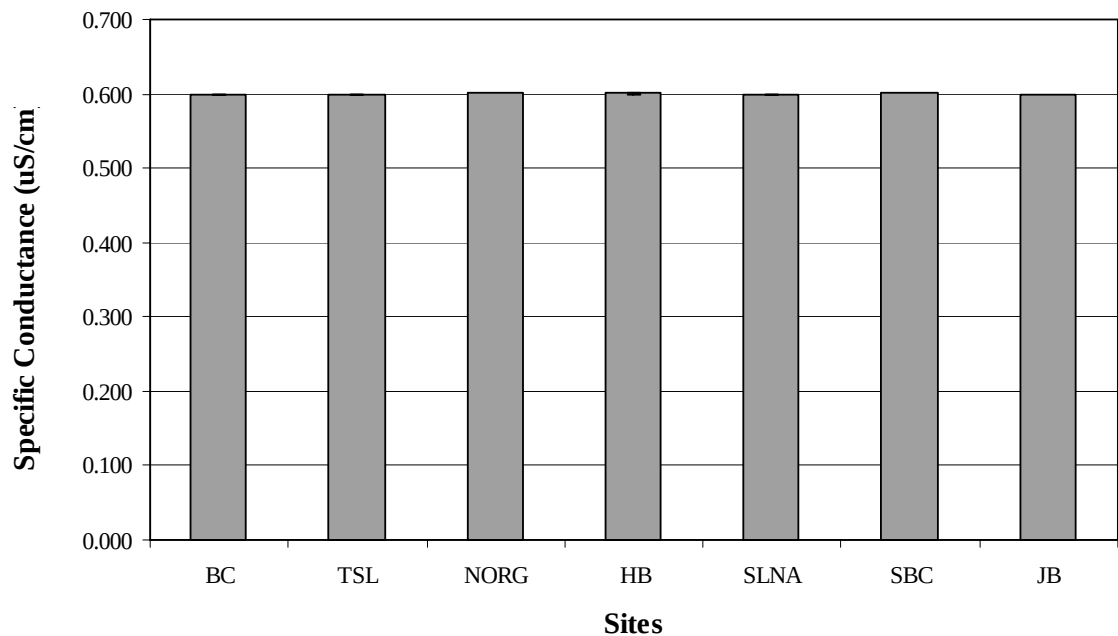


Figure A-43 Specific conductance in the nearshore zone of Sylvan Lake, September 2004. Values represent mean and SE for Birchcliff (BC), Town of Sylvan Lake (TSL), Half Moon Bay (HB) and Sylvan Lake Natural Area (SLNA), and single measurements at Norglenwold (NORG), Jarvis Bay (JB) and Sunbreaker Cove (SBC)

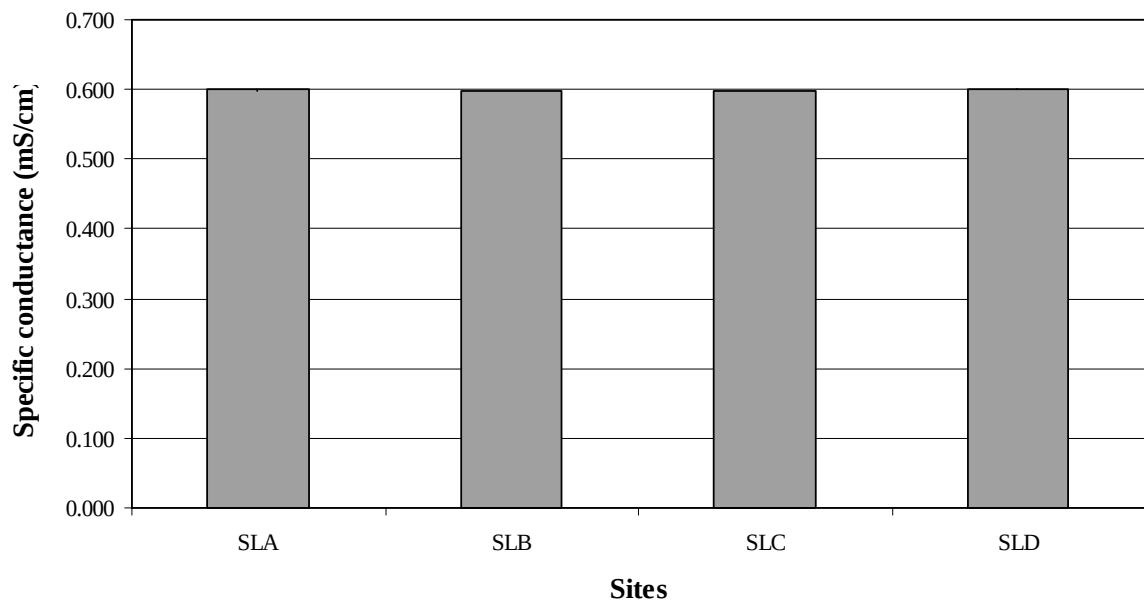


Figure A-44 Mean ($\pm$ SE) specific conductance at deepwater sampling sites in Sylvan Lake, September 2004. Values represent averages of depth profiles at sites SLA, SLB and SLC and the single euphotic zone composite sample collected at SLD

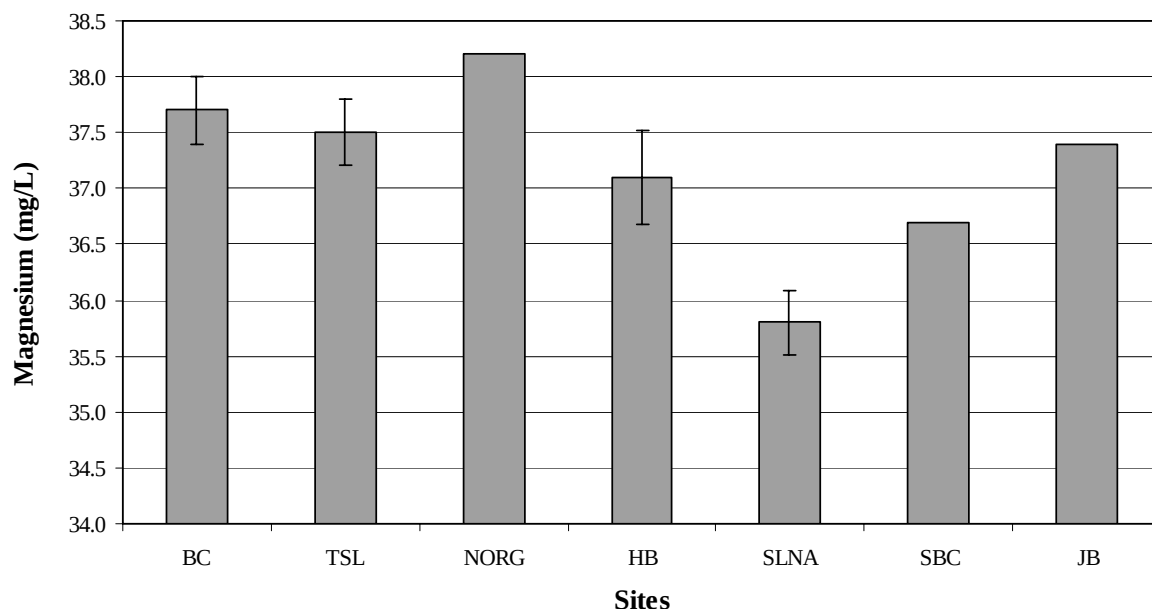


Figure A-45 Magnesium concentrations in the nearshore zone of Sylvan Lake, September 2004. Values represent mean and SE for Birchcliff (BC), Town of Sylvan Lake (TSL), Half Moon Bay (HB) and Sylvan Lake Natural Area (SLNA), and single measurements at Norglenwold (NORG), Jarvis Bay (JB) and Sunbreaker Cove (SBC)

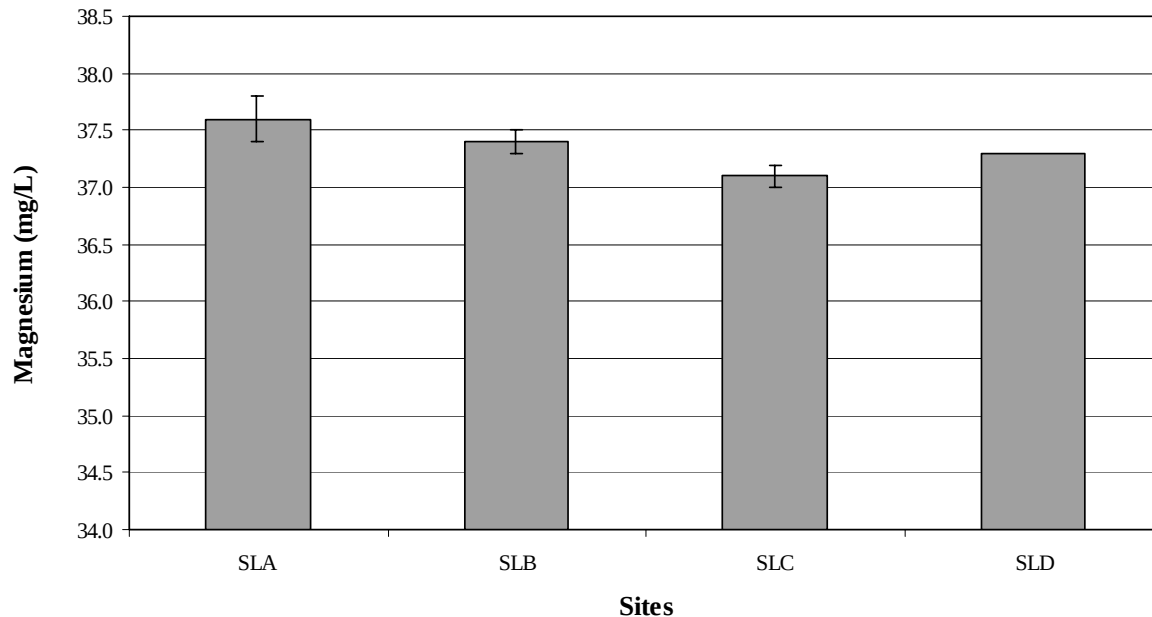


Figure A-46 Mean ($\pm$ SE) concentrations of magnesium at deepwater sampling sites in Sylvan Lake, September 2004. Values represent averages of depth profiles at sites SLA, SLB and SLC and the single euphotic zone composite sample collected at SLD

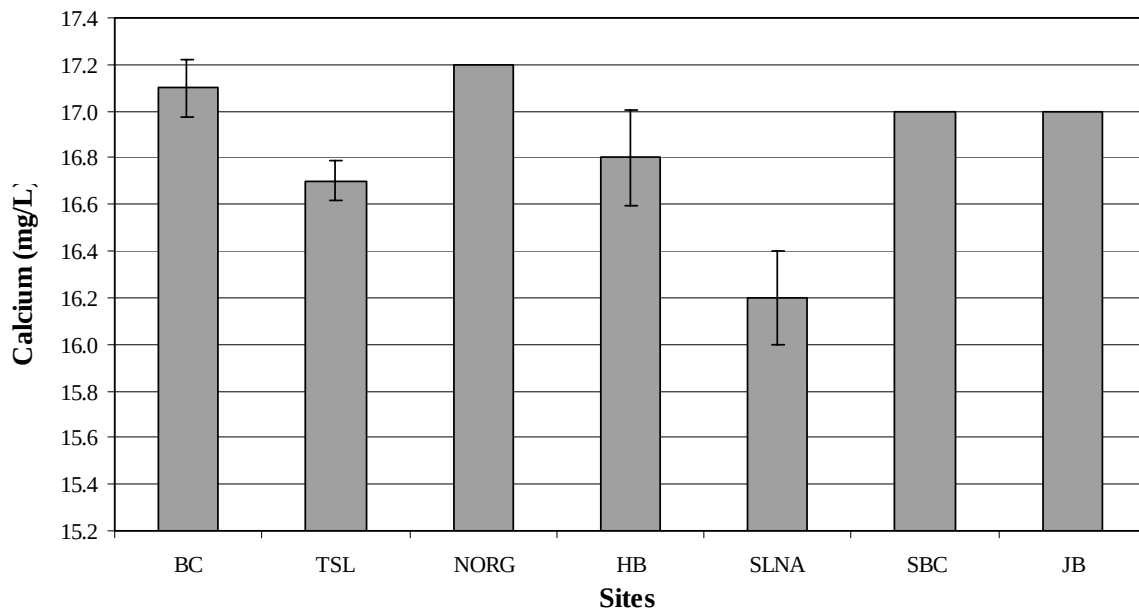


Figure A-47 Calcium concentrations in the nearshore zone of Sylvan Lake, September 2004. Values represent mean and SE for Birchcliff (BC), Town of Sylvan Lake (TSL), Half Moon Bay (HB) and Sylvan Lake Natural Area (SLNA,) and single measurements at Norglenwold (NORGL), Jarvis Bay (JB) and Sunbreaker Cove (SBC)

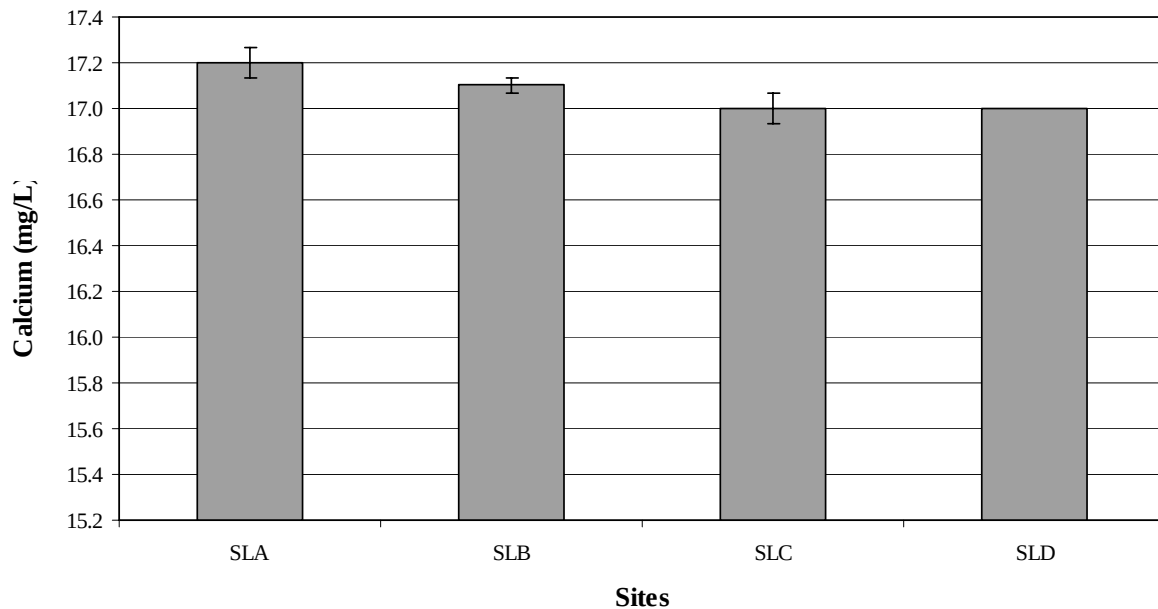


Figure A-48 Mean ($\pm$ SE) concentrations of calcium at deepwater sampling sites in Sylvan Lake, September 2004. Values represent averages of depth profiles at sites SLA, SLB and SLC and the single euphotic zone composite sample collected at SLD

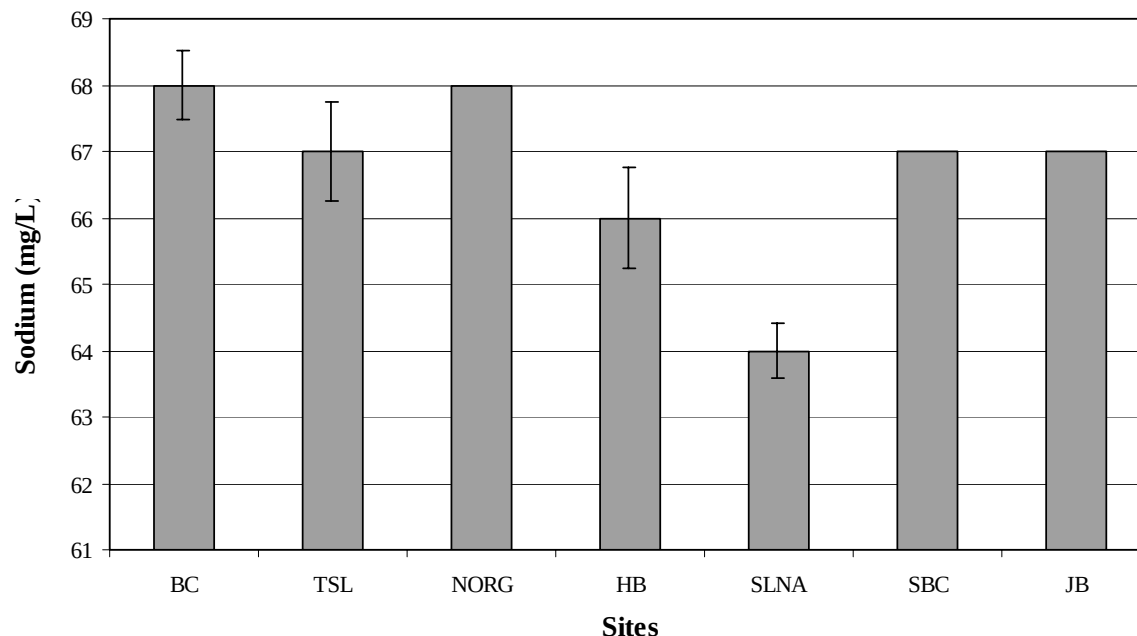


Figure A-49 Sodium concentrations in the nearshore zone of Sylvan Lake, September 2004. Values represent mean and SE for Birchcliff (BC), Town of Sylvan Lake (TSL), Half Moon Bay (HB) and Sylvan Lake Natural Area (SLNA), and single measurements at Norglenwold (NORG), Jarvis Bay (JB) and Sunbreaker Cove (SBC)

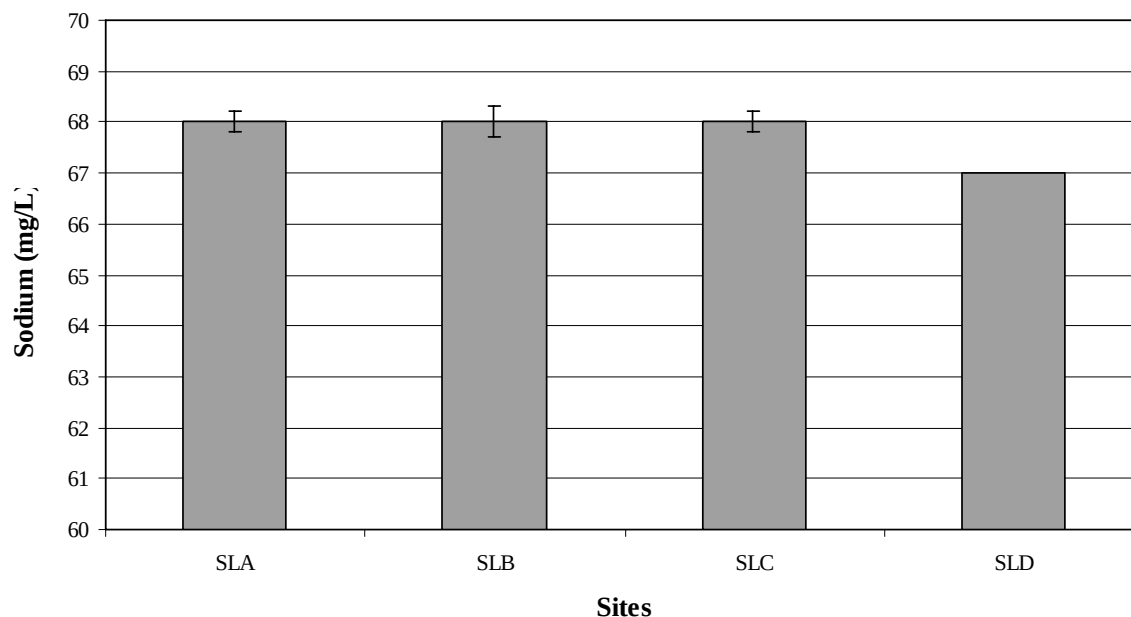


Figure A-50 Mean ($\pm$ SE) concentrations of sodium at deepwater sampling sites in Sylvan Lake, September 2004. Values represent averages of depth profiles at sites SLA, SLB and SLC and the single euphotic zone composite sample collected at SLD

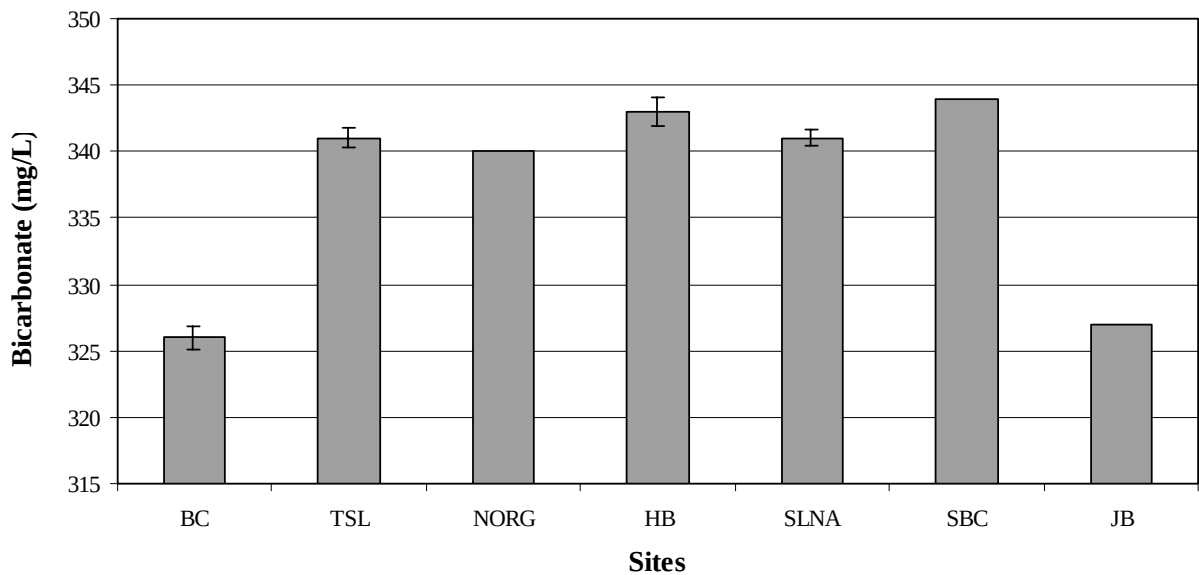


Figure A-51 Bicarbonate concentrations in the nearshore zone of Sylvan Lake, September 2004. Values represent mean and SE for Birchcliff (BC), Town of Sylvan Lake (TSL), Half Moon Bay (HB) and Sylvan Lake Natural Area (SLNA), and single measurements at Norglenwold (NORG), Jarvis Bay (JB) and Sunbreaker Cove (SBC)

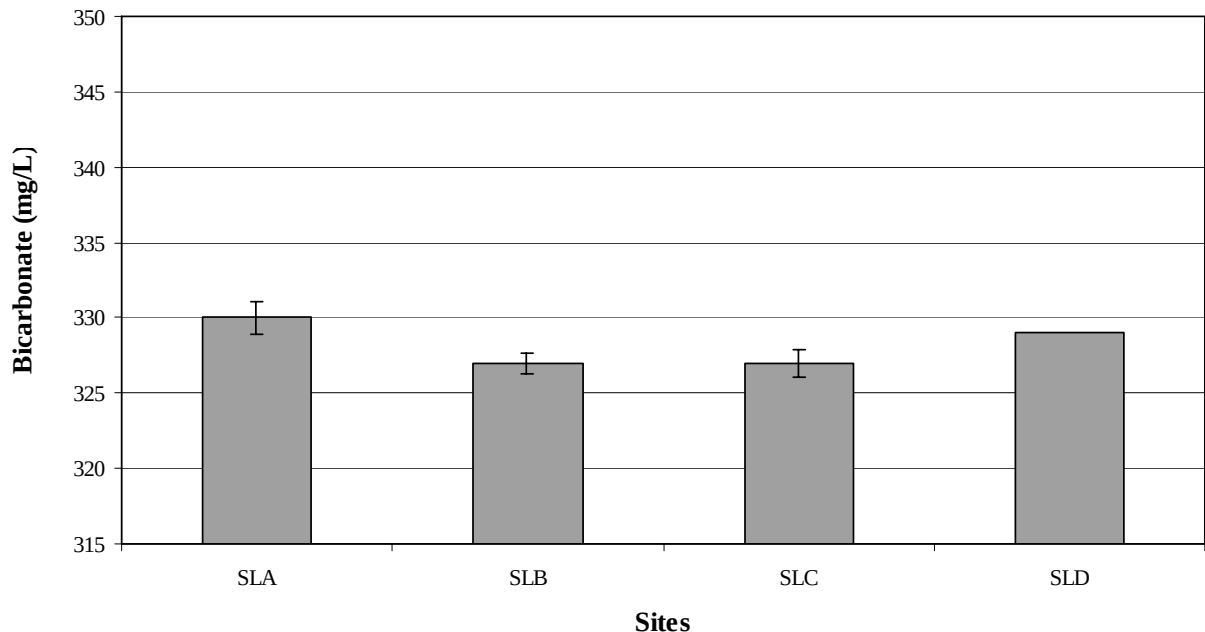


Figure A-52 Mean ($\pm$ SE) concentrations of bicarbonate at deepwater sampling sites in Sylvan Lake, September 2004. Values represent averages of depth profiles at sites SLA, SLB and SLC and the single euphotic zone composite sample collected at SLD

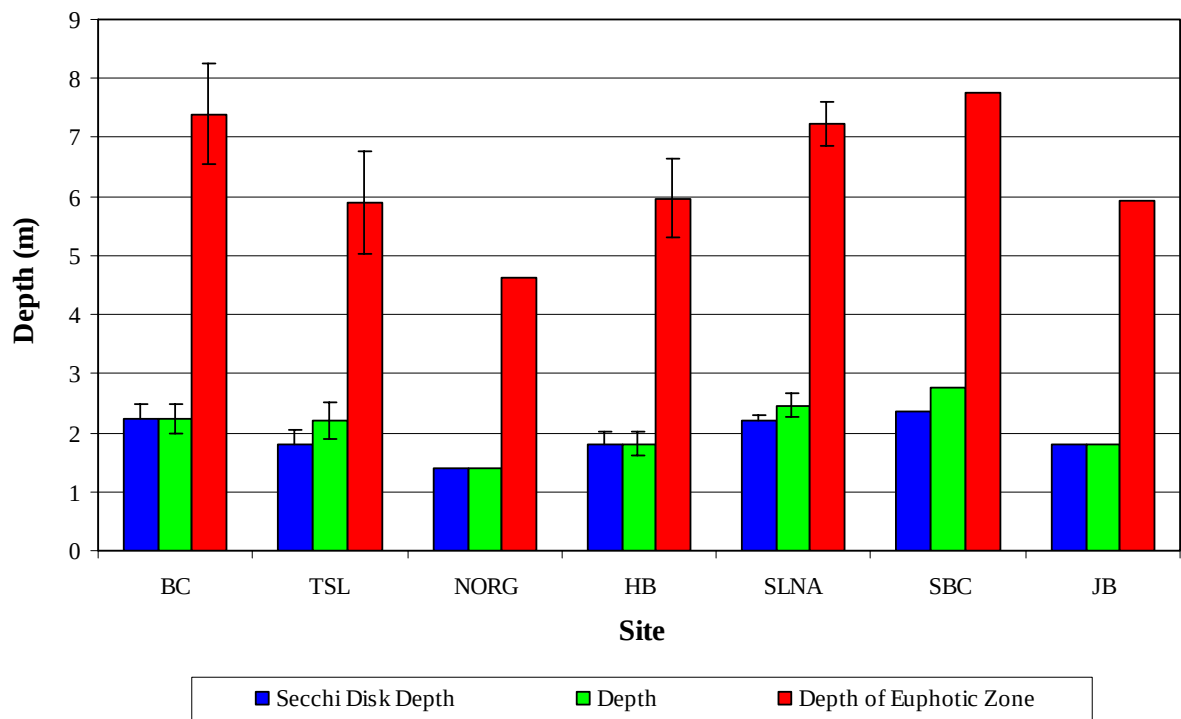


Figure A-53 Secchi disk depth, total depth, and depth of the euphotic zone in the nearshore zone of Sylvan Lake, September 2004. Values represent mean and SE for Birchcliff (BC), Town of Sylvan Lake (TSL), Half Moon Bay (HB) and Sylvan Lake Natural Area (SLNA), and single measurements at Norglenwold (NORG), Jarvis Bay (JB) and Sunbreaker Cove (SBC)

Chlorophyll a

Chlorophyll *a* levels in nearshore areas of Sylvan Lake were within a similar range but levels observed adjacent to the Town of Sylvan Lake were significantly lower than those measured at Birchcliff, Half Moon Bay, or the Sylvan Lake Natural Area (Figure A-54). However, overall, concentrations were fairly similar between areas and to levels measured at deepwater sites. In addition, nearshore concentrations were similar to levels measured historically in the offshore zone of Sylvan Lake in September. Levels were low to moderate and not indicative of algal blooms or nuisance growth.

Evaluation of Effects of Nearshore Developments on Nearshore Water Quality

Water quality data collected in September 2004 in nearshore areas of Sylvan Lake do not indicate any major effects of nearshore developments on water quality. Conditions measured in the nearshore areas were generally consistent with those encountered at deepwater sites at this time. However, it is not known if conditions may differ in the littoral areas relative to offshore areas at other times of year, particularly in late August or under ice cover when other variables tend to exhibit seasonal effects.

A.2.1.3 Water Quality of Tributary Streams

There are no perennial streams flowing into Sylvan Lake but there are five ephemeral streams that drain into Sylvan Lake: Golf Course Creek; Northwest Creek; Birchcliff Creek; Honeymoon Creek; and Lambe Creek. Additionally, Sylvan Lake does not have a permanent outflow and only discharges (at the Sylvan Lake outflow) when water levels reach 936.66 m ASL (Section A.4).

The historical water quality data for the six ephemeral tributaries that flow into Sylvan Lake and the Sylvan Lake outflow has been limited in nature due to intermittent flows in these streams. Data have been periodically collected by AENV for these streams during years and time periods where discharge occurred. No data are available to describe water quality in these streams prior to 1993. More recently (beginning in 2003), AENV launched a Sylvan Lake tributary sampling program and water quality as well as stream discharge have been periodically measured during discharge periods. As such, the most intensive sampling periods for tributaries occurred in April 2003 and April/May 2004. Prior to that, most creeks were sampled once or twice during winter 2001, while Sylvan, Golf Course and Northwest creeks were also sampled once or twice during summer 1993. The Sylvan Lake outflow was only sampled in summer 1993 likely due to non-existent flow during subsequent sampling events. No outflow was documented in fall 2004. Golf Course and Northwest creeks were discharging to the lake in September 2004 when the water quality sampling component of the present study was conducted by North/South Consultants Inc. Discharge and water quality were measured at these locations.

The sampling pattern for these tributaries precluded the use of statistical data analysis. Therefore raw data for select water quality parameters were presented in a series of scatterplots to facilitate the assessment of inter-annual and seasonal variability (Figures A-55 to A-61). The following data interpretation has a deliberate focus on nutrient, suspended solid and bacteriological parameters as these were the most relevant to the study objectives. Additional water quality data collected in September 2004 are presented in Appendix C.

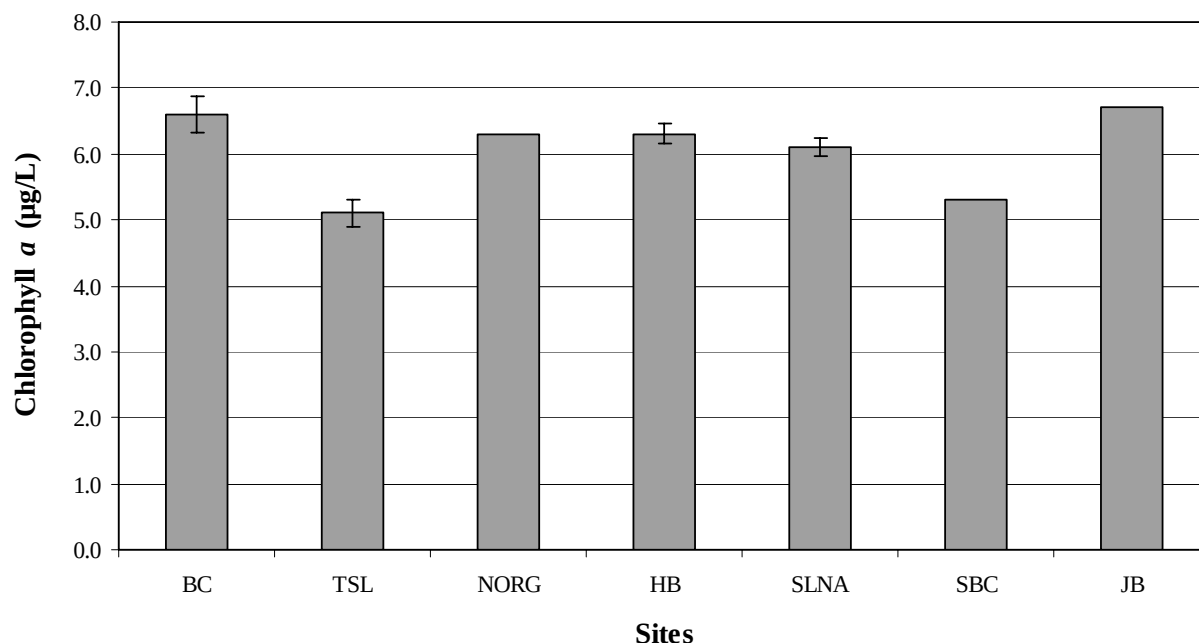


Figure A-54 Concentrations of chlorophyll a in the nearshore zone of Sylvan Lake, September 2004. Values represent mean and SE for Birchcliff (BC), Town of Sylvan Lake (TSL), Half Moon Bay (HB) and Sylvan Lake Natural Area (SLNA), and single measurements at Norglenwold (NORG), Jarvis Bay (JB) and Sunbreaker Cove (SBC)

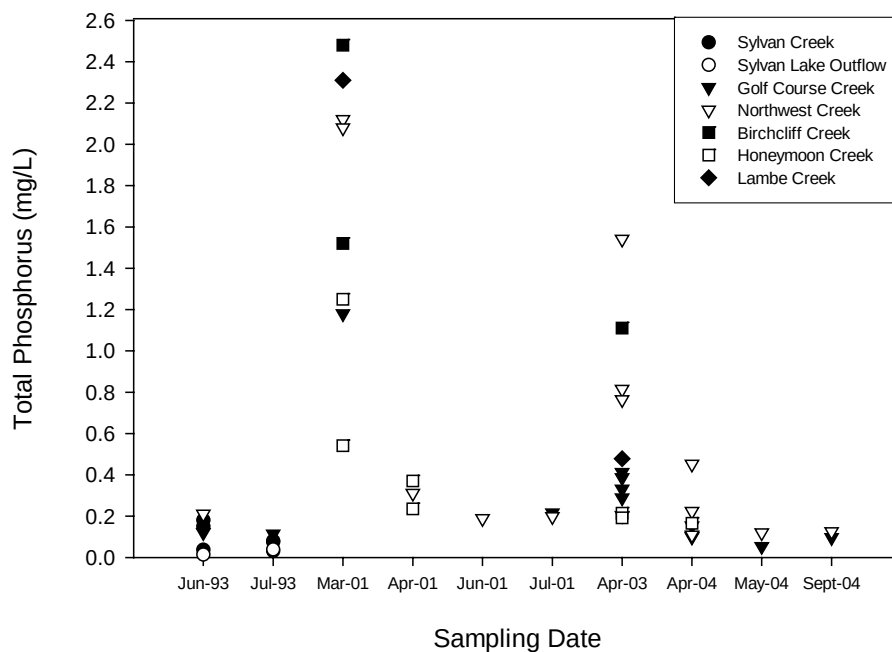


Figure A-55 Total phosphorus (TP) concentrations in Sylvan Lake tributaries and the lake outflow

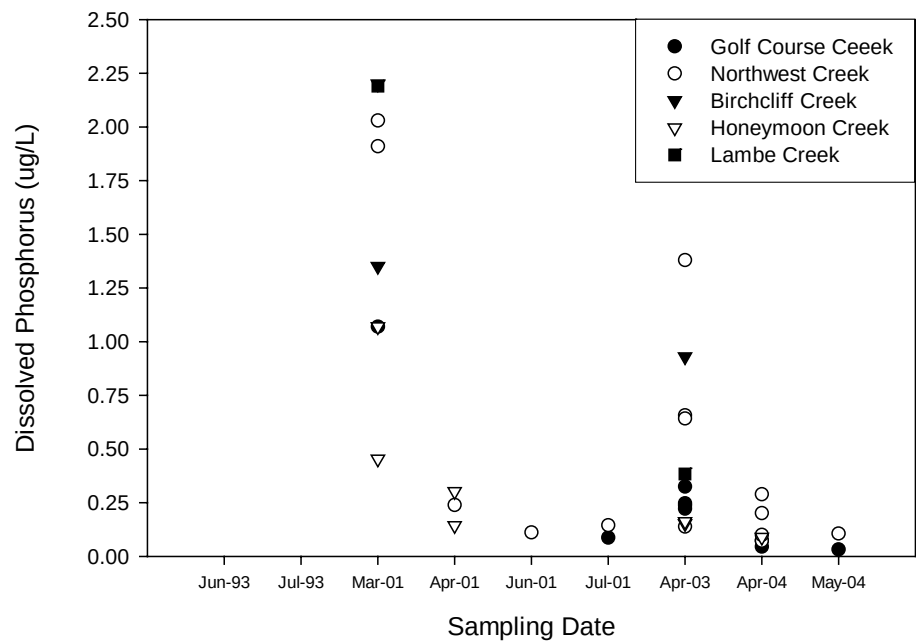


Figure A-56 Dissolved phosphorus (DP) concentrations in Sylvan Lake tributaries and the lake outflow

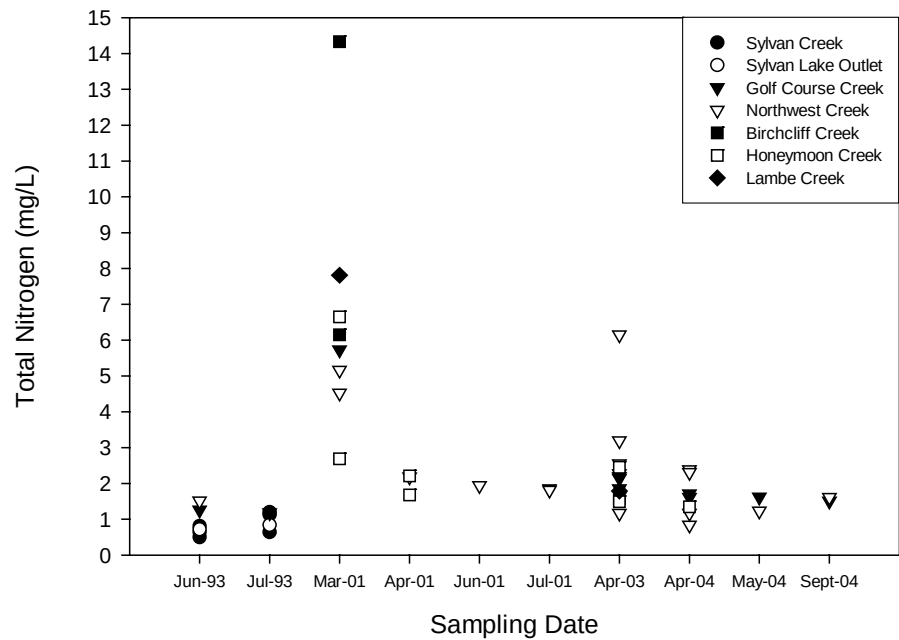


Figure A-57 Total nitrogen (TN) concentrations in Sylvan Lake tributaries and the lake outflow

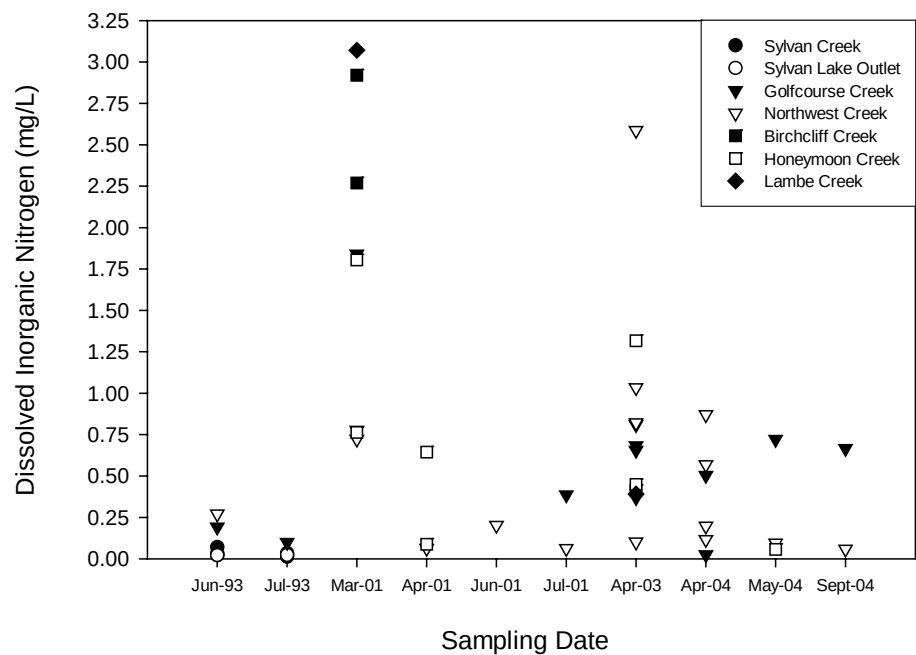


Figure A-58 Dissolved inorganic nitrogen (DIN) concentrations in Sylvan Lake tributaries and the lake outflow

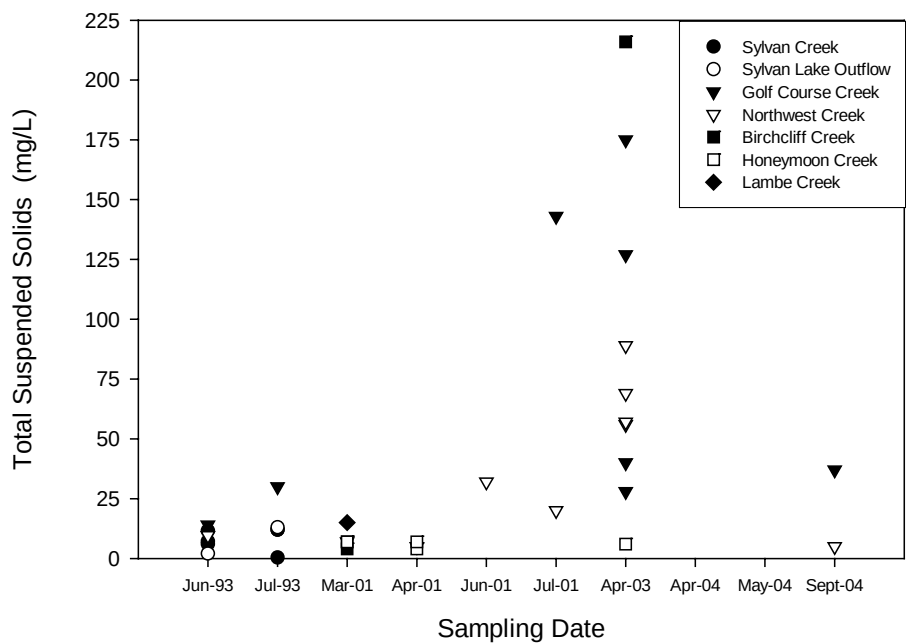


Figure A-59 Total suspended solid (TSS) concentrations in Sylvan Lake tributaries and the lake outflow

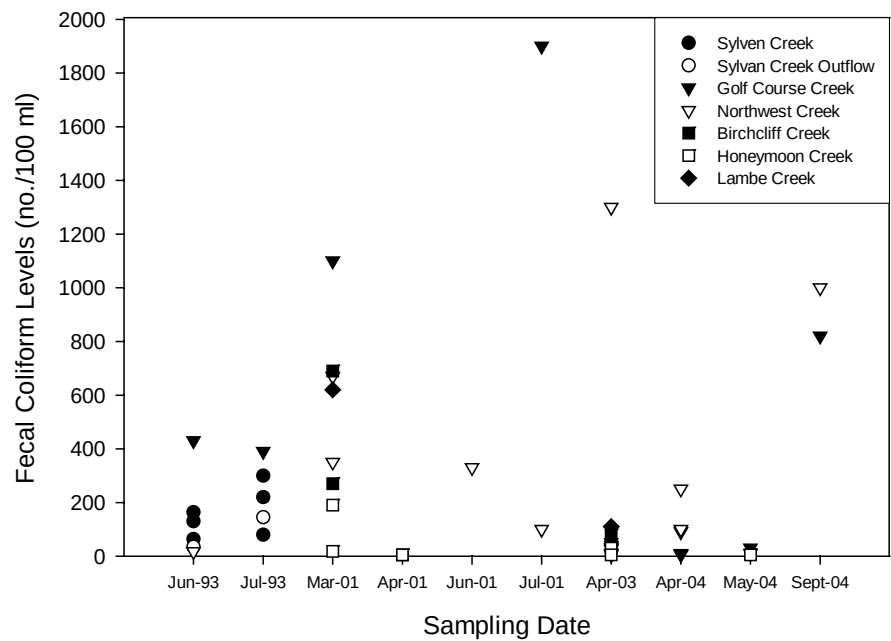


Figure A-60 Total fecal coliform levels in Sylvan Lake tributaries and the lake outflow

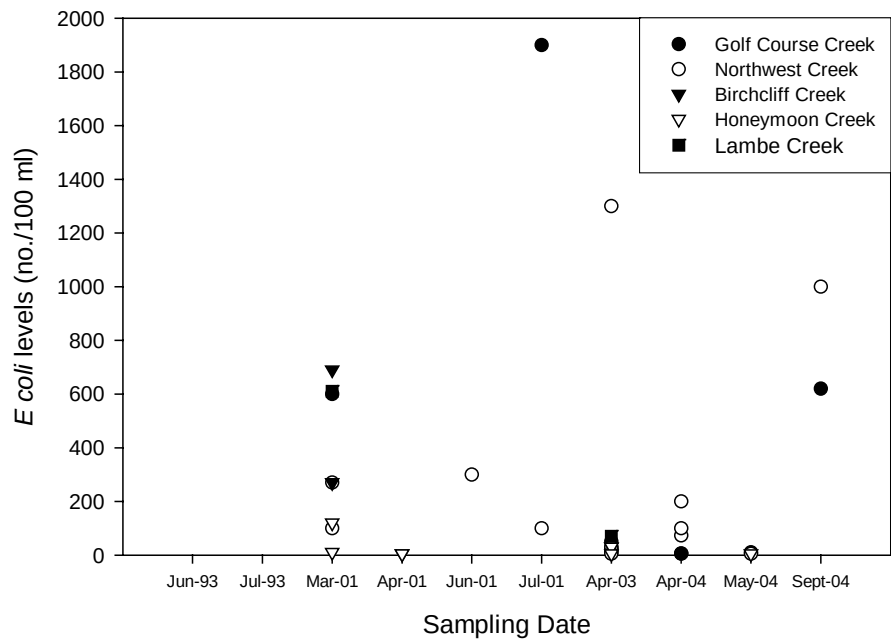


Figure A-61 Total *E. coli* Levels in Sylvan Lake Tributaries and the Lake Outflow

Summary of Water Quality of Tributary Streams

Sylvan Lake tributaries generally flow intermittently and sampling effort has been primarily directed towards the spring season when the streams were most likely to be flowing. Typically, run off from surrounding land would also have approached maximum levels at this time. The dominant land use in the drainage basin has been agriculture and the upper and middle reaches of these tributary streams tend to flow through agricultural land. The lower reaches of these streams (prior to the confluence with Sylvan Lake) flow through different shoreline land use types according to the confluence location. For example, Northwest Creek and Golf Course Creek flow through wet meadow shoreline habitat and developed shoreline, respectively (Westworth 2002).

Total and Dissolved Phosphorus

The highest TP values recorded in all inflow tributaries were measured in March 2001 (~1.2-2.5 mg/L; Figure A-55). Discharge data for March were not available but flows were likely very low resulting in much reduced dilution capacity. Streams tend to be more dependent on groundwater inputs during the winter months and a greater proportion of groundwater may have increased the TP concentration. Alternatively, these samples may have been taken during snow melt. TSS levels were similar to other seasons (<25 mg/L) and did not peak during this sampling event.

TP levels for all other seasons sampled remained below 0.3 mg/L with the exception of measurements taken in spring 2003 in Northwest, Birchcliff, Golf Course and Lambe creeks (~0.3-1.6 mg/L); spring 2001 in Northwest and Honeymoon creeks (0.31 and 0.37 mg/l); and April 2004 in Northwest Creek (0.45 mg/L). TP concentrations in Northwest and Golf Course creeks were substantially higher (up to 4 times) in April 2003 compared with April 2004. Flows recorded in April 2003 for Northwest and Golf Course creeks (1.3-3.7 m³/s and 3.6-7.1 m³/s, respectively) were 2-3 orders of magnitude greater than those recorded in spring 2004 (0.015-0.033 m³/s and 0.005 m³/s, respectively). Higher flows in April 2003 resulted in elevated TSS levels in these two creeks. Dissolved phosphorus concentrations were elevated and peaked during the same time periods as TP concentrations (Figure A-56).

Overall, the available data set for these tributaries shows that there were two large spikes in both total and dissolved forms of phosphorus (winter 01 [March]; spring 03 [April]). Though it is likely that a number of peaks were missed prior to more intensive sampling by AENV in recent years, which focused on spring run off and storm events. In comparison, phosphorus levels in summer and fall (where data were available) tended to be relatively low. TP levels in the Sylvan Lake outflow in 1993 were substantially lower than those measured in the inflow streams.

Large spatial differences in total or dissolved phosphorus were not evident between tributary streams based on the current dataset but the limited sampling record confounded the identification of differences. It was however, possible to identify some spatial differences between streams during individual sampling events. The three most intensive sampling events were examined: 14th March 2001, 10th April 2003 and 5th April 2004 (Table A-9). The highest TP concentrations were observed in Northwest Creek during all three sampling events, while the lowest concentrations occurred either in Honeymoon Creek or Golf Course Creek. Dissolved phosphorus concentrations followed the same trends.

Table A-9 **Total phosphorus concentrations measured in four Sylvan Lake tributaries during March 2001, and April 2003 and 2004**

Sampling Event	Total Phosphorus (mg/L)			
	Honeymoon Creek	Northwest Creek	Birchcliff Creek	Golfcourse Creek
14 th March 2001	1.25	2.12	1.52	<i>1.18</i>
10 th April 2003	<i>0.214</i>	1.54	1.11	0.331
5 th April 2004	0.165	0.223	–	<i>0.099</i>

Notes: **Text set in boldface** – indicates this tributary had the highest concentration of total phosphorus
Text set in italics – indicates this tributary had the lowest concentration of total phosphorus
 – No data available

The shoreline habitat at the mouth of Northwest Creek is wetland meadow, whereas Golf Course Creek flows through developed shoreline habitat and Honeymoon Creek flows through wetland/woodland habitat (Westworth 2002). Differences in TP concentrations observed in March 2001, and April 2003, 2004, likely do not reflect shoreline habitat; rather they likely reflect the degree and nature of agricultural land use upstream. It would appear that Northwest Creek may be more heavily influenced by land use practices compared with the other two streams. A larger percentage of Northwest Creek and its tributaries flow through agricultural land (76%) compared with Golf Course creek (49%) and Honeymoon creek (27%; Table A-10).

Table A-10 **Land Use Surrounding the Major Tributaries to Sylvan Lake**

Tributary	Agriculture (%)	Development (%)	Forest (%)	Wetlands (%)
Golf Course Creek	49	16	20	15
Honeymoon Creek	27	1	40	32
Northwest Creek	76	1	1	22
Lambe Creek	63	2	35	0
Birchcliff Creek	20	9	71	0

Total and Dissolved Nitrogen

The highest TN values recorded between 1993 and 2004 in Birchcliff, Lambe, Honeymoon and Golf Course creeks were in March 2001 (~5-14 mg/L; Figure A-57). The highest levels in Northwest Creek were recorded in March 2001 and April 2003 (~3-6 mg/L). Although data are limited, it appears that for all other sampling events TN concentrations remained between <1 and 3 mg/L. Dissolved inorganic nitrogen (DIN) which represents the more bioavailable form of nitrogen to aquatic biota, also peaked in Lambe, Birchcliff, Golf Course, and Honeymoon creeks in March 01 (~1.75-3 mg/L; Figure A-58). DIN levels peaked in Northwest Creek in April 2003 (2.59 mg/L). TN and DIN levels in the Sylvan Lake outflow in 1993 were substantially lower than those measured in the inflow streams. Only nitrate/nitrite was measured in Sylvan Lake itself in 1993 and all measurements were below the analytical detection limit and slightly lower than the outflow concentrations.

Large spatial differences in TN were not evident between tributary streams based on the current dataset but the inconsistent sampling record confounded the identification of differences. It was however, possible to identify some spatial differences between streams during individual sampling events. The three most intensive sampling events were examined: 14th March 2001, 10th April 2003 and 5th April 2004 (Table A-11). The highest TN concentrations were observed in Northwest Creek during April 2003 and 2004, but the highest TN concentration in March 2001 was observed in Birchcliff Creek. As previously stated for phosphorus, the spatial pattern of nitrogen concentrations in these tributaries is likely to have been mainly due to the effect of agriculture further upstream, rather than shoreline habitat type (Table A-10).

Table A-11 Total Nitrogen Concentrations Measured in Four Sylvan Lake Tributaries during March 2001, and April 2003 and 2004

Sampling Event	Total Nitrogen (mg/L)			
	Honeymoon Creek	Northwest Creek	Birchcliff Creek	Golfcourse Creek
14 th March 2001	6.65	<i>5.16</i>	6.15	5.73
10 th April 2003	2.45	6.15	<i>1.58</i>	2.27
5 th April 2004	<i>1.35</i>	2.31	–	1.61

Notes: **Text set in boldface** – indicates this tributary had the highest concentration of total nitrogen
Text set in italics – indicates this tributary had the lowest concentration of total nitrogen
 – No data available

Total Suspended Solids

TSS levels peaked in Birchcliff, Northwest and Golf Course creeks in April 2003 (~50-220 mg/L) which coincided with elevated flow in these streams (Figure A-59). There was also a TSS spike recorded for Golf Course Creek in July 2001 (143 mg/L) but unfortunately discharge data were not available for that sampling event. Otherwise, TSS levels in these streams typically remained below 25 mg/L with the exception of samples from Golf Course Creek in July 1993, April 2003 and September 2004; and Northwest Creek on June 2001 (~25-50 mg/L). TSS levels in the Sylvan Lake outflow in summer 1993 were also below 25 mg/L.

Bacteriological Parameters

In a previous report concerning the recreational water quality of Sylvan Lake, Mitchell (1988) considered fecal coliform counts in excess of 100 counts/100 ml as elevated in stormwater drainage. From 1993 to 2004, all Sylvan Lake tributary streams periodically contained fecal coliform levels in excess of 100 counts/100 ml (Figure A-60). Maximum levels (no./100 ml) were: 1900 for Golf Course Creek; 1300 for Northwest Creek; 690 for Birchcliff Creek, 620 for Lambe Creek and 190 for Honeymoon Creek. Due to limited discharge and incidental information, it was difficult to delineate patterns in the data but fecal coliform levels did appear to be particularly elevated in several streams during typically low flow sampling periods (e.g., winter 2001; summer 1993; fall 2004). Furthermore, all streams sampled during the high flow period in April 2004 (except Northwest Creek on one occasion) had counts close to or below 100 counts/100 ml. It is not clear why very high fecal coliform counts (>800/100 ml)

were periodically observed in Golf Course (March and July 2001; September 2004) and Northwest creeks (April 2003; September 2004).

The upper range of measurements from Golf Course and Northwest creeks, and maximum levels measured in Birchcliff and Lambe creeks were within the range of fecal coliform counts measured in storm water runoff by Mitchell (1988). However, it should be noted that some stormwater counts were several times higher than the maximum counts measured in these tributary streams (3000-8500/100 ml vs 1900/100 ml). Still, as recently as fall 2004 fecal coliform levels in Golf Course and Northwest creeks were comparable to some storm water discharges measured in the 1988 study.

Elevated fecal coliform bacterial counts are indicative of potentially elevated levels of pathogenic organisms. *E. coli* is a single species of fecal coliform bacteria that occurs only in fecal material from humans and other mammals (Weiner 2000). *E. coli* levels showed the same trends as previously discussed for fecal coliforms (Figure A-61). Maximum levels (no./100 ml) were: 1900 for Golf Course Creek; 1300 for Northwest Creek; 690 for Birchcliff Creek, 610 for Lambe Creek and 190 for Honeymoon Creek. It is not clear why very high *E. coli* counts (>800/100 ml) were periodically observed in Golf Course (July 2001) and Northwest creeks (April 2003; September 2004).

Comparison of Water Quality Data to Water Quality Guidelines

For the most part, TP concentrations in all inflow tributaries exceeded the Alberta water quality guideline for the protection of aquatic life (0.05 mg/L TP; Figure A-55; AENV 1999).

In March 2001 this guideline was exceeded by 2-3 times in Honeymoon and Golfcourse creeks, and by 3-5 times in Birchcliff, Lambe and Northwest creeks. Likewise in April 2003, this guideline was exceeded by 1.5-3 times in Northwest and Birchcliff creeks. In spring and fall 2004 TP concentrations were above 0.05 mg/L in Northwest, Golf Course and Honeymoon creeks. These tributary streams can be classified as eutrophic according to the stream trophic classification criteria suggested by USEPA (2000). TP levels recorded for the Sylvan Lake outflow (summer 1993) remained below the aquatic water quality guideline (0.014 and 0.038 mg/L) and were similar to values recorded from composite samples from the euphotic zone of Sylvan Lake.

Tributary TN levels generally exceeded the provincial water quality guideline for the protection of aquatic life (1 mg/L; Figure A-57). The guideline was exceeded by 2-3 times during all sampling events except for March 2001 (up to 15 times) and April 2003 (up to 6 times). These tributary streams can be classified as eutrophic according to the stream trophic classification criteria suggested by USEPA (2000).

Alberta recreation and aesthetic water quality guidelines for fecal coliform and *E. coli* bacteria state that the geometric mean of 5 samples taken over 30 days should not exceed 200 counts/100 ml (AENV 1999). As the current data set does not allow this calculation, a conservative approach was taken where the guideline of 200 counts/100 ml was applied to single measurements. Levels of fecal coliform and *E. coli* bacteria in all tributaries except Honeymoon Creek, were periodically above 200 counts/100 ml (Figures A-60, A-60). This may have been due to wildlife and/or livestock use of the stream or agricultural run off (e.g., after manure application).

Discussion of Implications for Sylvan Lake Water Quality

The water quality data set for inflow tributaries was incomplete, in part due to the ephemeral nature of these streams. Limited tributary water quality data precluded a comprehensive assessment of the implications for Sylvan Lake water quality. What is clear is that provincial aquatic life water quality guidelines for total nutrients were generally exceeded when these streams were flowing, and that concentrations of the dissolved bioavailable fractions were also high. The phosphorus and nitrogen concentrations in these streams indicated that they were eutrophic. Elevated levels of fecal coliform and *E. coli* bacteria also periodically occurred in most streams.

Subsequently, there were likely to have been short episodic events where elevated nutrients, TSS and bacterial loads were discharged to Sylvan Lake. Nevertheless, because these streams tend to flow for only part of the year, the nutrient loading to the lake via these streams would likely be lower than if these streams flowed all year round. Golf Course and Northwest creeks were most likely to exhibit some prolonged flow throughout the year, and so were most likely to make the largest contribution to the nutrient budget of Sylvan Lake. Generally it was thought that there is no significant surface inflow to the lake due to the size and intermittent nature of the tributaries (Baker 2003). Yet due to elevated nutrient, TSS and bacterial levels in some of these streams, this issue should undergo further consideration. The contribution of tributary loading to the nutrient budget of Sylvan Lake is addressed further in Section A-5.

When episodic elevated nutrient loads are discharged to the lake there may have been some localized effects at the nearshore discharge points (e.g., enrichment related). An interesting observation was that Northwest Creek which discharged close to the Sylvan Lake Natural Area generally had the highest nutrient levels. More data are required to confidently assess the contribution of these streams to the nutrient budget of the lake. Outflow water quality data from 1993 indicated that the nutrient and TSS loads were below Alberta aquatic life water quality guidelines and were low compared to those of inflow streams.

A.2.2 Sediment Quality

A.2.2.1 Lake Sediments: Nutrient Sinks and Sources

Sediments act as a sink by accumulating waterborne contaminants (e.g., trace metals, hydrocarbons) and nutrients over time. Yet under certain physiochemical conditions sediments can also act as an internal source of nutrients to the water column (Wetzel 1983; Marsden 1989). Biological activity can also influence the mobilization of nutrients from the sediment to the water column, through bioturbation (invertebrate burrowing activities) and microbial activity (Wetzel 1983). In general, sediments tend to retain phosphorus rather than release it, a factor that tends to slow down the eutrophication process (Marsden 1989). The release of sediment bound nutrients over time is dependent on several key factors, notably:

- physicochemical conditions at the sediment-water interface (e.g., turbulence, dissolved oxygen, redox potential, iron availability, temperature).
- the phosphorus buffering capacity of the sediments; and
- the biological activities of sediment biota

(Wetzel 1983; Marsden 1989)

Shallow lakes tend to be more affected by turbulence caused by wind and watercraft use, and therefore are generally well mixed and oxygenated. The upper few millimetres of the sediment surface can be referred to as the “microzone” and this surficial layer tends to be oxygenated (aerobic) in shallow lakes. In deeper lakes that undergo periodic or prolonged stratification, the hypolimnion (water below the thermocline) tends to be low in oxygen and the sediment microzone is often oxygen deficient (anaerobic). The oxygen status of the microzone is one of the important factors controlling the exchange of nutrients between the sediment and the overlying water column (Wetzel 1983). In deep lakes which are predisposed to stratification and oxygen depletion near the sediment-water interface, sediments can release phosphorus to the hypolimnetic water. In shallow, non-stratifying eutrophic Alberta lakes, the sediments can also provide large amounts of phosphorus to the water column. This occurs because the oxic sediments are prone to physical disturbance by wind and watercraft use. Disturbance and resuspension of these surficial sediments causes dissolved phosphorus to be released to the overlying water (Kalff 2002).

The sediment phosphorus buffering capacity is the ability of sediment to accumulate increasing quantities of phosphorus from the water column, and it can be expressed as the phosphorus sorption capacity ($\mu\text{g/kg P}$) and/or the phosphorus sorption index (PSI, L/kg ; Sims 2000). Oligotrophic lake sediments tend to have a high buffering capacity suggesting that they would have to adsorb a large quantity of phosphorus before the sediments became saturated (Marsden 1989). On the other hand, sediments close to saturation have low phosphorus buffering capacities as they have a low capacity to adsorb additional phosphorus from the water column.

As integrators of environmental change, sediments can provide information on the nutrient status and historical water quality conditions in a lake. Sediments become buried over time, thus the determination of sediment quality in several depth intervals (horizons) in cores can provide a chronological record of historical sediment conditions and nutrient status at that site.

A.2.2.2 Sediment Quality in Sylvan Lake

Prior to the sediment survey conducted in 2004 for this study, there were no sediment quality data available for Sylvan Lake. There was however some concern that the lake sediments may have accumulated significant levels of nutrients from the water column, specifically phosphorus (Mitchell 1999). Phosphorus concentrations in lake sediments can potentially be several orders of magnitude greater than those measured in the water column (Wetzel 1983). Sediment quality is important in ultimately defining the current water quality and nutrient status of Sylvan Lake for two main reasons, namely:

- Sediments act as a sink by accumulating waterborne nutrients over time. Nutrients that are not flushed out of the lake (i.e., through outlet channels) ultimately become incorporated in the sediments.
- Under certain physical (e.g., low dissolved oxygen; temperature; turbulence), chemical (low redox potential; iron availability) and biological (invertebrate burrowing activity) conditions, sediments can also act as an uncontrolled internal source of nutrients to the water column (Wetzel 1983; Marsden 1989). This is referred to as the internal loading of phosphorus within a lake.

Low redox potentials (i.e., reducing conditions as a result of low oxygen levels) in Sylvan Lake have only been measured on a few occasions. However, available data indicate that

redox potentials may vary substantively over the open-water season and may decline to levels that are generally conducive to the release of phosphorus from sediments to the overlying water column. There is some indication of nutrient fluxes from sediments to the overlying water column (i.e., 'internal loading'), based on the available historical data. Depth profiles for dissolved phosphorous (DP) and total phosphorous (TP) collected at the deepest site in the lake indicate that vertical differences do develop at some times in some years, reflecting the release of phosphorus from the sediments.

Sediments could possibly become an unregulated internal phosphorus source in Sylvan Lake at some point in the future, as has occurred for other lakes in the region (e.g., Pine Lake [Sosiak 1996]; Amisk Lake [Prepas et al. 1997]). When this occurred in these lakes, action had to be taken to reduce nutrient inputs to the lake and to remediate the enriched sediment to reduce the nutrient loading (Prepas 1997; Sosiak 2002). Generally once the sediment nutrient concentrations have decreased below a particular threshold, the sediment ceases to be a significant internal nutrient source to the water column, and the waterborne nutrient concentration depend directly on external nutrient inputs. External loading is generally controllable, whereas without in-lake remediation, internal loading tends to be unregulated.

To establish the current nutrient status of Sylvan Lake sediments, a sediment quality survey in key nearshore and offshore areas was conducted in September 2004. Nutrient concentrations in sediments were evaluated at several deep locations and a number of nearshore locations in September 2004. Sampling consisted of measuring nutrients, phosphorus sorption capacity and supporting parameters of surficial sediments (i.e., upper 5 cm) in the nearshore environment adjacent to the Summer Villages of Half Moon Bay and Birchcliff, the Town of Sylvan Lake, and the Sylvan Lake Natural Area and at two locations in deeper areas of the lake (14 m and 16 m depths). In addition, a sediment core was collected from a deposition area at a depth of approximately 7 m to examine changes in nutrient loads and phosphorus sorption capacity in the lake over time. Specific details of survey design and methodology are provided in Appendix C.

The following section discusses the results of this study in terms of spatial and temporal differences, comparisons to sediment nutrient criteria and historical sediment nutrient levels in other lakes, and the phosphorus sorption capacity of Sylvan Lake sediments.

Results of 2004 Sediment Quality Survey

Data Analysis

The mean and standard error estimates were calculated for select sediment parameters measured in replicate surficial samples taken from the nearshore areas (n=3). Mean and standard error estimates were also calculated for the three replicate surficial samples taken offshore (14 m grab, 16 m grab, upper 5 cm of the sediment core taken at 7 m depth). The data are presented in Figures A-62 to A-72 and the raw data are presented in Appendix C. For select parameters, one-way ANOVA statistical tests were run to determine if there were significant differences between areas. Tukeys multiple comparison post-hoc test procedure was used to identify any significant differences (Minitab, version 13).

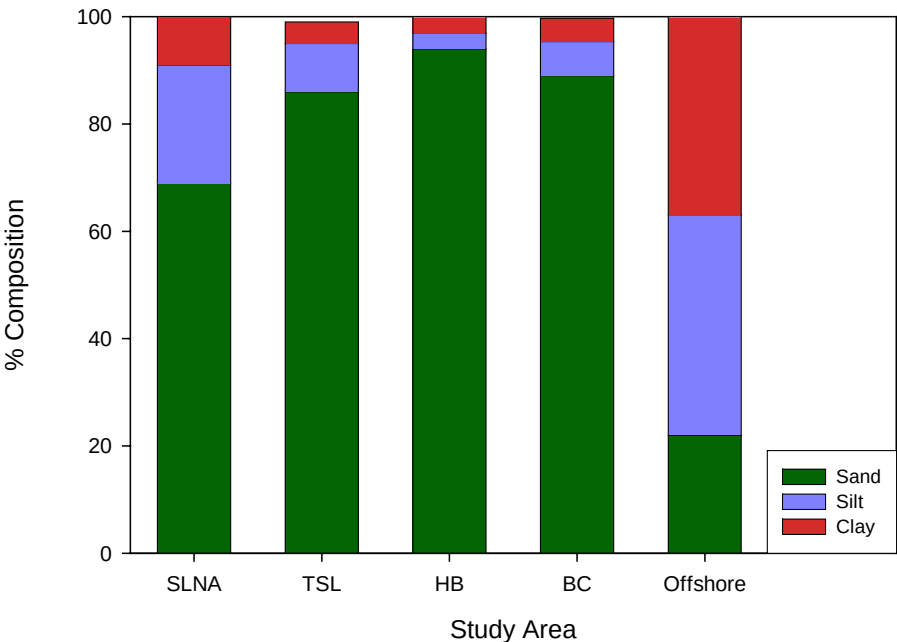
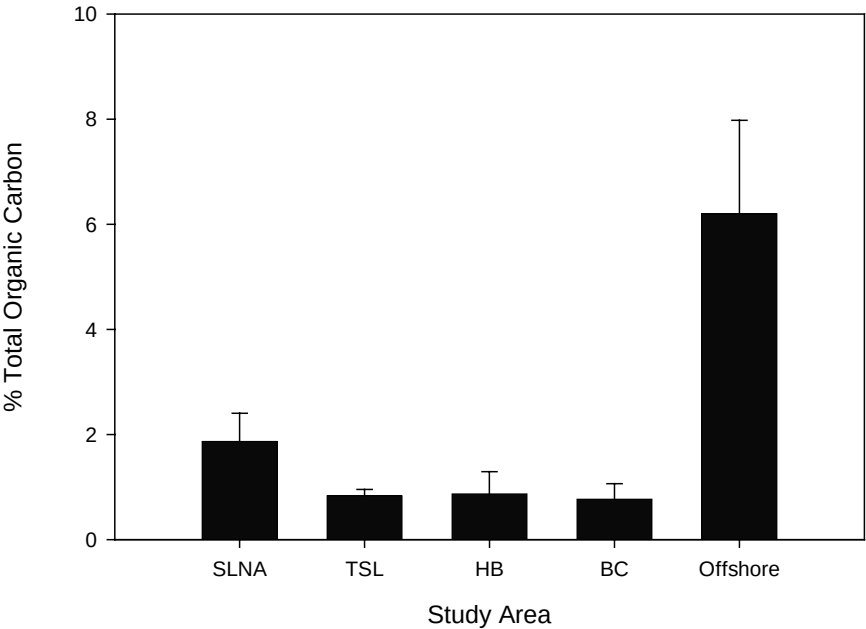


Figure A-62 Mean % composition of sediments collected from nearshore and offshore areas in Sylvan Lake

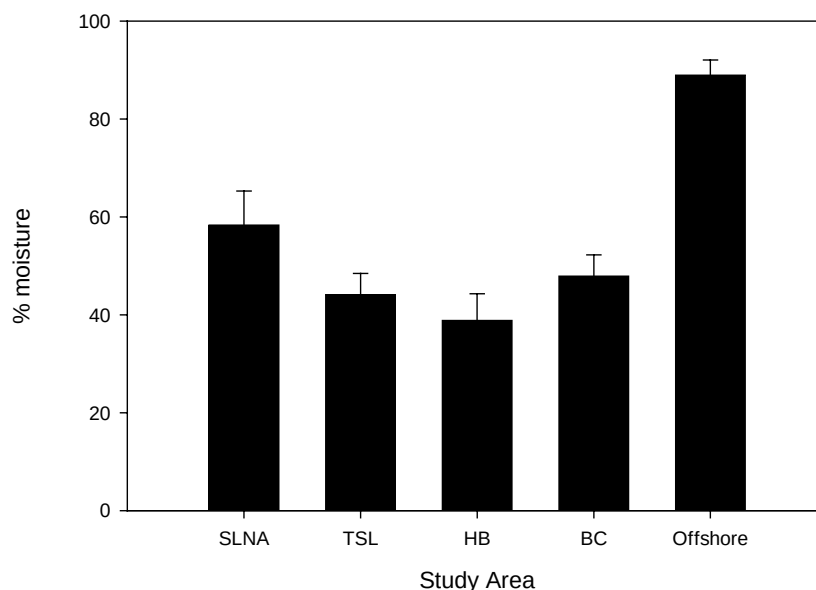
Sylvan Lake Natural Area (SLNA); Town of Sylvan Lake (TSL); Summer Villages of Honeymoon Bay (HB) and Birchcliff (BC); Offshore Areas (Offshore)



Note: * indicates significance at the $p=0.05$ level (significantly different from all other sites)

Figure A-63 Total organic carbon (%) in sediments collected from nearshore and offshore areas in Sylvan Lake (mean $\pm$ SE)

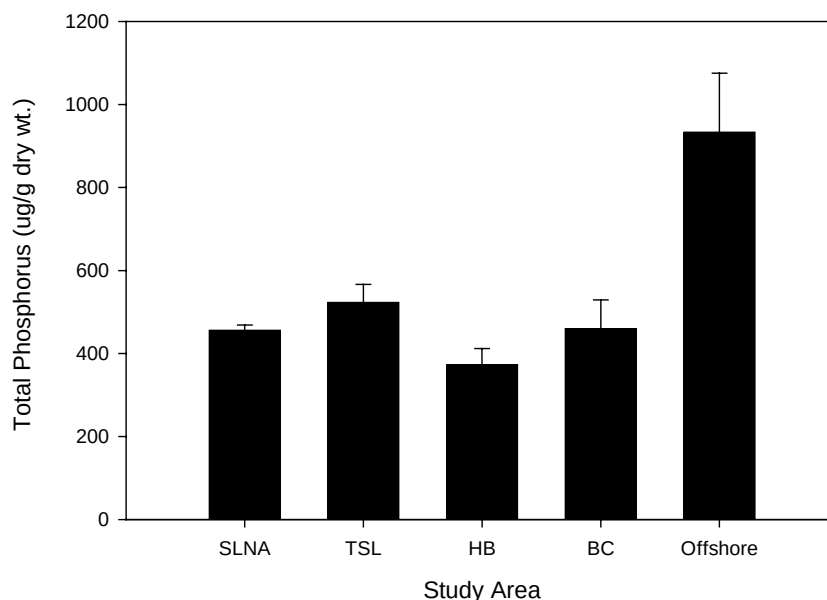
Sylvan Lake Natural Area (SLNA); Town of Sylvan Lake (TSL); Summer Villages of Honeymoon Bay (HB) and Birchcliff (BC); Offshore Areas (Offshore)



Note: * indicates significance at the $p=0.05$ level (significantly different from all other sites)

Figure A-64 Moisture Content (%) in sediments collected from nearshore and offshore areas in Sylvan Lake (mean $\pm$ SE)

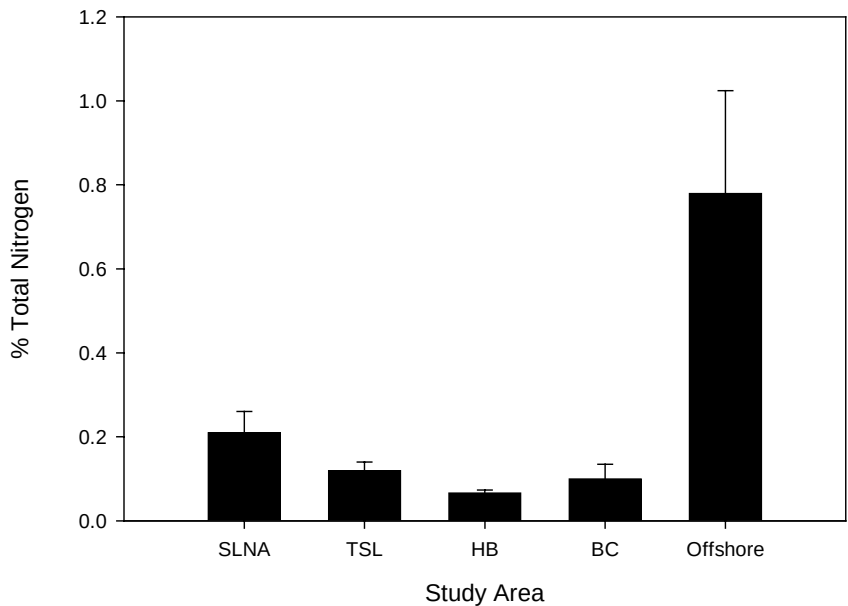
Sylvan Lake Natural Area (SLNA); Town of Sylvan Lake (TSL); Summer Villages of Honeymoon Bay (HB) and Birchcliff (BC); Offshore Areas (Offshore)



Note: * indicates significance at the $p=0.05$ level (significantly different from all other sites)

Figure A-65 Total phosphorus (TP; µg/g dry wt) in sediments collected from nearshore and offshore areas in Sylvan Lake (mean $\pm$ SE)

Sylvan Lake Natural Area (SLNA); Town of Sylvan Lake (TSL); Summer Villages of Honeymoon Bay (HB) and Birchcliff (BC); Offshore Areas (Offshore)



Note: * indicates significance at the p=0.05 level (significantly different from all other sites)

Figure A-66 Total nitrogen (TN; %) in sediments collected from nearshore and offshore areas in Sylvan Lake (mean±/SE)

Sylvan Lake Natural Area (SLNA); Town of Sylvan Lake (TSL); Summer Villages of Honeymoon Bay (HB) and Birchcliff (BC); Offshore Areas (Offshore)

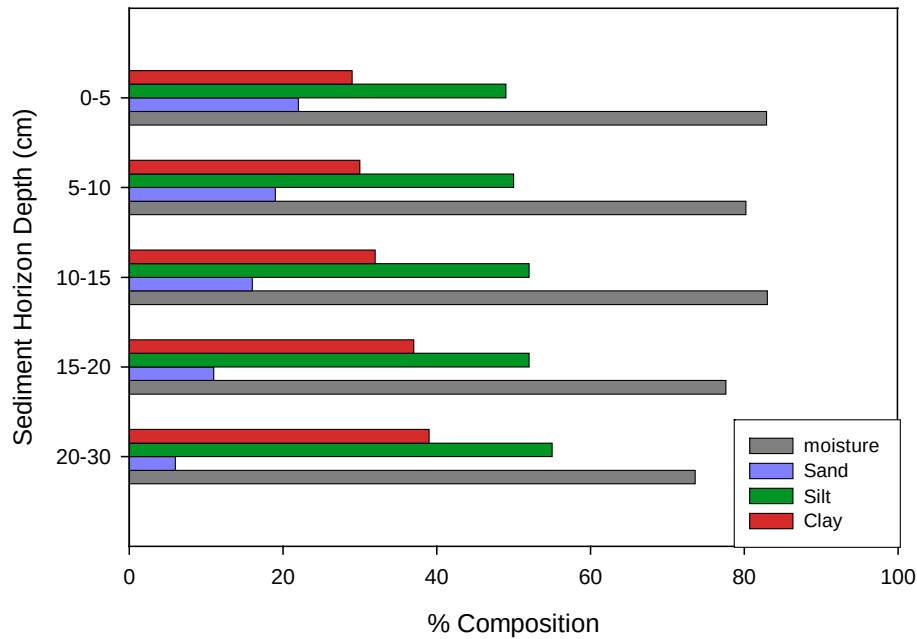


Figure A-67 Percent composition of five horizons from a sediment core taken offshore from the Town of Sylvan Lake

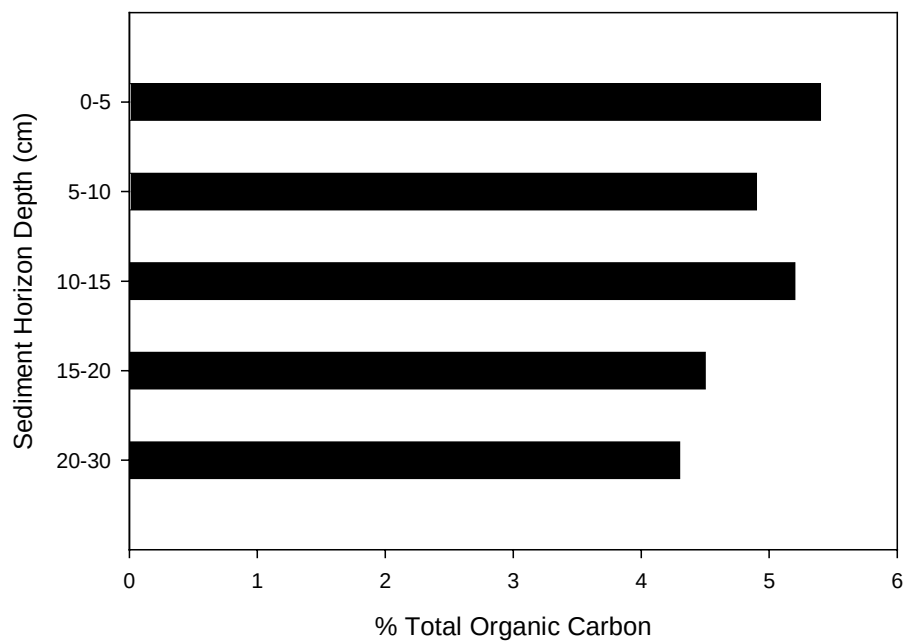


Figure A-68 Percent total organic carbon (TOC) of five horizons from a sediment core taken offshore from the Town of Sylvan Lake

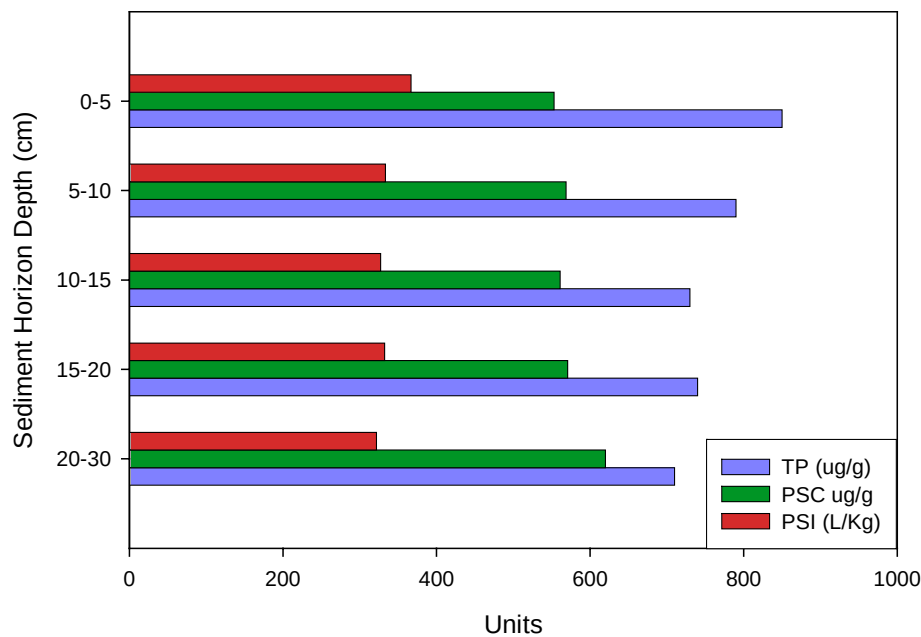


Figure A-69 Total phosphorus (TP), phosphorus sorption capacity (PSC) and phosphorus sorption index (PSI) of five horizons from a sediment core taken offshore from the Town of Sylvan Lake

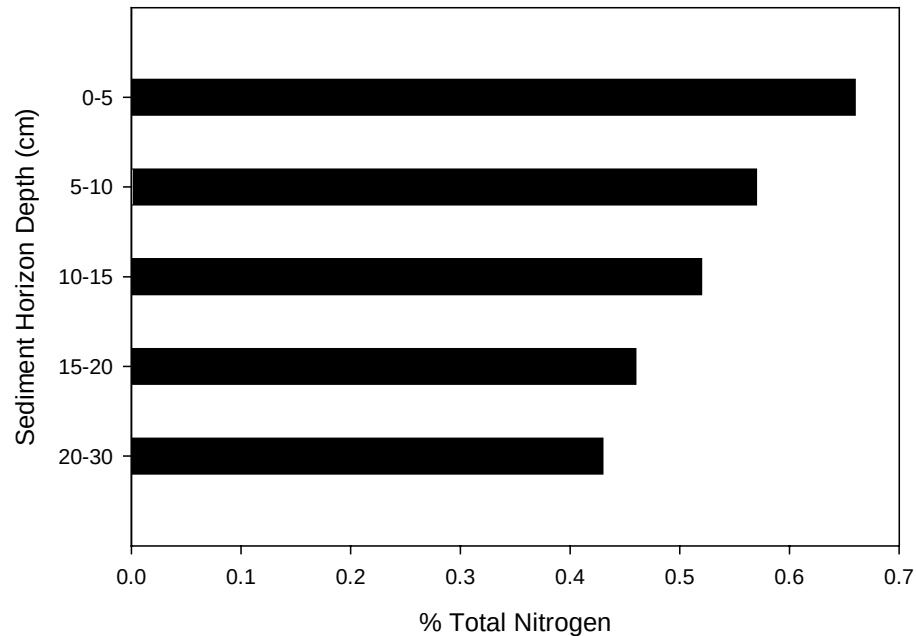
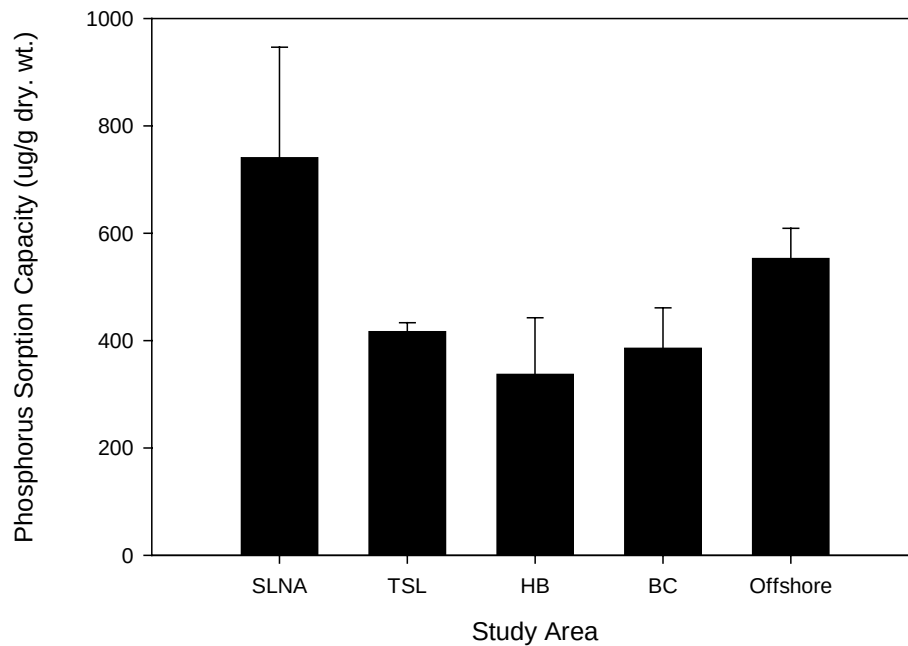


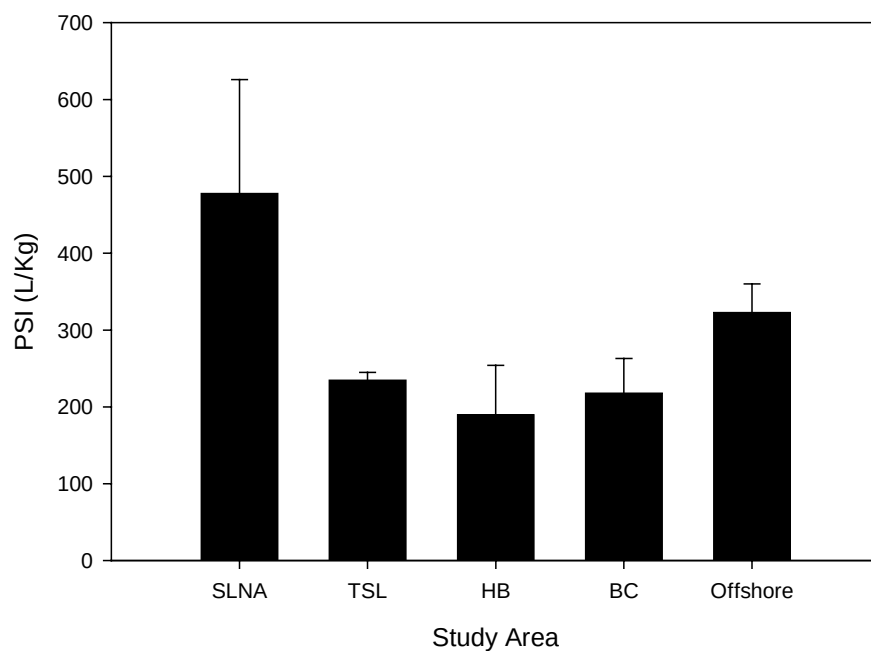
Figure A-70 Percent total nitrogen (TN) of five horizons from a sediment core taken offshore from the Town of Sylvan Lake



Note: There was no significant difference between sites at the $p=0.05$ level

Figure A-71 Phosphorus sorption capacity (PSC; µg/g dry wt) in sediments collected from nearshore and offshore areas in Sylvan Lake (mean $\pm$ SE)

Sylvan Lake Natural Area (SLNA); Town of Sylvan Lake (TSL); Summer Villages of Honeymoon Bay (HB) and Birchcliff (BC); Offshore Areas (Offshore)



Note: There was no significant difference between sites at the $p=0.05$ level

Figure A-72 Phosphorus sorption index (PSI; L/Kg) in sediments collected from nearshore and offshore areas in Sylvan Lake (mean $\pm$ SE)

Sylvan Lake Natural Area (SLNA); Town of Sylvan Lake (TSL); Summer Villages of Honeymoon Bay (HB) and Birchcliff (BC); Offshore Areas (Offshore)

Data Interpretation

Surficial sediment from the nearshore areas was predominantly sand (69-94%) with some silt (3-22%) and clay (1-9%; Figure A-62). The Sylvan Lake Natural Area had the lowest proportion of sand (69%), and the highest proportion of silt (22%) and clay (9%) compared to the other nearshore areas, which were all fairly similar in sediment composition. Surficial sediments from the deeper part of the lake were noticeably different in composition compared with nearshore sediments. Offshore sediments contained a lower proportion of sand (4-40%) and higher proportions of silt (28-49%) and clay (29-50%). Sediments from offshore areas also had elevated levels of total organic carbon (TOC) compared with the Sylvan Lake Natural Area (3 times higher) and other nearshore areas (7 times higher; Figure A-63). The offshore sediments also had higher water retention capacities (% moisture) compared to the nearshore sediments (1.5-2 times higher; Figure A-64). Sediment phosphorus and nitrogen levels were significantly higher offshore compared with the nearshore areas, which were not significantly different from each other ($p < 0.05$; Figures A-65 and A-66). Offshore sediments contained approximately double the TP concentration and 4-11 times the TN concentrations reported for nearshore areas (Figures A-65 and A-66). Higher nutrient concentrations in the offshore sediments are mainly due to the greater clay and silt content in those sediments relative to the nearshore sediments. This is typical of Albertan lakes (see Section A.3.5).

For one offshore replicate sample (close to the Town of Sylvan Lake), sediment quality was also determined in four successive sediment horizons spanning 5 cm to 30 cm below the sediment surface (at 7 m water depth). These horizons represent a range of sediment depths which correspond to a range of time periods, during which sedimentation processes deposited sediment in the lake bottom. Thus, where recently deposited surface sediments represent current conditions; sediments sampled from successive depths represent historical conditions (sediment has been deposited at some time in the past). Typically, the deeper the sediment; the further back in time the sediment was deposited, unless there has been significant vertical mixing. Consequently, the determination of sediment quality and nutrient status at various depths generally represents the historical record of for an unspecified time period.

Sediment composition was similar at the various depths, except for sand content which decreased from 22% at the surface to 6% in the 20-30 cm horizon (Figure A-67). TOC decreased slightly with depth from 5.4 to 4.3% (Figure A-68). TP and nitrogen both also decreased slightly with depth (850 to 710 $\mu\text{g/g}$ and 0.66 to 0.43%, respectively; Figures A-69 and A-70). Overall, these preliminary results suggest sediment composition and nutrient status were consistent down to 30 cm depth. It however should be noted that this was a preliminary assessment of nutrient loading for Sylvan Lake, and to definitively assess historical nutrient loading, a more intensive sampling program would have to be initiated. None of the sediments tested were saturated in phosphorus as they were able to take up additional phosphorus from solution. Phosphorus sorption capacities ranged from 221 to 949 $\mu\text{g/g}$, with the two highest values recorded in replicate sediment samples taken from the Sylvan Lake Natural Area (Figures A-71 and A-72). The phosphorus sorption capacity of the third replicate sample from the Sylvan Lake Natural Area (329 $\mu\text{g/g}$) was however substantially lower than the other two (944 and 949 $\mu\text{g/g}$), and was more comparable to values recorded for other nearshore and offshore sites. Regardless, there was no significant difference between the phosphorus sorption capacities of surficial sediments from the Sylvan Lake Natural Area, the other nearshore sites and offshore. The phosphorus sorption index values ranged from 120 to 627 L/kg

and since these values were derived from the PSC measurements, the trends were the same (Figure A-72). Thus, PSI values were not significantly different between areas.

The phosphorus sorption capacity of the various sediment horizons remained within the range 553-571 µg/g down to a depth of 20 cm (Figure A-71). The phosphorus sorption capacity of the deepest horizon sampled (20-30 cm) was slightly higher (620 µg/g). These values were within the range reported for the phosphorus sorption capacity of nearshore sediments in Sylvan Lake. The PSI values were similar for all sediment horizons and did not change with depth.

Comparison of Sediment Quality Data to Sediment Quality Guidelines

The TOC and phosphorus levels found in Sylvan Lake sediments were compared against applicable sediment quality guidelines. There are no federal or Albertan nutrient or TOC sediment quality guidelines, so guidelines set by the province of Ontario were used as surrogates (Persaud et al. 1993). TP and TOC concentrations in nearshore sediments were all below the Lowest Effect Levels (LELs; 1% and 550 µg/g, respectively). TOC and TP offshore sediment concentrations both exceeded the LEL thresholds but remained well below the severe effect levels (SELs). TN concentrations could not be compared to Ontario sediment quality guidelines because the units of measurement were not comparable. The Lowest Effect Level relates to the level where adverse effects on benthic species become apparent, whereas the Severe Effect Level relates to the levels that could potentially eliminate the majority of benthic organisms (Persaud et al. 1993).

Comparison to Sediment Quality Data From Other Lakes

Table A-12 is a compilation of available sediment TP data for lakes in Alberta plus relevant data from British Columbia and Pennsylvania, and the 2004 data from Sylvan Lake. When these data are compared some clear patterns emerge. The historical range of phosphorus concentrations in sediments from nearshore or shallow areas (261-909 µg/g) were lower than phosphorus concentrations in sediments taken at maximum or variable depths (846-3300 µg/g) in these lakes. This was also true of sediments taken from Sylvan Lake (373-523 vs 933 µg/g). TP concentrations in Sylvan Lake nearshore sediments were within the lower end of the range of concentrations measured in the shallow areas of several Alberta lakes in 1986 by AENV (261-909 µg/g) but were comparable to that measured in littoral sediments from Lake Pleasant in Pennsylvania in 2001 (567.9 µg/g). Lake Pleasant is a glacial lake which is still considered to have relatively good water quality (Western Pennsylvania Conservancy 2004). TN concentrations in nearshore sediments from Sylvan Lake were also similar to that measured in littoral sediments from Lake Pleasant (Johnson and Ostrofsky 2004).

The TP concentration measured in offshore sediments from Sylvan Lake in 2004 (933 µg/g) was within the range reported for lakes located in eastern sub-regions of BC that were considered to be uncontaminated (888.7-1427 µg/g). Correspondingly, the offshore Sylvan Lake phosphorus sediment concentration was in the lower end of the concentration range measured in offshore sediments from several Alberta lakes in 1988 (846-2348 µg/g), and it was lower than the range of concentrations measured in offshore sediments from three Alberta lakes in 1994 (1500-3300 µg/g).

Table A-12 Sediment Total Phosphorus Concentrations in Select North American Lakes

Province/State	Year Sampled	Lake/Sub-Region	Depth Sampled	Mean Total P (µg/g DW)	Range or Error Term (µg/g DW)	Data Source
Alberta	2004	Sylvan Lake	Nearshore	457	12 (SE)	1
		Sylvan Lake	Nearshore	523	43 (SE)	1
		Sylvan Lake	Nearshore	373	38 (SE)	1
		Sylvan Lake	Nearshore	460	69 (SE)	1
		Sylvan Lake	7-16 m	933	56 (SE)	1
Pennsylvania	2001	Lake Pleasant	Littoral	567.9	107.1-1309.9	2
Alberta	1994	Amisk Lake	Deepest	1500	100 (SE)	3
		Baptiste Lake	Deepest	3300	700 (SE)	3
		Crooked Lake	Deepest	1600	100 (SE)	3
Alberta	1988	Baptiste Lake N.	Variable	1418	-	4
		Battle Lake	Variable	1251	-	4
		Bonnie Lake	Variable	2054	-	4
		Buck Lake	Variable	2276	-	4
		Goose Lake	Variable	1621	-	4
		Isle Lake	Variable	2348	-	4
		Lac St. Anne Lake	Variable	1252	-	4
		Moonshine Lake	Variable	964	-	4
		Muriel Lake	Variable	1394	-	4
		Nakamun Lake	Variable	2335	-	4
		Sandy Lake N.	Variable	1575	-	4
		Sandy Lake S.	Variable	1331	-	4
		Sturgeon Lake	Variable	2099	-	4
		Tucker Lake	Variable	1377	-	4
		Winagami Lake	Variable	846	-	4
		Wizard Lake	Variable	1560	-	4
Alberta	1986	Baptiste Lake	≤5 m	379	-	5
		Figure Eight Lake	Shallow	909	-	5
		Island Lake	≤7.5 m	413	-	5
		Jenkins Lake	≤7.5 m	338	-	5
		Long Lake	≤5 m	771	-	5
		Minnie Lake	≤7.5 m	786	-	5
		Narrow Lake	≤10 m	261	-	5
		S-9 Lake	Shallow	477	-	5
		Tucker Lake	≤7 m	705	-	5
British Columbia	1982-1987	Alberta Plateau sub region	Deepest	995.6	626.7 (SD)	6
		Northern Rocky Mountain sub region	Deepest	1427	1738 (SD)	6
		Southern Rocky Mountain sub region	Deepest	888.7	458.3 (SD)	6

Sources: 1 Field sampling for this study SD- Standard Deviation
 2 Johnson and Ostrofsky 2004 SE – Standard Error
 3 Burley 1998
 4 Shaw and Prepas 1990
 5 AENV unpublished data
 6 Rieberger K. 1992

Evaluation of Effects of Nearshore Developments on Sediment Quality in Sylvan Lake

Overall, sediment quality at nearshore sites close to the Sylvan Lake Natural Area, Town of Sylvan Lake, and the summer villages of Half Moon Bay and Birchcliff was similar with no significant differences in TP, nitrogen or organic carbon levels. Furthermore, TP and carbon concentrations were within provincial SQGs for the protection of aquatic life (Persaud et al. 1993). Based on the results of this single study there appeared to be no enrichment of phosphorus, nitrogen or carbon in sediments close to Town of Sylvan Lake and the summer villages of Half Moon Bay and Birchcliff, relative to the sediment quality determined for a site close to the undeveloped shoreline in the Sylvan Lake Natural Area.

In comparison to nearshore areas in other regional lakes, some of which are considered to be eutrophic, sediment phosphorus concentrations appear to be relatively low in Sylvan Lake nearshore areas (Table A-12). This is also the case for phosphorus sediment concentrations in deeper offshore areas. Both nearshore and offshore sediment phosphorus concentrations in Sylvan Lake were comparable to lakes considered to have relatively good water quality in BC; though they were also similar to a lake considered to be mesotrophic-borderline eutrophic in Pennsylvania.

A.2.3 Phytoplankton Community

A.2.3.1 Phytoplankton Community Composition

Studies of phytoplankton communities can indicate the amount of productivity in an aquatic system, the diversity of the community, and may provide information about the trophic condition of an ecosystem. Phytoplankton communities typically vary seasonally in north temperate systems, in accordance with varying environmental conditions such as light and temperature (i.e., seasonal succession). Typically, lakes exhibit spring pulses of diatoms with increasing dominance of cyanophytes (blue-green algae) in late summer. Abundance of blue-green algae may indicate eutrophication in lake and river systems.

The composition of the phytoplankton community in Sylvan Lake has been evaluated in three studies: (1) in 1973 and 1974 (Grant 1976); (2) in July and August of 1976 (Jones et al. 1976); and, (3) on September 06, 2004 as a component of this study. Due to differences in taxonomists, times of year sampled, and sampling methods, the results of the two studies are not directly comparable. In particular, for the study conducted in 1973 and 1974 sampling and analysis methods were not indicated and the results were not presented in raw form. For the purposes of this report, relative abundance of major phytoplankton groups were estimated from a figure presented in Grant (1976). It was further assumed that the relative abundance presented in Grant (1976) was based on the number of algal cells (i.e., abundance) and not on biomass. It is cautioned that the use of algal cell biovolumes as an indicator of algal abundance is not the preferred method and the results should be viewed with caution.

For the study reported in Jones et al. (1976), phytoplankton species were identified and the number of individual cells was counted from samples of water collected at 1 and 10 m depths from the deepest site at Sylvan Lake. The most recent study (i.e., 2004) consisted of identifying and enumerating phytoplankton (to primarily the Genus level) from a composite sample collected from the euphotic zone of Sylvan Lake. The timing of the latter study was also somewhat later in the open-water season than the 1976 study, which

complicates direct comparisons due to inherent seasonal succession of the algal community. Furthermore, Jones et al. (1976) did not present the data in terms of algal biomass. However, despite these inconsistencies, a comparison between the results of these two studies is presented below.

Although the data should be viewed with caution, the results of the 1973 and 1974 phytoplankton study indicated that blue-green and green algae comprised a significant fraction of the algal community at that time (Grant 1976, Figure A-73). In 1973, blue-green algae dominated earlier in the summer (May and July) whereas in 1974, they were dominant in late summer (July and August). Also of interest was the lack of a spring diatom pulse, which is typical of north-temperate lakes. Zhang and Prepas (1996) similarly found notable year to year variations in the seasonal succession and relative abundance of major algal groups in four eutrophic Alberta lakes.

In 1976, the phytoplankton community was composed of 74 species, representing five major groups (Figure A-74). Of the major groups, the greatest diversity was observed for chrysophytes. In July and early August, the community was dominated by chrysophytes (i.e., golden brown algae) at the 1 m depth but by mid-August, the community became dominated by cyanophytes (blue-green algae, Figures A-74 and A-75). At 10 m depth, slight differences were observed in relative abundance but similar seasonal differences were observed relative to the 1 m depth sampling site. Numbers of algal cells varied over the summer, but generally increased over the course of the study.

Dominant species measured at 1 m depth varied over the course of the summer of 1976 (Figures A-74 and A-75). In early July, the community was generally dominated by *Anabaena* sp. (a blue-green algae), *Chromulina* sp. and *Pseudopedinella* sp. (chrysophytes). Similarly, the most abundant species in mid-July were *Anabaena* sp. and two other chrysophytes (*Chrysochromulina parva* and *Dinobryon divergens*). In early August, *Chrysochromulina parva* became the dominant species and by mid-August, the community was dominated by three species of blue-green algae (*Anabaena flos-aquae*, *Aphanizomeon flos-aquae*, and *Coelosphaerium kuetzingianum*). Additionally, colonies of *Nostoc* sp. (a blue-green algae) were also observed in shallow areas of Sylvan Lake during the conduct of the study (Crosby 1990). The blue-green algal bloom observed in mid-August 1976 coincided with one of the reported fish kills for Sylvan Lake. The kill involved primarily young-of-the-year yellow perch and although the occurrence of the blue-green algal bloom was identified as a possible cause, the cause was not determined (Jones et al. 1976).

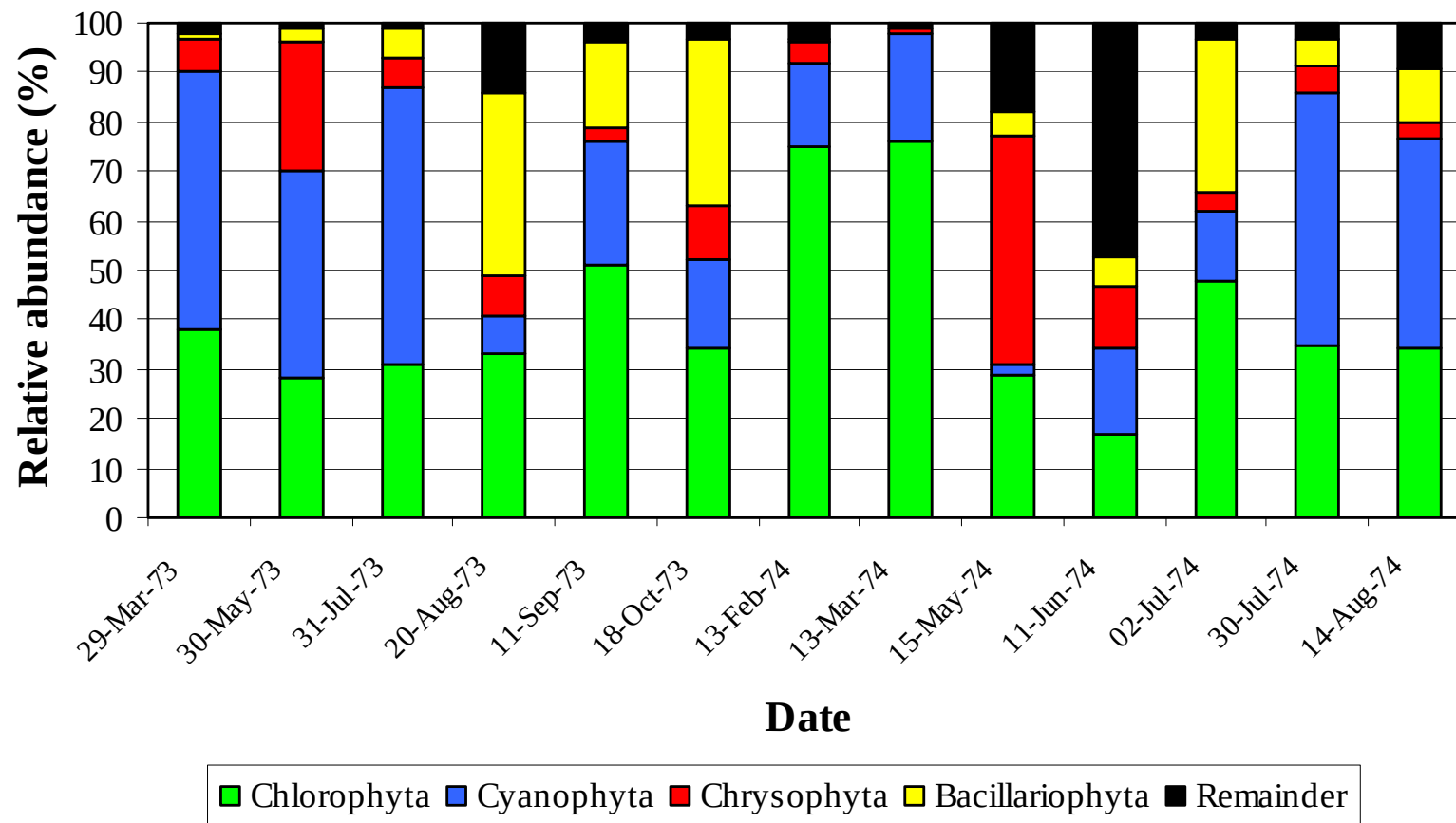


Figure A-73 Relative abundance of major phytoplankton groups in Sylvan Lake in 1973 and 1974. Values are estimates based on data presented in Grant (1976)

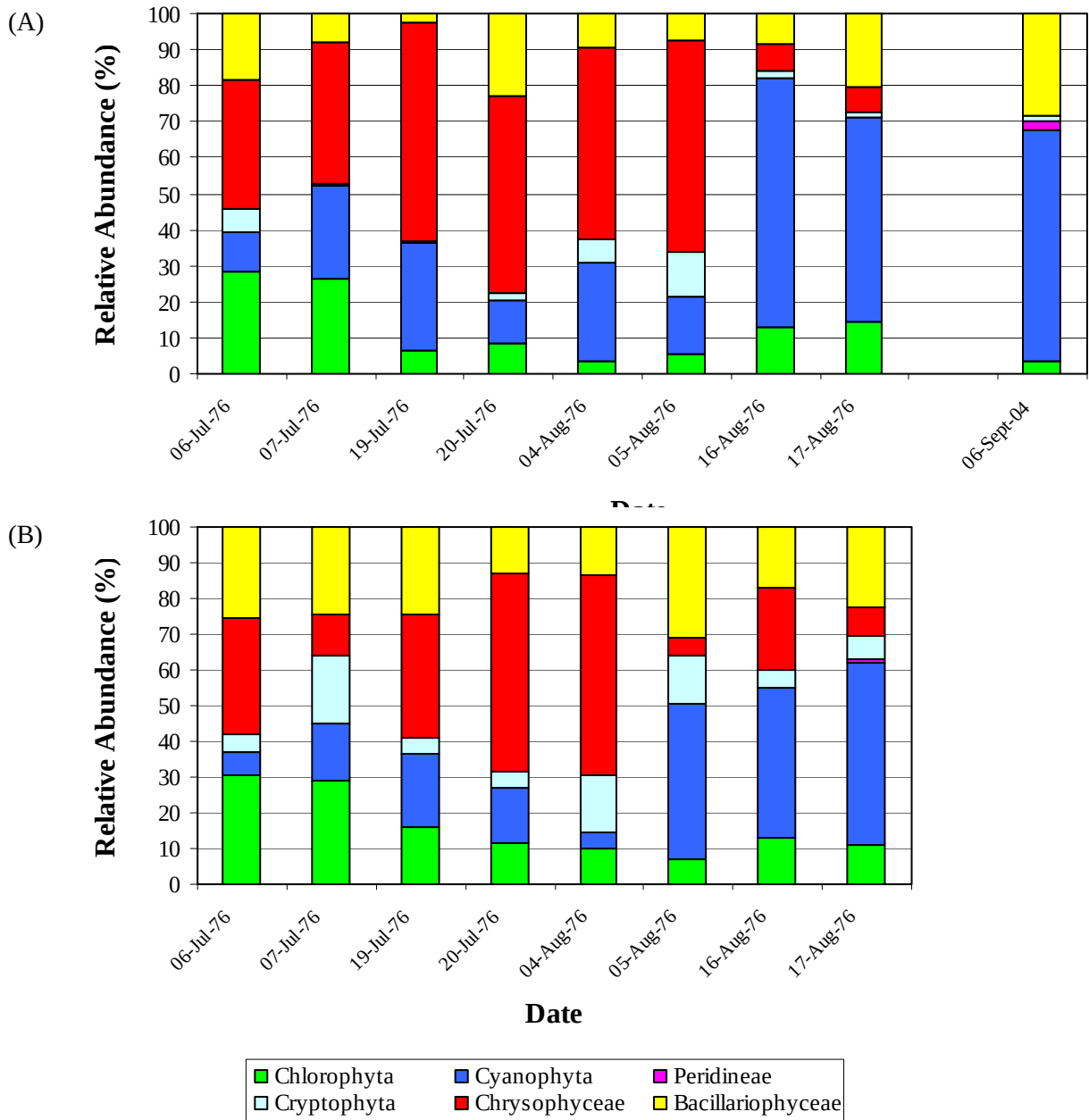


Figure A-74

Relative abundance of major phytoplankton groups collected in Sylvan Lake in July and August 1976, and September 2004. Samples collected in 1976 were collected at 1 m depth (A) and 10 m depth (B). The single sample collected in 2004 was a composite sample of the euphotic zone. Abundance was based on number of cells/mL

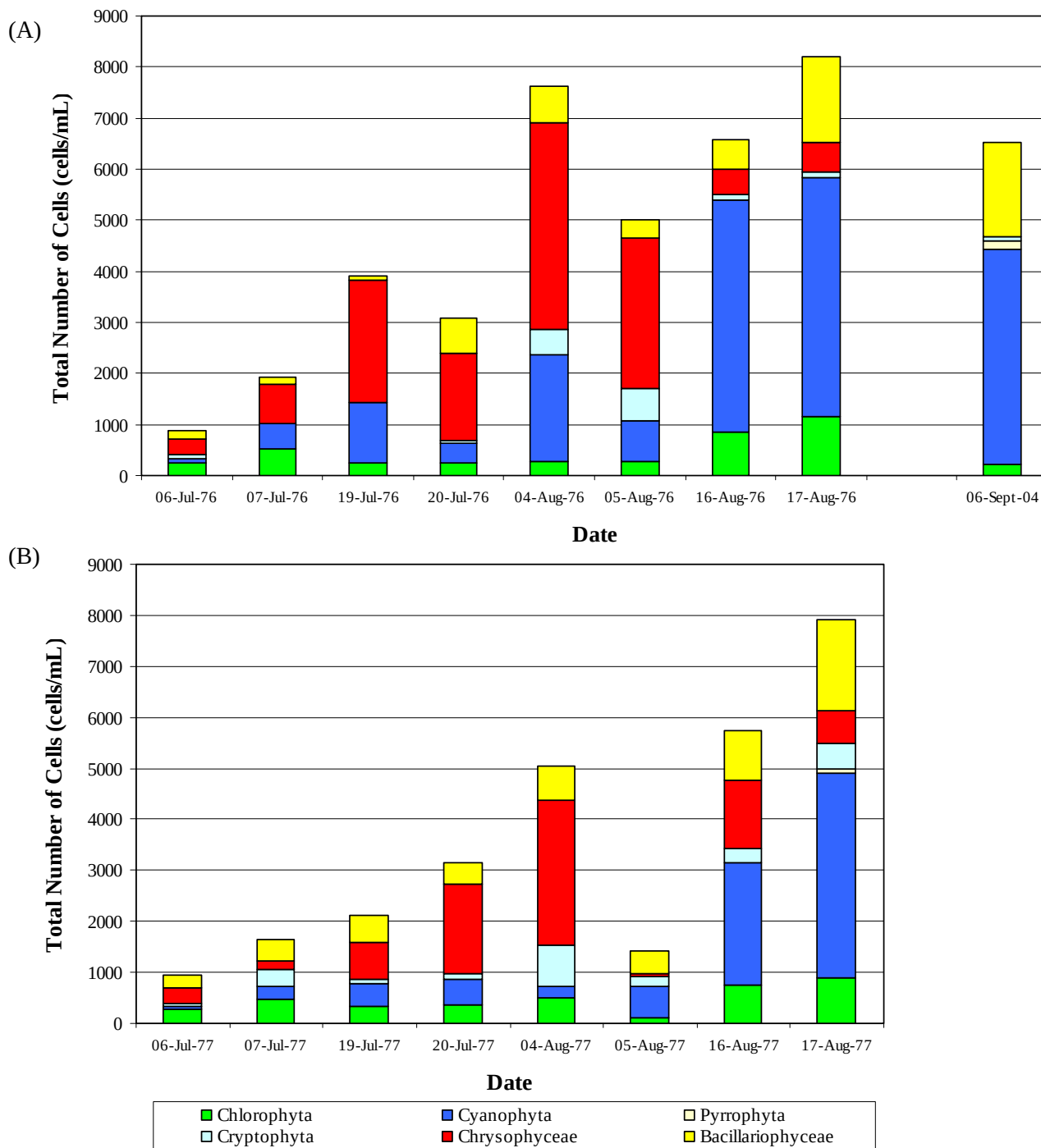


Figure A-75 Abundance of major phytoplankton groups collected in Sylvan Lake in July and August 1976, and September 2004. Samples collected in 1976 were collected at 1 m depth (A) and 10 m depth (B). The single sample collected in 2004 was a composite sample of the euphotic zone

The single sample collected in September 2004 indicated a similar relative abundance of major algal groups as observed in mid-August 1976 (Figures A-75 and A-76). The community was overwhelmingly dominated by blue-green algae, expressed in terms of either biovolume or numbers of cells (Figure A-76). The number of algal cells in this sample was also remarkably similar to samples collected in mid-August 1976 from Sylvan Lake. The dominant species in September 2004 was *Aphanizomeon flos-aquae* (35.7%), based on the number of algal cells, and *Aphanocapsa* sp. (51.8%), based on biomass. Both are species of blue-green algae. Additionally, the diatom *Fragillaria crotonensis* was the second most abundant species in September 2004, when abundance is expressed as numbers of cells/L. These data are also quite consistent with the species dominance observed in mid-August 1976, when *Aphanizomeon flos-aquae* was also abundant (Jones et al. 1976). Furthermore, dominance of the filamentous blue-green *Aphanizomenon flos-aquae* in late summer/early fall has been observed in eutrophic Alberta lakes (Zhang and Prepas 1996). In general, Zhang and Prepas (1996) found that dominance of blue-green algae in eutrophic Alberta lakes was positively related to water temperature ($>15^{\circ}\text{C}$) and a wide range of water column stability.

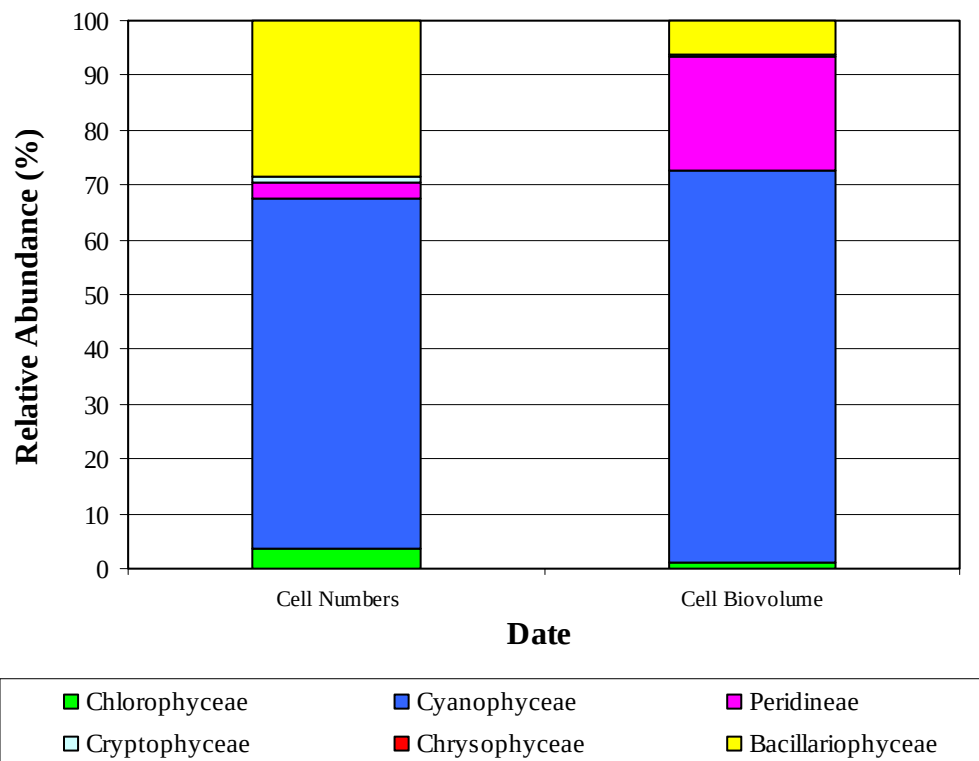


Figure A-76 Relative abundance of major phytoplankton groups collected in a composite sample of the euphotic zone of Sylvan Lake on September 06, 2004. Relative abundance is presented based on the number of cells/mL and as a biomass (mg/m^3)

A.2.3.2 Factors Affecting Algal Growth in Sylvan Lake

There is on-going debate regarding the factors most limiting to or most important in determining phytoplankton biomass and species composition. In general, it is well known the key variables that affect algal growth and productivity are the absolute concentrations as well as relative concentrations of key nutrients (primarily nitrogen and phosphorus), in addition to light, temperature, aquatic primary consumer grazing, climate, and hydraulic and hydrological characteristics of the aquatic ecosystem. The relative importance of each of these variables may vary between years, between regions, lakes, seasons, and portions of a waterbody. Additionally, anthropogenic alterations to the supply of nutrients to aquatic ecosystems may alter the limiting factor(s).

The following is a brief discussion of some of the major variables that may affect phytoplankton production in Sylvan Lake, based upon the available information.

Nutrients

In general, lakes are considered to be phosphorus-limited based on the relative abundance of nitrogen and phosphorus in surface waters and the demand for the two nutrients for algal growth. The ratio of nitrogen to phosphorus in surface water is commonly used as an indicator of the limiting nutrient, with respect to phytoplankton growth, with molar ratios of less than 10 indicative of nitrogen limitation and molar ratios greater than 16 indicative of phosphorus limitation (values in between are typically considered indicative of co-limitation). To provide some estimate of the limiting nutrient in Sylvan Lake, molar N:P ratios were calculated using available historical water quality data (1995-2003, Table A-2). Mean (3.4) and median (1.6) DIN: TP ratios were indicative of nitrogen limitation in Sylvan Lake over that period. Similarly ratios derived from DIN and dissolved phosphorus although somewhat higher than the latter were also indicative of nitrogen limitation (i.e., ratios were less than 10). Higher ratios were observed in the open-water season of 1996, relative to other times where data were available.

Overall, the nutrient ratios indicate that nitrogen may be more significant in determining phytoplankton growth than phosphorus, given the current concentrations of phosphorus in the lake. Similarly, studies conducted during the Pine Lake Restoration Study determined that Pine Lake, a lake that is also in the Red Deer River Basin, also indicated strong nitrogen limitation until late July (Sosiak and Trew 1996). The low N:P ratios observed during this time coincided with the highest algal biomass of nitrogen-fixing blue-green algal species and the highest production of heterocysts (nitrogen-fixing cells).

Empirical models between concentrations of nitrogen and phosphorus and chlorophyll *a* are also used to examine both the limiting nutrient as well as to determine the importance of either nutrient in determining phytoplankton biomass in lakes. Regressions between TN and TP and chlorophyll *a* were constructed for the period of record and presented in Figure A-77. A weak relationship ($R^2 = 0.42$, $n = 83$) was found between TP and chlorophyll *a*, whereas a stronger correlation ($R^2 = 0.74$, $n = 20$) between TKN and chlorophyll *a* is evident in Sylvan Lake (Figure A-77). This finding lends further support to the notion that nitrogen may be more limiting to phytoplankton growth in Sylvan Lake at the present time. The significance of nitrogen as a limiting plant nutrient is not in itself unusual. The interest and attention paid to phosphorus and its role in phytoplankton growth in lakes owes its roots to the “phosphorus paradigm” that emerged several decades ago (Kalff 2002). However, even in the formative eutrophication studies the importance of nitrogen was acknowledged and it has been demonstrated in fertilization and limnecorral studies that for the vast majority of studies, both nitrogen and

phosphorus had to be added together to cause a substantive stimulation of algal production (Elser et al. 1990). Nitrogen limitation becomes more significant in eutrophic systems where there is an abundance of phosphorus. Nitrogen limitation has been recently identified for a number of prairie lakes and rivers (CCME 2004).

Although it appears that relatively speaking nitrogen may be more limiting than phosphorus in Sylvan Lake, whether concentrations of either nutrient actually limit phytoplankton growth in whole or in part are not known. However, the suggested nitrogen limitation in Sylvan Lake may indicate that the lake is more predisposed to development of blue-green algal blooms due to the ability of some cyanophytes to fix atmospheric nitrogen. Conversely, Zhang and Prepas (1996) found that the most significant factors relating to the dominance of cyanophytes were high water temperature ($>15^{\circ}\text{C}$) and to some extent, water column stabilization. It is noteworthy that these authors also noted the significance of nitrogen in determining phytoplankton biomass in Alberta lakes.

Light

Phytoplankton productivity may be limited in some systems either primarily or secondarily by light. There are two aspects to light availability to consider in this regard: (1) climatological conditions; and, (2) water clarity. From a climatological perspective, the number of hours of daylight, the intensity of the solar radiation, and cloud cover and shading are of significance in determining what light reaches the surface of a waterbody. In north temperate environments, light is limiting in the winter due to short daylight hours, low intensity of solar radiation, and ice and snow cover (which severely impedes light penetration to the water column). Therefore, light is a significant limiting factor for plant and algal growth in winter. In the open-water season, the amount of light reaching the water surface is much more substantive and the conditions of the waterbody itself become more important in determining light availability. Water clarity is a function of the amount of algae in the water, as well as other organic and inorganic materials present that affect light penetration, and lake morphometry.

In general, Sylvan Lake is characterized by high water clarity, with low levels of suspended solids and a deep euphotic zone. The average Secchi disk depth for the open-water season is 4.8 m and is generally considered indicative of oligotrophic conditions. This is twice as high as the average of 144 lakes in Alberta (data provided by AENV 2004) and indicates that light conditions are likely not limiting to phytoplankton.

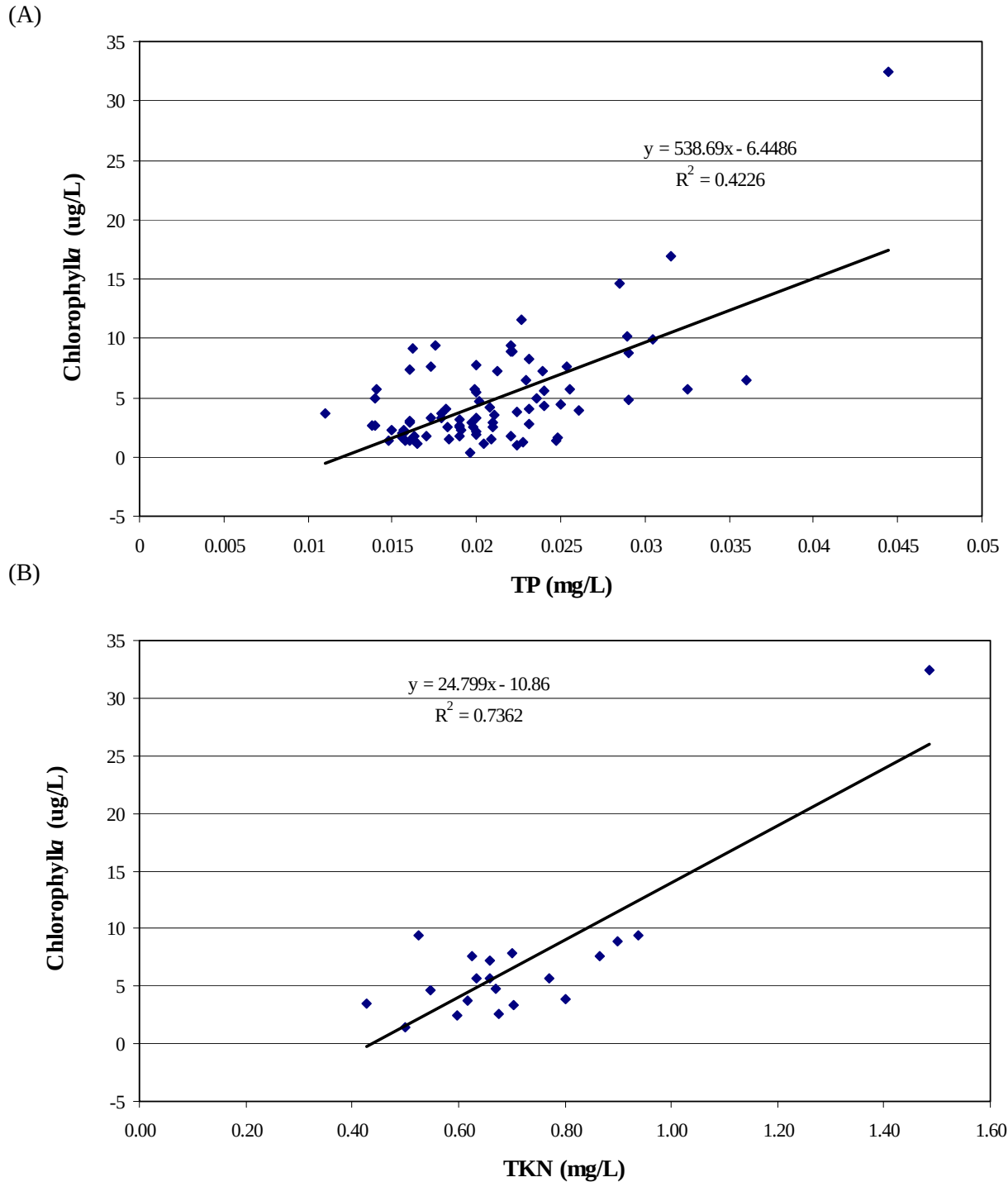


Figure A-77 Linear regressions between (A) chlorophyll a and total phosphorus (TP); and (B) chlorophyll a and TKN in Sylvan Lake. Data based on historical record provided by AENV. $p=0.05$

Temperature

Temperature plays a significant role in phytoplankton productivity, as it does in most biological processes. In winter, growth of plants and algae are limited by low temperatures, in combination with low light levels, in north temperate systems including Sylvan Lake. Growth of phytoplankton appears to increase over the course of the open-water season as water temperature increases. Zhang and Prepas (1996) noted that water temperature was the most significant factor determining the relative dominance of diatoms and blue-green algae in four Alberta Lakes, with the former dominating at water temperatures of less than 15°C and the latter dominating above 15°C. They concluded that temperature was a significant factor in determining the relative abundance of various groups but that TP was most significant at determining the overall biomass of phytoplankton. Therefore, diatoms tend to dominate in lakes early in the open-water season with increasing dominance of blue-green algae as the water temperature increases over the summer. Phytoplankton data for Sylvan Lake indicate that blue-green algae become more abundant as the lake warms up in the summer.

A.2.3.3 Lake Trophic Status

The trophic status of a lake is a means of expressing lake productivity and is generally based on the levels of nutrients (most notably phosphorus) and chlorophyll *a* (as an indicator of phytoplankton productivity). Typically, as the nutrient concentrations increase in a lake (i.e., eutrophication), phytoplankton production increases. Nutrient enrichment may lead to deterioration of lake water quality through stimulation of excessive macrophyte and algal growth which may in turn lead to the production of algal toxins and depletion of dissolved oxygen. Many species of blue-green algae produce microtoxins (some liver toxins and some nervous system toxins) that are toxic to aquatic life, as well as to wildlife and humans that consume the water. Dissolved oxygen depletion may result from death and decay of algal blooms (a process that requires oxygen) and diurnal variations in algal and plant photosynthesis and respiration processes. In the daytime, higher plants and algae produce oxygen but at night, when there is no light, they consume it. Subsequently, in highly productive aquatic systems dissolved oxygen may swing widely over a 24-hour period. This can cause problems to aquatic biota through depletion of DO to critical levels and in extreme situations may cause fish kills. Additionally, algal blooms may affect the recreational quality of a lake as they are often perceived as aesthetically unpleasant.

There are a number of classification schemes for determining the trophic status of a lake which incorporate different characteristics into the categorization and apply different numerical criteria (Table A-13). In addition to the conventional trophic status classification schemes that rely upon levels of nutrients, chlorophyll *a*, and water transparency, examination of the aquatic biota in a lake may provide valuable insight into the trophic condition of that system. The following provides a discussion of the trophic status of Sylvan Lake based on different classification schemes as well as a brief discussion of the biological indicators of trophic status.

Table A-13 Classification schemes for lake trophic status. Means of water quality parameters for Sylvan Lake derived from historical data (1983-2003) for the open-water season

Variable	Lake Trophic Status							Reference
	Ultra-oligotrophic	Oligotrophic	Oligo-mesotrophic	Mesotrophic	Meso-eutrophic	Eutrophic	Hypereutrophic	
Total Phosphorus (µg/L)	-	<10	-	10 - 35		35-100	>100	OECD (1982)
	<4	4-10	-	10-20	20-35	35-100	>100	CCME (2004)
	-	<10	-	10 – 20	-	>20	-	Thomann and Mueller (1987)
	-	<5	-	10 – 30	-	-	>100	Chambers et al. (2001)
	<5	-	5-10	-	10-30	30-100	>100	Wetzel (1983)
	-	<10	-	10 – 30	-	-	>100	Nürnberg (1996)
Mean in Sylvan Lake				21				
Chlorophyll <i>a</i> (µg/L)	-	<2.5		2.5 - 8		8-25	>25	OECD (1982)
	-	<4	-	4 – 10	-	>10	-	Thomann and Mueller (1987)
	0.01-0.5	0.3-3	-	2-15	-	10-500	-	Wetzel (1983)
	-	<3.5	-	3.5 - 9	-	9.1 - 25	>25	Nürnberg (1996)
Mean in Sylvan Lake				4.6				
Secchi Depth (m)	-	>6	-	3-6	-	<1.5	-	OECD (1982)
	-	>4	-	2 – 4	-	<2	-	Thomann and Mueller (1987)
	-	>4	-	2 – 4	-	1 – 2.1	<1	Nürnberg (1996)
Mean in Sylvan Lake				4.8				

Table A-13 **Classification schemes for lake trophic status. Means of water quality parameters for Sylvan Lake derived from historical data (1983-2003) for the open-water season (cont'd)**

Variable	Lake Trophic Status							Reference
	Ultra-oligotrophic	Oligotrophic	Oligo-mesotrophic	Mesotrophic	Meso-eutrophic	Eutrophic	Hypereutrophic	
Total nitrogen (µg/L)	-	<350	-	350 - 650	-	651 – 1,200	>1,200	Nürnberg (1996)
	<1-250	-	250-600	-	500-1,100	-	500->15,000	Wetzel (1983)
Mean in Sylvan Lake					715			
Hypolimnetic oxygen saturation (% saturation)	-	>80	-	10 – 80	-	<10	-	Thomann and Mueller (1987)
Inorganic nitrogen (µg/L)	<200	-	200-400	-	300-650	500-1,500	>1,500	Wetzel (1983)
Mean in Sylvan Lake	46							
Organic nitrogen (µg/L)	<200	-	200-400	-	400-700	700-1,200	>1,200	Wetzel (1983)
Total Organic Carbon (mg/L)	-	<1 - 3	-	<1 - 5	-	5 - 30	-	Wetzel (1983)
Dissolved Organic Carbon (mg C/L)	-	2	-	3	-	10	-	Kalff (2002)

Total Phosphorus

If the Alberta Environment classification scheme, which is based on the scheme provided in OECD (1982), is used, and total phosphorus as the indicator of lake trophic status, Sylvan Lake would be classified as mesotrophic (Figure A-78). Recently, the CCME (2004) provided a slightly revised OECD trophic classification scheme for TP (see Table A-13). Applying the CCME (2004) scheme, Sylvan Lake would be classified as meso-eutrophic. The average TP concentration for the open-water season in Sylvan Lake (0.021 mg/L) is approximately five times lower than the average for Alberta lakes (0.118 mg/L, AENV 2004, Figure A-78).

Chlorophyll *a*

Alberta Environment regularly classifies Alberta lakes into trophic categories using chlorophyll *a* as an indicator of productivity (OECD classification, Table A-13). According to the AENV scheme, Sylvan Lake would be categorized as mesotrophic based on the mean chlorophyll *a* concentration for the open-water season from 1980-2003 (4.6 µg/L). The trophic status of Sylvan Lake and other Alberta lakes is shown in Figures A-78 and A-79. Compared with other Alberta lakes, Sylvan Lake has a relatively low level of chlorophyll *a*; the mean chlorophyll *a* for 169 lakes is 22.4 µg/L (AENV 2004).

Nitrogen

Trophic classifications for lakes often exclude values for nitrogen. Two suggested classification schemes based on TN and one for dissolved nitrogen are provided in Table A-13. On the basis of TN, Sylvan Lake would be classified as meso-eutrophic (Wetzel 1983) to slightly eutrophic (Nürnberg 1996). However, on the basis of inorganic nitrogen, Sylvan Lake would be considered ultra-oligotrophic, as the nitrogen pool in the lake is overwhelmingly dominated by organic nitrogen.

Algal Species Composition

The occurrence of algal blooms, particularly blue-green algae, is also indicative of nutrient rich systems. Algal blooms have been reported to occur on Sylvan Lake at least as far back as the 1970's. Researchers observed blooms of the blue-green algae *Nostoc* in the shallow areas of Sylvan Lake in 1976, coincident with a massive fish kill (Crosby 1990).

Jones et al. (1976) concluded that on the basis of the phytoplankton and benthic macroinvertebrate communities, Sylvan Lake was mesotrophic to eutrophic in 1976. The phytoplankton species composition observed in mid-August 1976 indicated that six species considered to be indicative of mesotrophic conditions were present in the lake: *Fragilaria crotonensis*, *Ceratium hirundinella*, *Pediastrum boryanum*, *Coelosphaerium* sp., *Anabaena* sp., and *Aphinezomenon flos-aquae*. Conversely, Grant (1976) concluded that on the basis of the relative abundance of major phytoplankton groups, Sylvan Lake was eutrophic in the early 1970's.

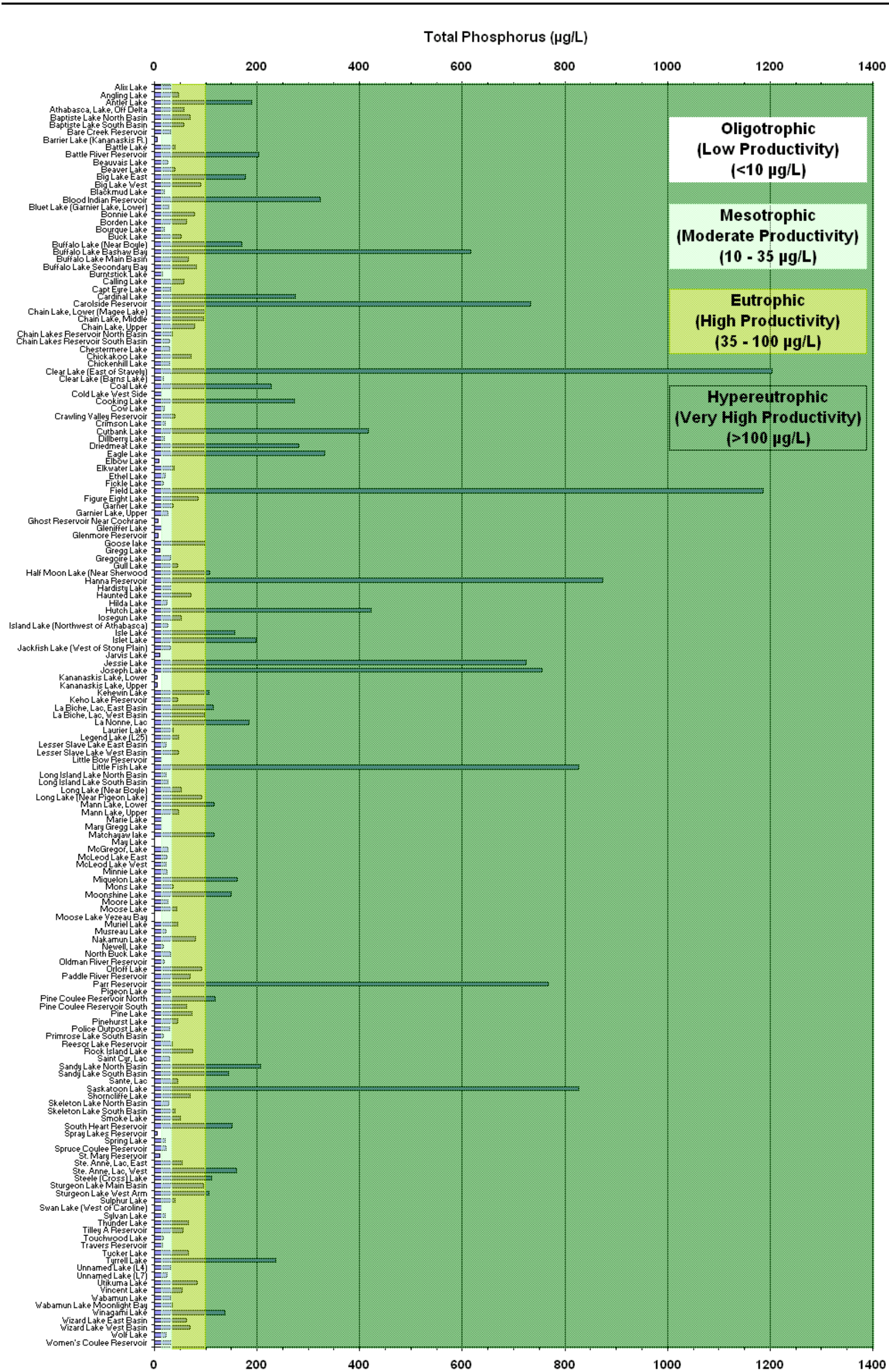


Figure A-78 Trophic status of Alberta lakes based on total phosphorus measured from May–September, 1980–2003. Figure provided by AENV (2004)

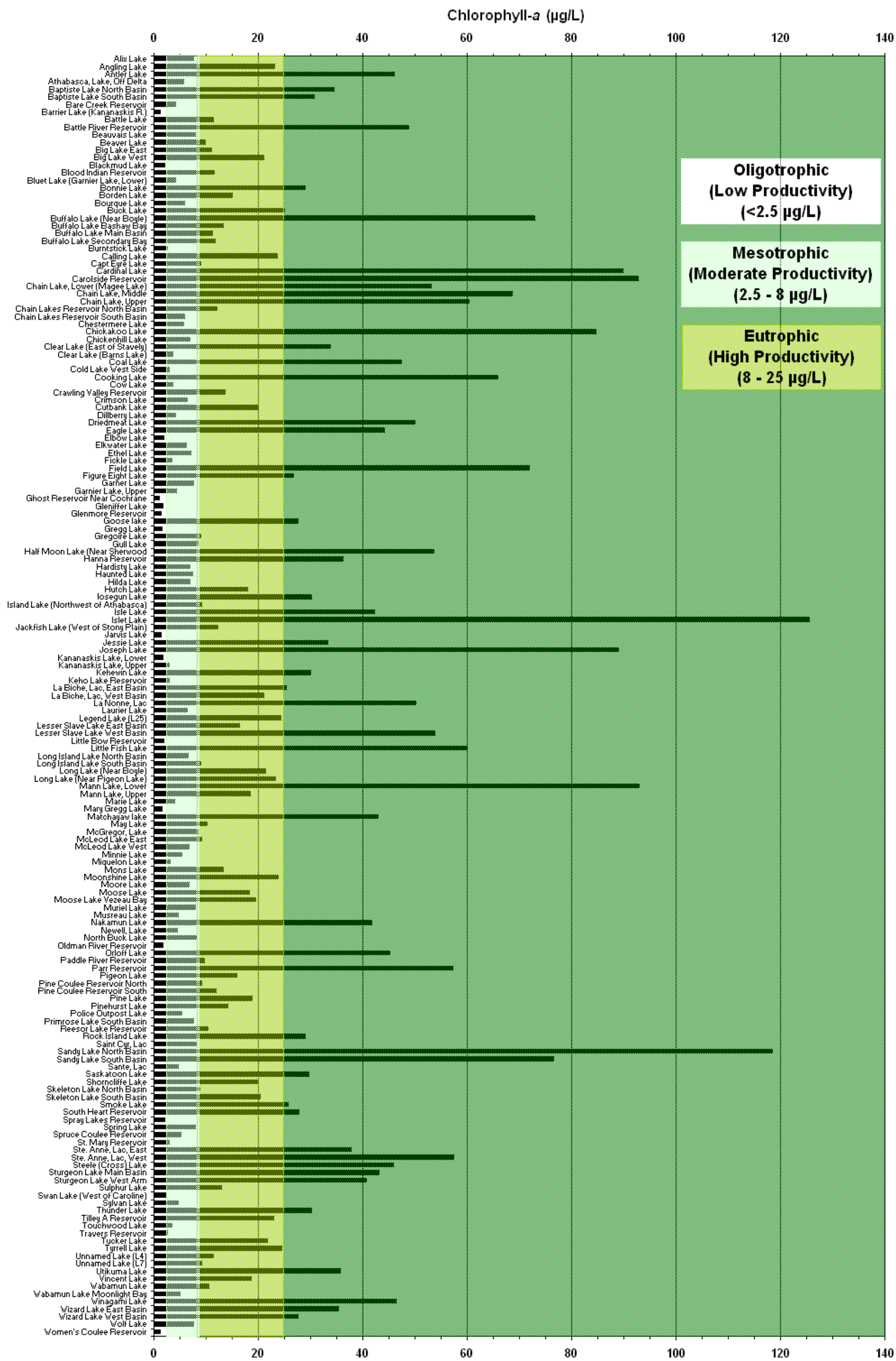


Figure A-79 Trophic status of Alberta lakes based on chlorophyll a measured from May-September, 1980-2003. Figure provided by Alberta Environment (2004)

The algal community observed in September 2004 is generally consistent with eutrophic lakes, in large part due to the dominance of blue-greens at that time and in consideration of the results of earlier studies. Dominance of blue-green algae, particularly *Microcystis*, *Aphanizomenon*, and *Anabaena*, in alkaline, nutrient enriched lakes during warmer periods of the year has been identified as an indication of eutrophic conditions (Wetzel 1983).

Benthic Invertebrates

The benthic invertebrate community in Sylvan Lake was examined in the summer of 1976. Jones et al. (1976) reported that the three profundal (i.e., 18 m depth) chironomid species found in the lake (*Chironomus* sp., *Procladius* sp., and *Cryptochironomus* sp.) are indicative of eutrophic conditions. The authors stated that this information indicated that Sylvan Lake was highly productive and eutrophic.

Fish Kills

Sylvan Lake has experienced several fish kills over the last several decades. The occurrence of fish kills may indicate some form of anthropogenic disturbance or natural causes. One of the possible causes is a depletion of dissolved oxygen, which may be itself related to the development of algal blooms. These types of kills may be indicative of eutrophic conditions in a lake.

Summerkills of young perch have been recorded in the shallow bays of Sylvan Lake (Smith 1988 cited in Crosby 1990). Jones et al. (1976), who were conducting a study of Sylvan Lake in the summer of 1976, provided a conservative estimate that the kill in early August of 1976 consisted of “well over 100,000” young-of-the-year yellow perch (*Perca fluviatilis*). However, mortalities of adults of other species were also observed, including white sucker (*Catostomus commersoni*), northern pike (*Esox lucius*), and burbot (*Lota lota*). Fish had piled up on the northeast shore of the lake. The cause of the summer 1976 fish kill was not identified but Jones et al. (1976) speculated it may have been related to the occurrence of blue-green algal blooms that they observed several days later. Without any information on the timing and duration of the fish kill or whether large fish were affected before or after smaller fish, it is not possible to narrow down the potential cause of the kill. Typically, fish kills associated with toxic algal blooms affect small fish primarily, with larger fish affected with progression of the stressor, and the event is associated with an abundance of algae capable of producing toxins (Meyer and Barclay 1990). This scenario sounds most consistent with the conditions of the fish kill in 1976. Jones et al. (1976) also indicated that local residents had observed dead fish along the northeast shore in previous years, indicating that earlier fish kills may have occurred.

A.3 Water Balance

A water balance for Sylvan Lake was calculated to estimate the inflows (water entering the lake) and outflows (water leaving the lake) over a 45-year period (1956-2000). The model was not extended to 2003 due to the lack of published evaporation rates beyond 2000. The basic formula used to construct the water balance was:

Change in lake storage = Total inflows - total outflows.

Inflows included groundwater, surface water inflows, and direct precipitation to the lake and outflows included surface outflow and lake evaporation.

Elements of the water balance were then used in the derivation of a nutrient balance for the period of 1983-2000, as discussed in Section A.5.

A.3.1 Historical Water Levels

Sylvan Lake water elevations have been periodically measured since 1918 by Water Survey of Canada (Station 05CC003 Sylvan Lake) but regular measurements began in 1955. A surface water balance model was based on the period of 1956 to 2000.

The level of Sylvan Lake is relatively stable, varying monthly by only 1.01 m from 1956-2000 and by only 0.8 m between years (Figure A-80). The average lake elevation for the period of 1956-2000, 936.57 m ASL (metres above sea level), is slightly lower than the average for the period of 1983-2000 (936.68 m ASL). Lake levels were generally elevated above the average during the following time periods: 1956-1959; 1974-1977; 1990-2000. Between 1983 and 1987 peak water levels periodically surpassed 936.57 m but levels were also periodically below average. Lake levels were noticeably below average during the following time periods: 1962-1972 and 1978-1982. Maximum elevation between 1956 and 2000 was 937.1 m ASL which occurred in June 1992. The highest mean annual water elevation for the period of 1956-2000, 936.95 m ASL, occurred in 1992 and the minimum for that period, 936.10 m ASL, occurred in 1964.

A.3.2 Lake Bathymetry

Bathymetry is the measurement and charting of the depths of water bodies in order to determine underwater topography. A bathymetric map is generated from this information, which displays the topographic contours of the bottom of the water body. A bathymetric map was last produced for Sylvan Lake in 1961 (Mitchell and Prepas 1990); however, bathymetric technology has advanced considerably since then, resulting in better data resolution. Therefore, a new Sylvan Lake bathymetric map was produced by North/South Consultants Inc. from bathymetric data collected during the September 2004 survey (Figure A-81).

Sylvan Lake's basin characteristics are summarized in Table A-14; results of the bathymetric mapping undertaken in 2004 and 1961 are compared. Generally, the rectangular shaped basin gently slopes at its widths and has a steeper gradient from its longer shores (Figure A-81). Offshore, the lake bottom is generally flat with some deeper holes (>18 m deep) situated off the points of land in the middle of the basin. From the 2004 survey, the maximum depth of Sylvan Lake was 20.3 m deep and the mean depth was 9.9 m. At an elevation of 936.55 m ASL (metres above sea level), the littoral zone (the area of the lake that is less than 3.5 m deep) was 18% of the total lake area; comparable to the 1961 value of 20% (Mitchell and Prepas 1990).

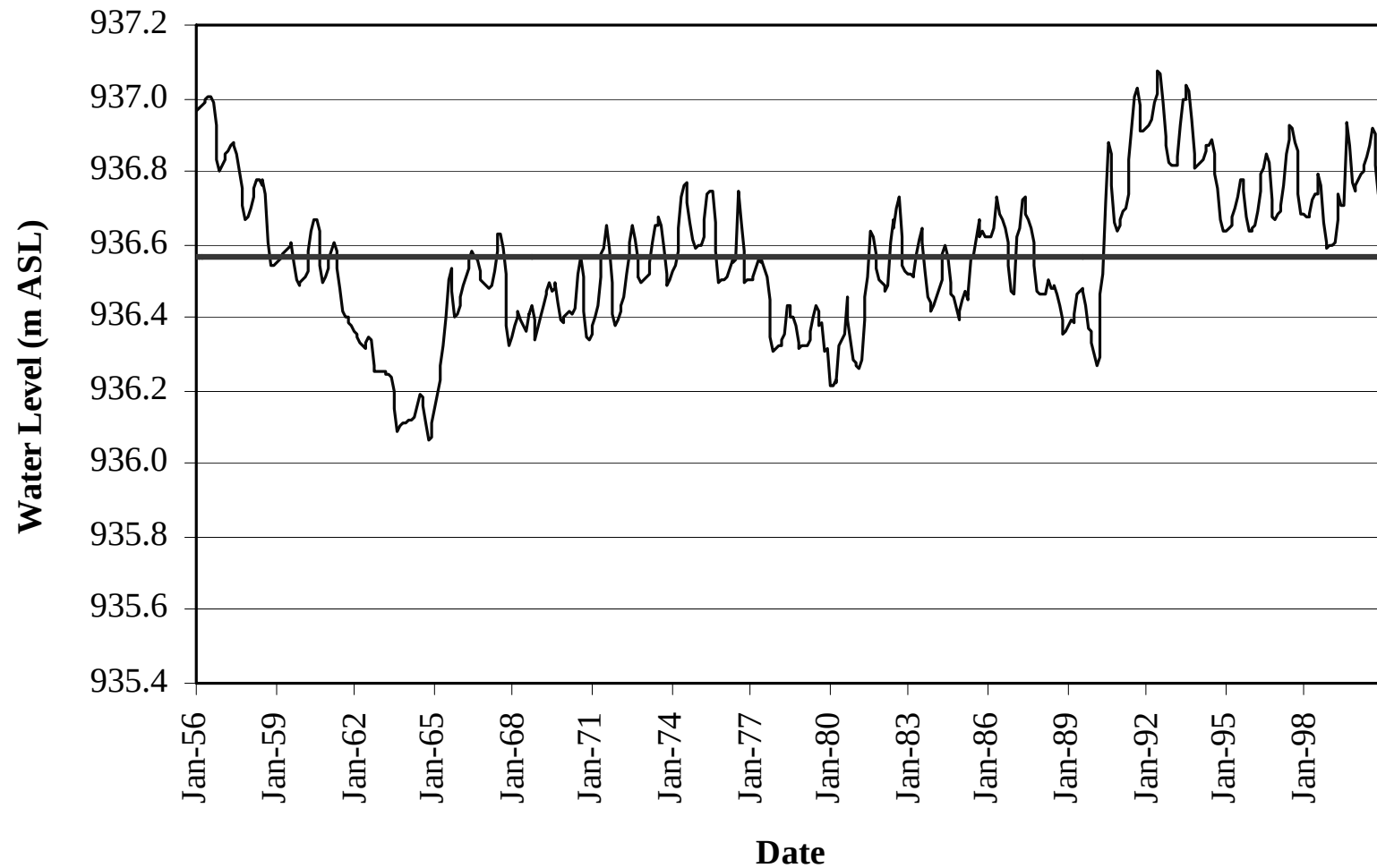


Figure A-80 Water level of Sylvan Lake from 1956 to 2000. Red line indicates mean. Data provided by AENV

Table A-14 Summary and Comparison of Sylvan Lake's Morphometric Characteristics, 2004 and 1961

Parameter	1961	2004	Difference
Lake Elevation (masl)	936.5	936.55	+0.05
Lake Area (km ²)	42.8	42.2	-0.6 (-1.4%)
Lake Volume (m ³)	412,000,000	420,080,983	+8,080,983 (2.0%)
Max. Depth (m)	18.3	20.3	+2.0
Mean Depth (m)	9.6	9.9	+0.3 (+3.5%)
Shoreline Length (km)	36.0	36.4	+0.4

Sylvan Lake morphometry does not vary considerably from year to year due to the relatively stable water levels. Mean lake area, volume, and depth for the period of 1956-2000 were generated from the bathymetric model constructed from the survey conducted in 2004 (Table A-15).

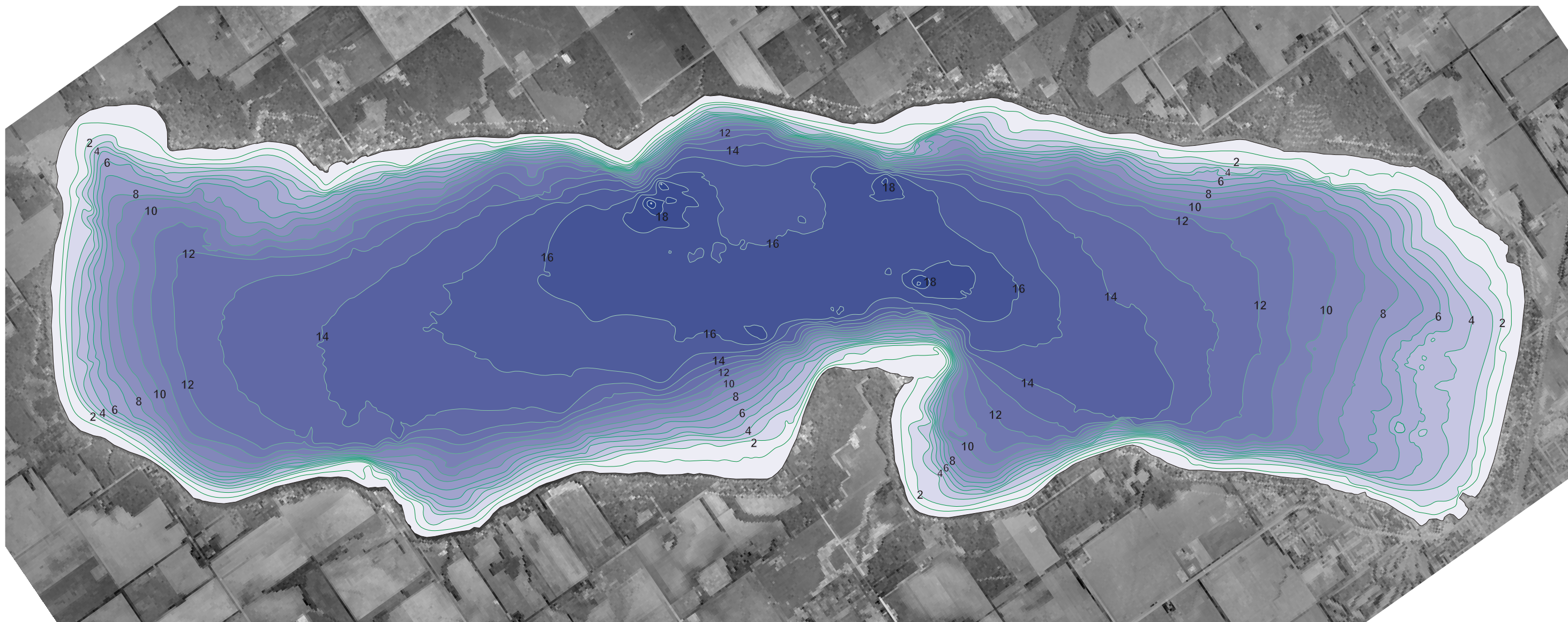
Table A-15 Lake Morphometrics for a 1956-2000 and 1983-2000 Averaging Periods

Years	Mean Lake Level (mASL)	Mean Lake Area (km ²)	Mean Lake Volume (m ³)	Maximum Lake Depth (m)	Mean Lake Depth (m)	Drainage Basin Area (km ²) ¹	Drainage Ratio
1956-2000	936.57	41.75	417,100,000	20.0 ²	10.0	109.25	2.6
1983-2000	936.68	42.01	421,700,000	20.1 ²	10.1	108.99	2.6

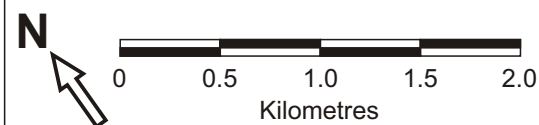
Notes: 1 Excluding the lake.
2 Maximum depth at that mean lake elevation.

A.3.3 Drainage Basin Area

A drainage basin area for Sylvan Lake was extracted from the Prairie Farm Rehabilitation Agency (PFRA) Incremental Gross Drainage Area database. The total drainage basin area is 151 km², including the lake (Figure A-82). The mean drainage area, excluding the lake, for the time frame of 1956-2000 is 109.25 km², based on an average lake area of 41.75 km² calculated from the bathymetric model (Section A.4.2).



Sylvan Lake Bathymetric Mapping:
 [based on lake surface elevation of 936.55 mASL]
 Surface Area = 42.19 km²
 Lake Volume = 420,080,983 m³
 Mean Depth = 9.9 m
 Maximum Depth = 20.3 m



Projection: UTM Zone 10
 Datum: NAD83
 Contour Intervals: 1.0 m

Produced: KK

Checked: CF

Date: Jan. 17, 2005

Figure A-81
 Bathymetric Map
 of Sylvan Lake

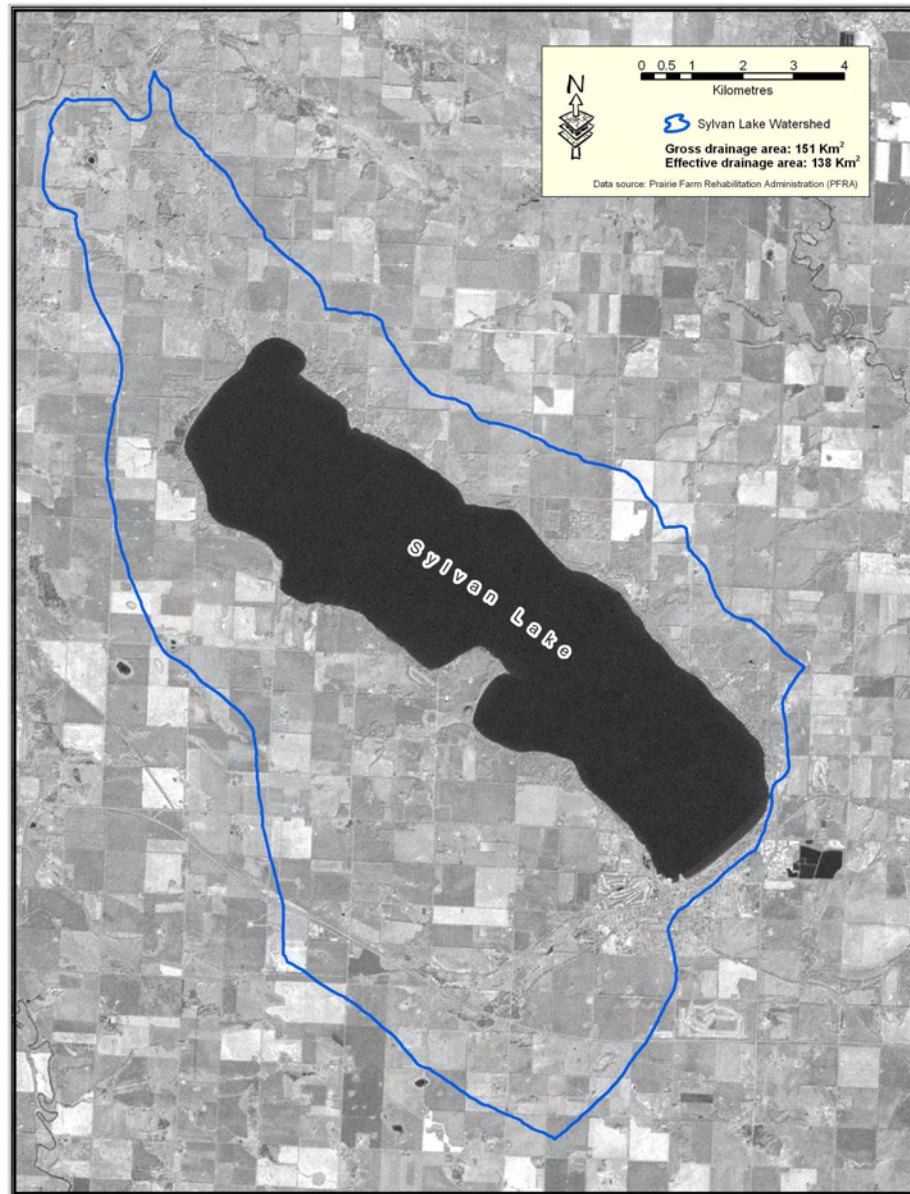


Figure A-82 Sylvan Lake Drainage Basin

Sylvan Lake is characterized by a low drainage ratio (i.e., the ratio of drainage area to lake area), averaging approximately 2.6 over a 45 year period (Table A-16). Nearby Gull Lake also shares a drainage ratio of 2.6 (Mitchell and LeClair 2003, Table A-16) whereas Pine Lake has a much higher ratio of 38.6 (Mitchell and Prepas 1990, Table A-16).

Table A-16 Comparison between physical properties of several Alberta lakes. Data for Sylvan Lake were derived from this study and refer to the average for the period of 1956-2000

Lake	Mean Lake Elevation (mASL)	Lake Area (km ²)	Lake Volume (million m ³)	Maximum Lake Depth (m)	Mean Depth (m)	Drainage Basin Area (km ²) ¹	Drainage Basin	Drainage Ratio	Source
Sylvan Lake	936.57	41.75	417.1	20 ²	10.0	109.25	Red Deer River	2.6	This study
Gull Lake	899.23	80.6	437	8.0	5.4	206	Red Deer River	2.6	Mitchell and LeClair (2003)
Pine Lake	889.34	3.89	20.6	12.2	5.3	150	Red Deer River	38.6	Mitchell and Prepas (1990)

Notes: 1 Excluding the lake.
2 Maximum depth at that mean lake elevation.

A.3.4 Groundwater Component

A.3.4.1 Natural Groundwater Inflow/Outflow

A numerical groundwater flow model of the Sylvan Lake groundwater basin was constructed to simulate groundwater flow within the basin and, specifically, to estimate the volume of groundwater inflow to Sylvan Lake. Detailed descriptions of the model and the modelling results are presented in Section B-3 of Appendix B. Without considering the effects of groundwater pumping from water wells, the modelling results indicate the groundwater inflow to Sylvan Lake is 12,498 m³/d. The model does not include natural lake water outflow into the subsurface because this outflow pathway has not been confirmed and the volume of any outflow could be negligible. The effect of groundwater pumping on the inflow rate is discussed in the next section.

A.3.4.2 Effect of Groundwater Use

To examine the effect of groundwater use on the inflow to Sylvan Lake, a groundwater use review was undertaken with the objective of identifying any groundwater use that would remove groundwater from the groundwater basin, thereby reducing the volume of groundwater available for discharge into Sylvan Lake. Groundwater use in the study area is discussed in Section B-2.2 of Appendix B. Information on groundwater use is provided in Alberta Environment's Groundwater Information System (GIS) database and in Alberta Environment's listing of licensed water wells.

In summary, the majority of the water wells within the Sylvan Lake groundwater basin are used for domestic and livestock-watering purposes. It is expected that essentially all

of this pumped groundwater remains in the groundwater basin through seepage back into the subsurface (e.g., septic fields, ground discharge of livestock effluent). On the other hand, almost all of the groundwater pumped from the Town of Sylvan Lake's water wells is removed from the groundwater basin through discharge into the surface water system. Specifically, most of the groundwater pumped from the Town's water wells is ultimately discharged into the Town's sewage system. Sewage is piped to the sewage lagoon located northeast of the Town and water in the lagoon is discharged into Cygnet Lake via the Outlet Channel.

The numerical groundwater flow model was used to estimate the effect of the Town's water wells on the groundwater inflow to Sylvan Lake. In the model, the quantity pumped from the Town's water wells was estimated at 1,061,730 m³/year (2,908 m³/d) using the 2003 water consumption volume (Table B-4 in Appendix B). This was incorporated into the model without returning the pumped groundwater back into the groundwater basin. The modelling results for this scenario indicate the groundwater inflow to Sylvan Lake is reduced from 12,498 m³/d to 9,727 m³/d. It is noted that this reduction of 2,771 m³/d represents only 3% of the total water inflow (34,200,000 m³/year) to the lake.

A.3.5 Surface Water Component

The water balance model for Sylvan Lake was prepared from information taken from a number of sources as listed below. The detailed water balance is provided in Appendix D.

A.3.5.1 Precipitation

The period of record for precipitation data available for Sylvan Lake was insufficient for input to the water balance. Thus an appropriate surrogate data set with a sufficient period of record was selected. Namely, precipitation data were obtained from the Atmospheric Environment Service (AES) meteorological monitoring station Red Deer (Red Deer A station) which had a period of record dating from 1940 to 2004. Monthly averages of total precipitation (mm) between January 1956 and December 2000 were used in the water balance (Figure A-83). The average total annual precipitation for the time period 1956-2000 was 477.1 mm, whereas the minimum and maximum annual precipitation estimates were 298.5 mm (1979) and 632.2 mm (1999), respectively. In general, more precipitation fell between 1980 and 2000 (annual average = 496.4 mm) compared with the preceding 25 years (1956-1980; annual average = 460.1 mm). Annual total volumes of precipitation which fell directly on to Sylvan Lake are presented in Figure A-84.

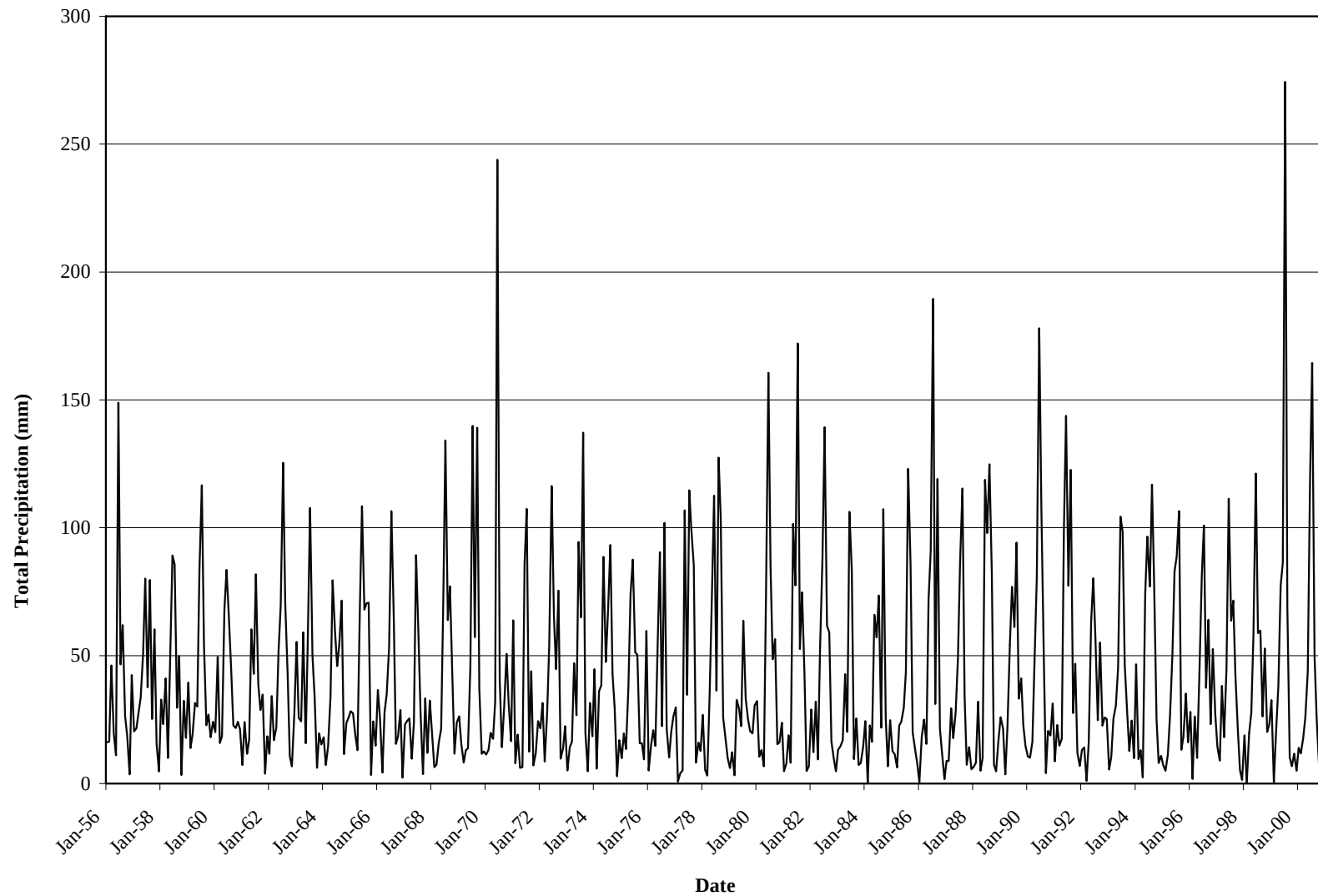


Figure A-83 **Precipitation at Red Deer, Alberta, 1956-2000**

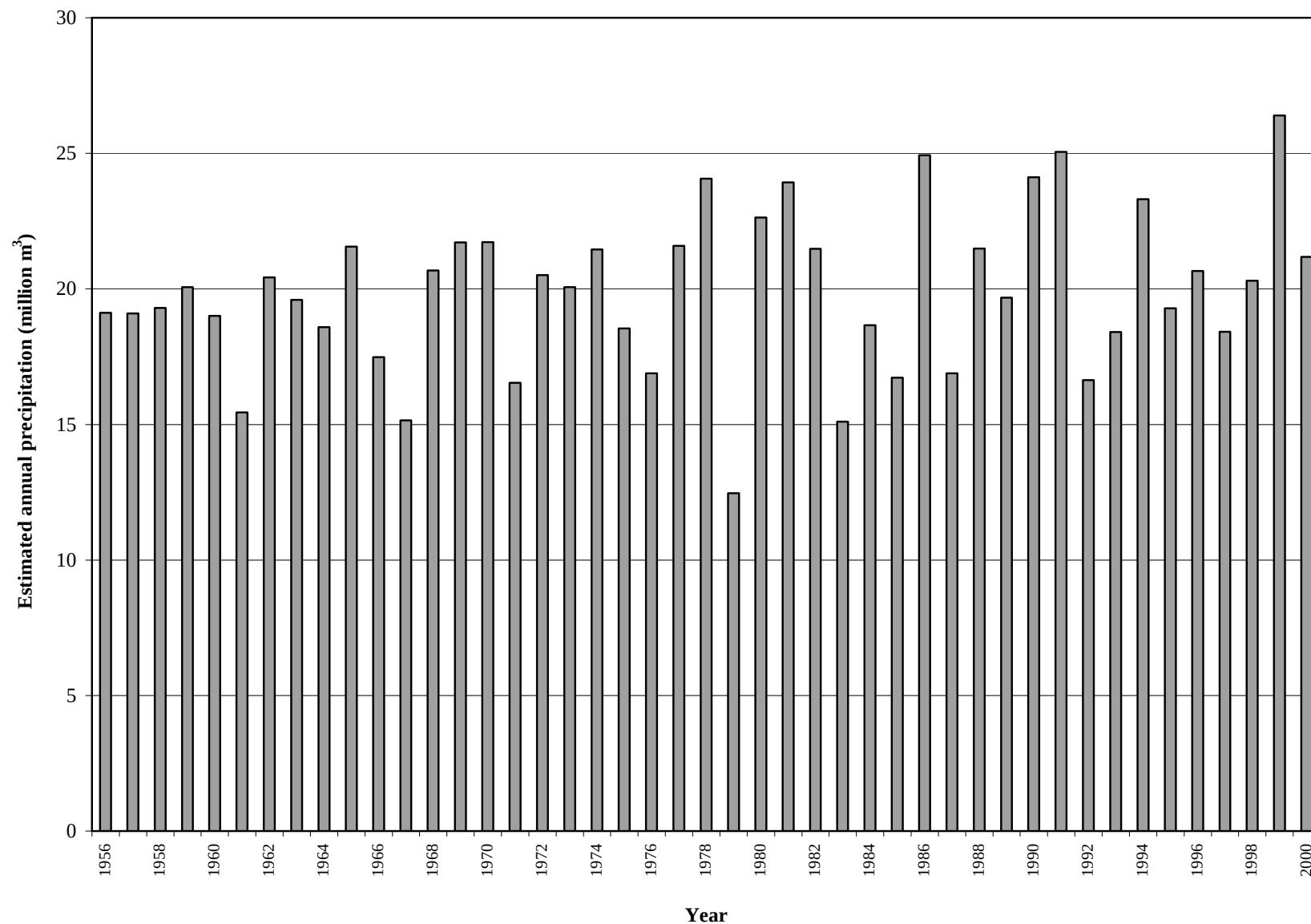


Figure A-84 Annual Total Precipitation on Sylvan Lake, 1956-2000

A.3.5.2 Evaporation

Evaporation has not been monitored at Sylvan Lake. Therefore, published monthly evaporation rates for Sylvan Lake for a 30-year period (1971-2000) were obtained from PFRA (2002). Mean annual total evaporation for 1956-2000 was 787.1 mm, amounting to approximately 32.9 million m³ (Table A-17). Mean annual evaporation volumes from 1956 to 2000 are presented in Figure A-85.

Table A-17 Mean Annual Inflows and Outflows for Sylvan Lake Water Balance: 1956-2000 and 1983-2000

	Averaging Period	
	1956-2000	1983-2000
	(million m ³)	
Inflows		
Total precipitation	19.9	20.4
Total surface inflows	10.8	10.8
Total groundwater inflows	3.5	3.4
Total	34.2	34.6
Outflows		
Total evaporation	32.9	31.2
Total lake surface outflow	1.6	2.9
Total lake groundwater outflow ¹	0	0
Total	34.5	34.2

Note: 1 Based on groundwater assessment.

A.3.5.3 Outflows

Discharge from the Sylvan Lake outflow is not regularly measured. Therefore, a stage-discharge rating curve for the outflow channel was constructed using lake level and the available discharge data (Figure A-86). Specifically, the outflow rating curve was prepared from recorded flows at AENV Station 05CC912 (Sylvan Lake Outflow at Highway 20), for the period from 1993 to 1995, inclusive. It should be noted that although a high degree of confidence is associated with the lake level data, recorded flow data from the outlet channel are limited and additional flow data would greatly facilitate the validation of this model.

The rating curve indicated that outflow from Sylvan Lake occurs at lake levels above elevation 936.66 m. Based on this calculation the channel would have had significant discharge for the periods of 1956 to 1958 and 1990 to 2000 (Figure A-87). This model also predicts that discharge occurred in 1974-1976, 1982, and 1985-1987. Discharge from the outflow has been observed every year from 1996-2002 but no water has been observed to flow out of the lake in 2003 and 2004 (Teichreb 2004, pers. comm.).

The groundwater outflow from Sylvan Lake could not be accurately calculated but was anticipated to be very low (Section A.4.4). For the purposes of the water balance, groundwater outflow was assumed to be zero.

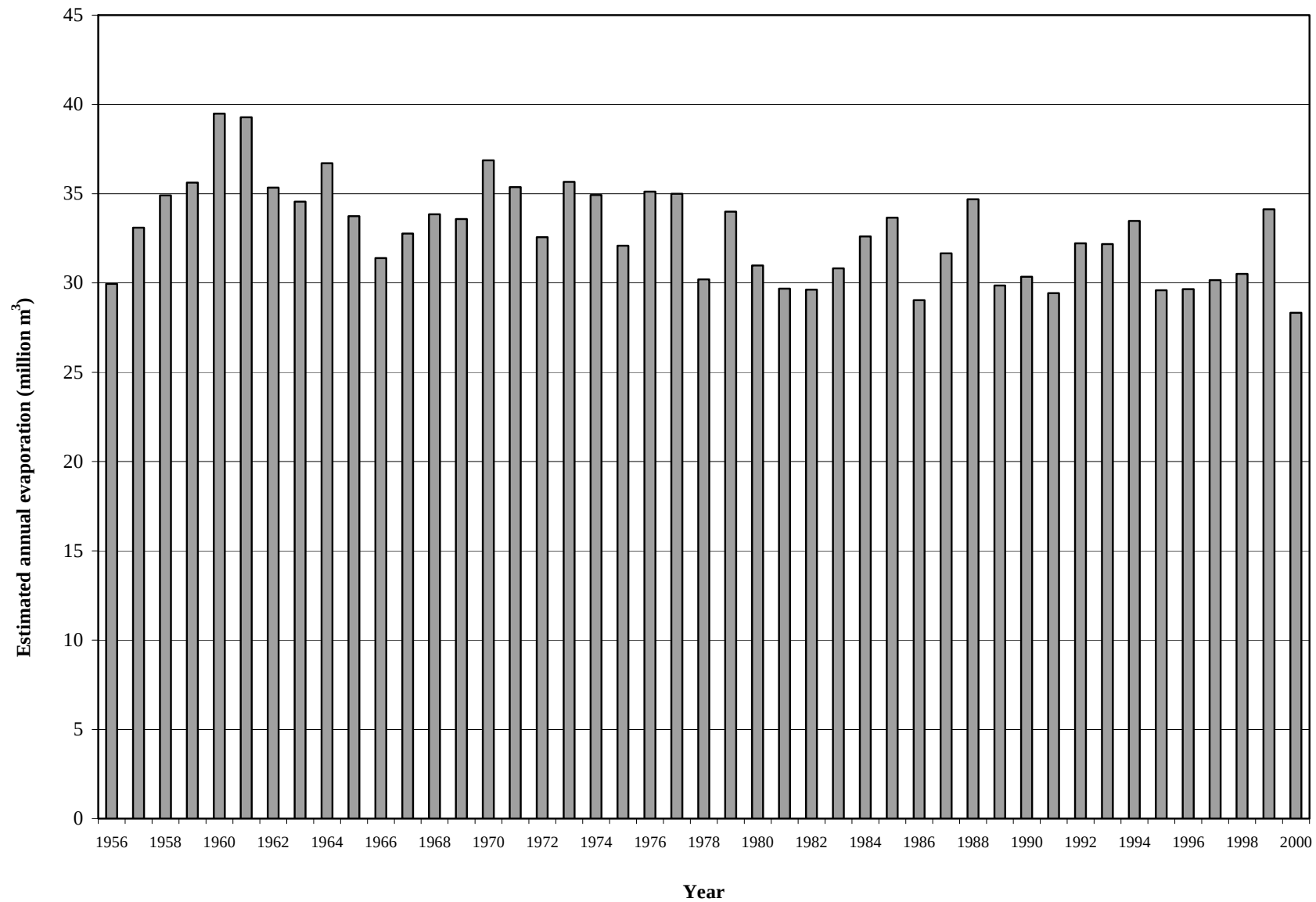


Figure A-85 Annual total evaporation from Sylvan Lake, 1956-2000

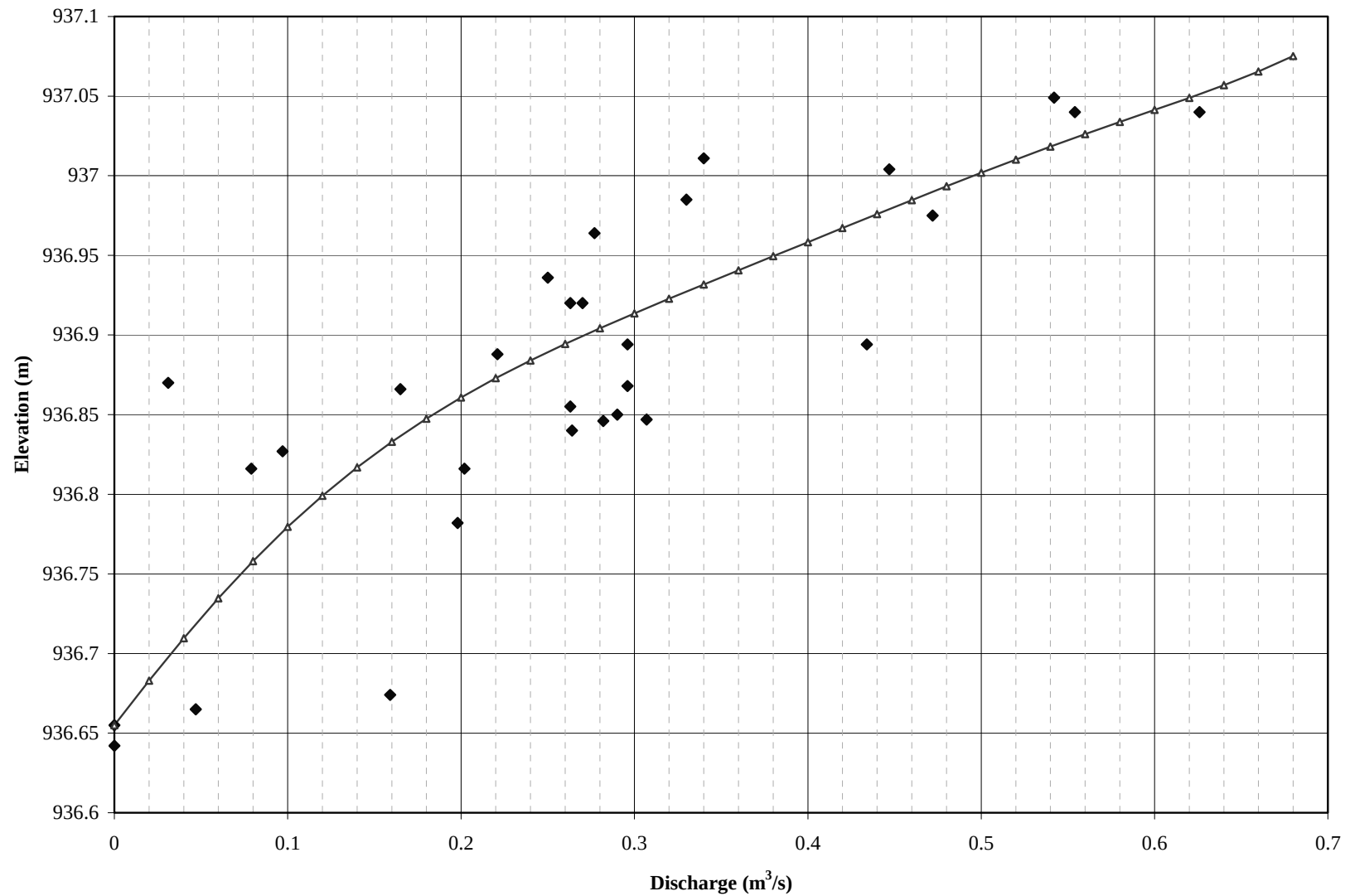


Figure A-86 Stage Discharge Rating Curve for the Sylvan Lake Outlet

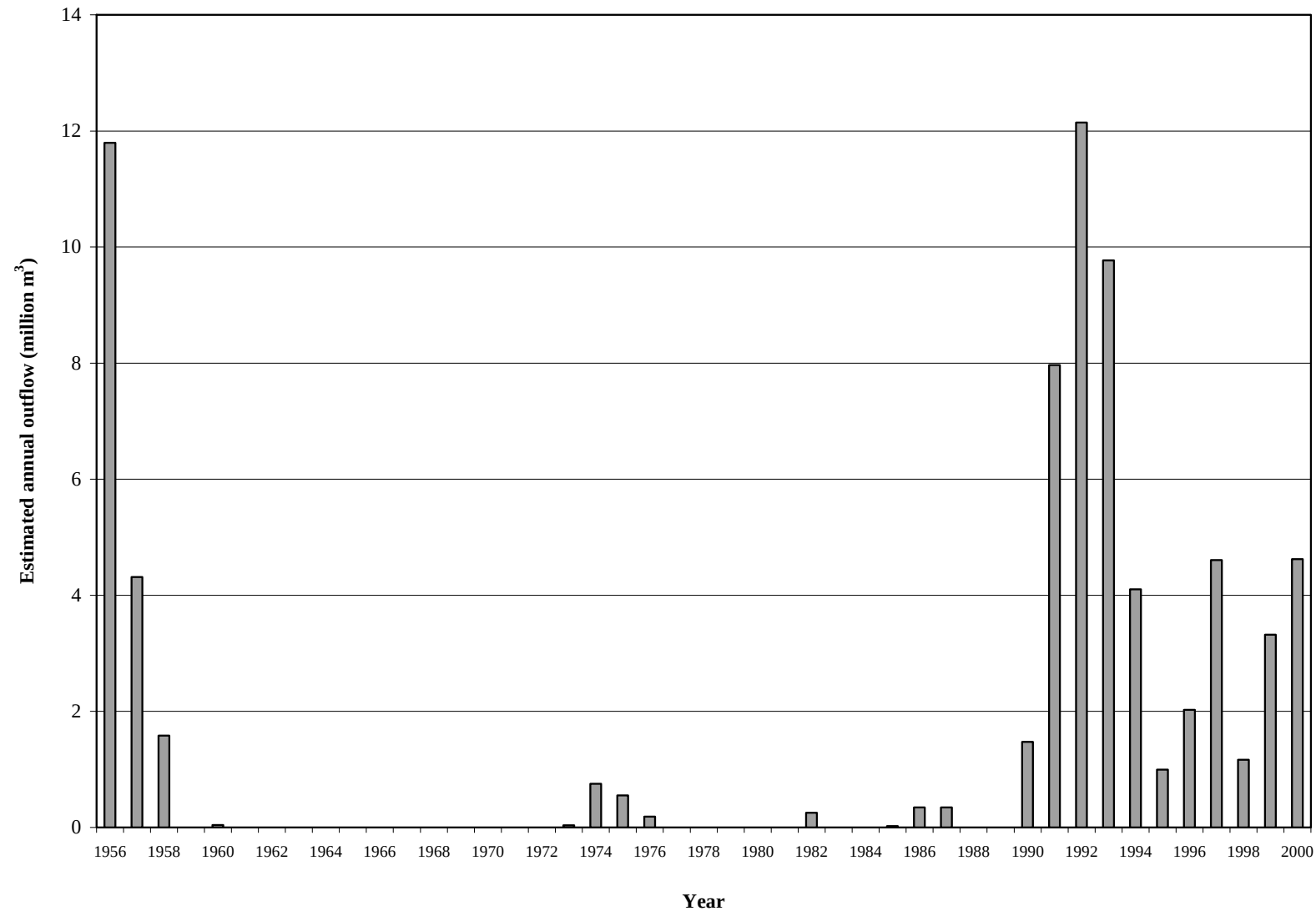


Figure A-87 Annual Total Surface Outflow from Sylvan Lake, 1956-2000

A.3.5.4 Surface Runoff

Discharge of the ephemeral tributary streams to Sylvan Lake has only been measured periodically in 2001 and 2003 and data are not sufficient to characterize the surface inflows to the lake. Given this data gap, the water balance was initially constructed using estimates of surface inflows based on runoff coefficients derived for a nearby surrogate stream, Lloyd Creek (Station 05CC009). Lloyd Creek was also used as a representative stream for derivation of surface inflow estimates for a water balance for Gull Lake (Mitchell and LeClair 2003). Monthly surface inflow was calculated using precipitation data from Red Deer A station, surface runoff coefficients for Lloyd Creek Station 05CC009, and the average area of the Sylvan Lake drainage basin as described above. Using these data, the long term mean monthly groundwater infiltration was computed as 19,000 m³/day. These initial estimates of groundwater inflow (i.e., 19,000 m³/day) were considerably higher than those derived from the detailed groundwater study (see Section A.4.4). Subsequently, the water balance was adjusted such that the estimate of groundwater inflow generated in the groundwater study (9,727 m³/day) was input to the model and the model was solved for surface inflows. This involved increasing the surface inflow estimates in accordance with the specified groundwater inflow rate of 9,727 m³/day. Final total annual surface inflow estimates averaged 10.8 million m³/year for the period of 1956-2000 and the period of 1983-2000 (Table A-17). Estimated total annual inflows varied (Figure A-88).

A.3.5.5 Water Balance

The water balance was based on the continuity equation in which Inflow minus Outflow equals the Change in Storage (Table A-17). Inflow to the lake consisted of monthly precipitation, runoff from the contributing area and groundwater inflow. Monthly outflow consisted of monthly evaporation and outflow (surface only). Change in storage was determined from computed lake levels and the Sylvan Lake storage capacity based on a lake surface area of 41.75 km². A summary of the water balance for the period of 1956-2000 and 1983-2000 are provided in Table A-17.

For the long-term period (i.e., 1956-2000), the calculated mean annual surface inflow was approximately 10.8 million m³, while the estimated mean annual precipitation was 19.9 million m³. Thus the total mean annual surface inflow to the lake was estimated to be 30.7 million m³. The estimated mean annual groundwater inflow to the lake was 3.5 million m³, resulting a total mean annual inflow to Sylvan Lake of 34.2 million m³.

The mean annual loss of water to evaporation in Sylvan Lake was estimated to be approximately 32.9 million m³, while the estimated mean annual surface outflow was 1.6 million m³. As the groundwater outflow was assumed to be zero, the total mean annual outflow to Sylvan Lake was calculated to be 34.5 million m³. Based on this water balance, the water residence time in Sylvan Lake for the time period 1956-2000 was calculated to be >200 years. However, because surface outflow from Sylvan Lake has occurred only periodically since 1956 but has been more substantive in recent years, a much shorter water residence time has occurred over the last decade. For example, the water residence time for Sylvan Lake for the period of 1990-2000, when discharge from the outlet channel has occurred almost continuously in the open-water season, the calculated water residence time is only approximately 90 years. Regardless of the precise value, Sylvan Lake is not rapidly flushed. A comparison of water balances for Sylvan, Gull, and Pine lakes is provided in Table A-18.

Table A-18 Comparison between water balances and trophic status of several Alberta lakes. Data for the Sylvan Lake water balance were derived from this study and refer to the average for the period of 1956-2000. Water quality data for Sylvan Lake were provided by AENV and refer to the averaging period of 1983-2003 (May–September)

Lake	Lake Area (km ²)	Drainage Basin Area (km ²) ¹	Mean Annual Precipitation on Lake (million m ³)	Mean Annual Inflow (million m ³)	Mean Annual Evaporation (million m ³)	Residence Time (years)	Trophic Status	TP (mg/L)	TKN/TN (mg/L)	Secchi Depth (m)	Chlorophyll a (µg/L)	Source
Sylvan Lake	41.75	109.25	20.4	34.2	32.9	>100	Mesotrophic	0.021	0.69	4.8	4.6	This study and AENV
Gull Lake	80.6	206	37.2	19.7 ²	51.6	>100	Mesotrophic-eutrophic	0.0451	1.55	2.5	8.4	Mitchell and LeClair (2003)
Pine Lake	3.89	150	2.0	2.77	2.5	9	Eutrophic	0.072	1.63	2.8	18.7	Mitchell and Prepas (1990)

Notes: 1 Excluding lake area.
2 Including 5.4 million m³ from diversion inflow.

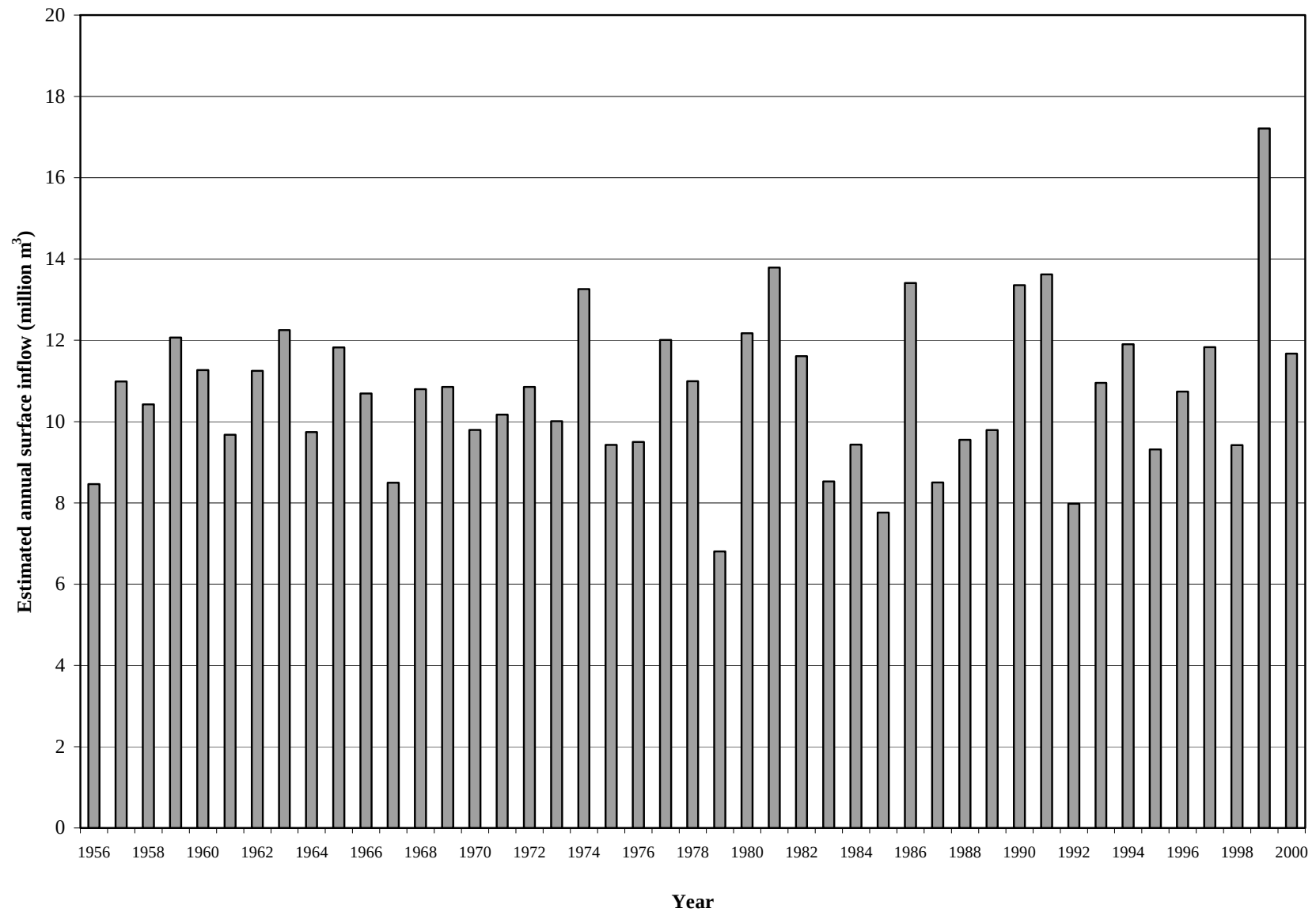


Figure A-88 Annual total surface water inflow to Sylvan Lake, 1956-2000

A.4 Sylvan Lake Nutrient Balance

Phosphorus and nitrogen levels and consequently the trophic status of Sylvan Lake is dependent upon the balance between external and internal nutrient inputs into the lake, and nutrient outputs (export) out of the lake. Inputs into the lake, defined as phosphorus and nitrogen loads, are derived from surface inflow, septic fields, groundwater inflow, atmospheric deposition, and internal loading from phosphorus enriched sediments. Phosphorus and nitrogen are potentially exported from the lake via surface outflow and groundwater outflow. The levels of phosphorus and nitrogen retained by the lake are calculated by subtracting the total nutrient loads exported from the lake (outputs), from the sum of the nutrient inputs into the lake and any internal loading from the sediments. The resultant nutrient loading represents the nutrient load retained in the lake (i.e., nutrient retention).

Because the majority of water quality monitoring activities in Sylvan Lake began in 1983, the nutrient balance was constructed for the period of 1983-2000 (further extension of the balance beyond 2000 was not possible owing to gaps in the data required for the water balance). Due to the uncertainties and gaps in the data required to construct a nutrient balance, a more detailed analysis (e.g., year by year nutrient budget) could not be undertaken. A discussion of data gaps and uncertainties is presented in Section A.6.

A.4.1 Nutrient Inputs: Sources and Loading Rates to Sylvan Lake

A.4.1.1 Surface Inflows

Inflows from Tributaries

Watersheds are usually major sources of nutrients, which are generally transported to the corresponding waterbody via surface inflow. Surface nutrient input to Sylvan Lake was calculated in two different ways. The first approach involved the estimation of nutrient loading using available discharge and nutrient concentrations measured by AENV in the six ephemeral tributaries draining to Sylvan Lake, in conjunction with estimates of surface inflow volumes generated from the water balance (see Section A.4.5). The second approach involved the estimation of non-point source nutrient run off into the lake, based on the areas of different land use types and estimates of nutrient export coefficients. Consequently, two variations on the nutrient balance were constructed: one incorporated surface nutrient input calculated from the tributary data; and the second incorporated surface nutrient input calculated according to watershed land use type.

Diffuse Run Off from the Drainage Area

To estimate nutrient loading from tributaries, flow-weighted mean concentrations (FWMC) were calculated from measured discharge and analytical data from six ephemeral streams flowing into Sylvan Lake. Samples were collected sporadically between 2001 and 2004. For each sampling date, the concentration of total phosphorus and total nitrogen were multiplied by the discharge on that date, producing an instantaneous load. All of the loads for the tributaries were added together, and divided by all of the flows. This resulted in a FWMC for TP and TN. This was multiplied by the average 1983-2000 watershed inflow from the water balance (Table A-19).

Table A-19 Estimated Annual TP and TN Loading to and out of Sylvan Lake Associated with Surface Inflow, Groundwater Inflow, and Lake Outflow

Component	Inflow/outflow volume (million m ³ /year)	Nutrient Concentrations (mg/L)		Loads (kg/year)	
		TP	TN	TP	TN
Surface inflows	10.8	0.606	2.73	6,564	29,572
Surface outflows	2.9	0.021	0.658	61.7	1,934
Deeper groundwater inflow	3.4	0.278	1.624	946	5,523
Septic Fields	0.14	3.39	7.51	483	1,069

Although the number of samples collected during this period was adequate (about 75), many of these did not have associated discharge data. Therefore, only about a third of these could be used to calculate the FWMC. Discharge data were not available for any of the March samples, yet concentrations on these dates were high. All of these factors contributed to uncertainty in estimating nutrient loading from the watershed.

Land Use Types and Nutrient Export Coefficients

Land within the watershed was separated into four different categories based on the underlying land use:

- agricultural land and pasture
- forest and shrub vegetation
- wetland vegetation
- developed land

Lands were classified using a composite of data obtained from Lacombe County and Red Deer County in 2004, and from the classification scheme presented in the Sylvan Lake Public Access Study (ISL 2002). Table A-20 provides a summary, by area, of different land use types within the watershed.

Table A-20 Extent of Land Use Types within Sylvan Lake Watershed

Land Use Type	Area (hectares)
Agricultural Land & Pasture	7,979.89
Forest & Shrub Vegetation	1,594.04
Wetland Vegetation, Stream	301.99
Developed Land	970.58
Total	10,846.5

The annual loading of phosphorus and nitrogen transported into the lake via surface run off from the various land use types in the watershed was estimated by applying associated nutrient export coefficients to various land use types within the watershed (Table A-21). Nutrient export coefficients are loading rates of nutrients, expressed as kg of TN or TP/km²/year, associated with a particular land use type that are transported to a

waterbody. The phosphorus and nitrogen coefficients applied in the present study were calculated based on coefficients previously applied to other Alberta Lakes (Trew et al. 1978; Rast and. Lee 1978; Reckow et al. 1980; Mitchell 1985).

Table A-21 Estimates of Annual TP and TN Loading to Sylvan Lake Based on Land Use Export Coefficients

Land Use Type	Land Area (km ²)	Export Coefficients		Estimated Annual Nutrient Loading	
		TP (kg/km ² /yr)	TN (kg/km ² /yr)	TP (kg/yr)	TN (kg/yr)
Agricultural Land & Pasture	79.80	25	130	1,995	10,374
Campground	1.84	100	500	184	922
Golf Course	0.44	100	500	44	221
Road Allowance	1.65	100	500	165	827
Developed Land	5.77	100	500	577	2,884
Streams	0.38	0	0	0	0
Wetland Vegetation	2.64	0	0	0	0
Forest & Shrub Vegetation	15.94	10	70	159	1,116
Sylvan Lake	42.23	0	0	0	0
Total	150.70	-	-	3,125	16,343

The nutrient export coefficients were the highest for developed land and lowest for wetland vegetation. This reflects the greater nutrient export typically associated with developed land compared to the greater nutrient retention capability associated with wetland habitats. Developed land use coefficients were substantially higher than the three other land use types. Agricultural/pasture and forested/shrubland export coefficients were intermediate between wetland and developed land export coefficients. Although agricultural/pasture land export coefficients were lower than those assigned to developed land; they were greater than those associated with forested land. Forested/shrub habitats have a greater capacity to retain nutrients compared with agricultural land, but a reduced capacity compared with wetland habitat.

A.4.1.2 Septic Effluent Inflows

Estimated Volume of Inflow

The volume of septic effluent entering the lake annually was estimated by multiplying the number of septic fields by the average daily water use per residence. Septic holding tanks were not factored into the calculations, as the effluent is not released to the lake. In order to be conservative, lots with unknown septic systems were considered to be septic fields for the purpose of estimating effluent discharge. Information on the number and types of septic systems was available for the Summer Villages of Birchcliff, Norglenwold, Sunbreaker Cove, and Halfmoon Bay, however records were not available for subdivisions outside of the Summer Villages or Town. The Summer Village of Jarvis Bay is connected to the Town of Sylvan Lake's Sewage System which removes all effluent from the Sylvan Lake Watershed. A summary of the septic effluent contribution to the lake from the summer villages is presented in Table A-22.

Table A-22 Estimated Annual Septic Effluent Volume Discharged to Sylvan Lake by the Summer Villages

Summer Village	Birchcliff ¹	Halfmoon Bay ²	Sunbreaker Cove ²	Norglenwold ³	All Villages
Total Lots Generating Sewage	223	62	229	150	664
Percentage of Lots with Permanent Residences ⁴	11.8%	14.9%	10.7%	44.5%	-
Percentage of Lots with Seasonal Residences ⁴	88.2%	85.1%	89.3%	55.5%	-
-Total Holding Tanks	109	15	36	26	186
-Total Septic Fields ⁵	92	28	47	77	244
- Permanent Residences	11	4	5	34	54
- Seasonal Residences	81	24	42	43	190
-Total Unknown Systems ⁶	22	19	146	47	234
- Permanent Residences	3	3	16	21	42
- Seasonal Residences	19	16	130	26	192
Annual effluent production from permanent residence septic fields (m ³ /year) ⁷	9,918	5,163	15,226	40,684	70,992
Annual effluent production from seasonal residence septic fields (m ³ /year) ⁷	18,280	7,271	31,333	12,511	69,396
Annual effluent production from all septic fields (m³/year)	28,198	12,435	46,559	53,196	140,387

- Notes:**
- 1 The total number of lots for Birchcliff includes 97 camp cottages with 91 using holding tanks and 6 with unknown systems.
 - 2 A municipal reserve strip is present between the lots and shoreline.
 - 3 There are a total of 220 Lots in the Summer Village of Norglenwold, but 30 of those are connected to the Town of Sylvan Lake sewage system and 10 vacant lots are eligible to be tied in to the Town's sewage system. The Summer Village is planning to connect the entire municipality to the Town's Municipal Sewage System by 2006.
 - 4 Percentage of permanent residences is based on the proportion of lots occupied by permanent residents, assuming an average of four people per household. Permanent population numbers are based on 2001 Alberta Census data.
 - 5 Pit toilets and cesspools are included in the total for Septic Fields.
 - 6 In order to be conservative, unknown systems are considered to be Septic Fields for the purpose of estimating effluent discharge.
 - 7 Prior studies assume each house/cottage has 3 bedrooms, each producing 0.675 m³/day of water, and that all of that water is disposed of in the septic field (Alberta Labour 1990). Permanent residences are assumed to be in use 12 months (365 days) per year. Seasonal residences are assumed to be in use 3 months (90 days) per year.

Source: Reiter 2004, pers. comm.

Information on sewage handling was also obtained from Camp Woods (Scouts Canada), which uses holding tanks (Stade 2004, pers. comm.), as well as for the Baha'I Camp and Camp Kum-in-Yar, both of which use septic fields (Anderson 2004, pers. comm.; Gold 2004, pers. comm.).

- The Baha'I Camp is in use seven days per week in summer (approximately 90 days) and one or two weekends per month in winter (approximately 32 days). With approximately 40 to 50 people per visit, septic effluent production is 1,708 m³ annually (50 people x 0.28 m³/day x 122 days).
- Camp Kum-in-Yar is in use by 60 people, including staff, for three weeks during the summer (21 days) with, plus some weekends. This results in an annual septic effluent production of approximately 353 m³ (60 people x 0.28 m³/day x 21 days).
- Total annual septic effluent production from the two camps is 2,060 m³.

The estimated annual septic effluent inflow to the lake, including summer villages and camps, is 142,447 m³. This is about 0.4% of the total water inflow to the lake of approximately 34,200,000 m³/year.

Nutrient Concentrations

A field program involving the installation, testing and sampling of eight shallow groundwater monitoring wells was undertaken during the study. The objective of installing these wells was to determine nutrient concentrations in the shallow groundwater adjacent to the Sylvan Lake shoreline, downslope from existing septic fields. The chemical quality data obtained were used to estimate the nutrient loading to the lake from septic field effluent. Complete details of the field program are provided in Section B-2.3.2 of Appendix B.

In summary, a reconnaissance of the Summer Villages of Half Moon Bay, Norglenwold, Birchcliff and Sunbreaker Cove was undertaken on September 4, 2004 to select sites for the monitoring wells. A representative from each summer village participated in the reconnaissance. The reconnaissance was completed using maps showing the known locations of septic fields. In consideration of access limitations, access restrictions (the wells could be installed only on village property) and proximity to known septic fields, eight sites were selected. Three sites are located in Half Moon Bay, two sites in Norglenwold and three sites in Sunbreaker Cove. The locations of these sites are shown on Figure A-1. The groundwater monitoring wells were drilled on October 6 and 7, 2004, and groundwater samples were collected the following week (October 12 and 13).

The laboratory results for the samples collected from the wells are presented in Table B-10 in Appendix B. The nutrient concentrations are summarized as follows:

- Total Phosphorus (TP) ranged from 0.784 to 12.7 mg/L;
- Ammonia-N ranged from 0.053 to 0.498 mg/L;
- Total Kjeldahl Nitrogen (TKN) ranged from 0.95 to 11.1 mg/L;
- Nitrite-N was detected in only four of the samples; the detected concentrations ranged from 0.12 to 0.28 mg/L; and
- Nitrate-N was not detected in two samples (detection limit of 0.1 mg/L); the detected concentrations ranged from 0.2 to 9.6 mg/L.

E. coli was not detected in seven of the samples; the one detection was 2 CFU/100 ml. Fecal coliforms were not detected in six of the samples; the two detections were 3 CFU/100 ml and >200 CFU/100 ml.

For comparison purposes only, the only nutrient for which a guideline concentration has been established in the Canadian Drinking Water Quality Guidelines is Nitrate-N. The maximum acceptable concentration (MAC) for Nitrate-N in the Guidelines is 10 mg/L and, therefore, all of the concentrations detected in the samples were less than this MAC.

The concentrations of TP, Ammonia-N and TKN vary by a factor of about 10, and the concentrations of Nitrate-N vary by a factor of about 100. There are a number of reasons for these ranges in concentrations such as the distance from each well to the nearest septic field, the number of septic fields upslope from the wells, the number of people served by the upslope septic field(s), and the age and efficiency of the upslope septic systems. With all of the concentration data taken as one data set, the data set is considered to be representative of nearshore groundwater quality for the summer villages with septic fields.

Estimated Nutrient Loading to Sylvan Lake

Estimates of annual loads of TN and TP associated with septic field inputs to Sylvan Lake were derived using the estimated annual discharge volume for septic fields of 142,447 m³/year and the mean concentrations of TN and TP measured in the samples from the eight shallow groundwater monitoring wells (Table A-23). Concentrations in the samples ranged from 0.784 mg/L to 12.7 mg/L for TP and from 1.00 mg/L to 14.1 mg/L for TN.

A.4.1.3 Groundwater Inflow

Estimated Volume of Groundwater Inflow

The groundwater flow model was used to estimate the volume of groundwater inflow to Sylvan Lake. The modelling results are summarized in Sections A.3.4 and A.3.5. Based on the modelling results, the estimated volume of groundwater inflow is 9,727 m³/d (3.5 million m³/year). In consideration of the annual septic effluent volume (approximately 0.1 million m³/year), the net groundwater inflow volume not affected by septic effluent is approximately 3.4 million m³/year.

Nutrient Concentrations

A field program involving the collection of groundwater samples from seven observation wells installed by Alberta Environment in 1990 and 1992 was conducted as part of the study. The chemical quality data obtained were used to estimate the nutrient loading to the lake from groundwater not affected by septic effluent. Technical information for the observation wells and the details of the field program are provided in Section B-2.3.1 of Appendix B.

Table A-23 Annual Nutrient Balance for Sylvan Lake Using Flow-weighted Mean Concentrations (FWMC) of TP and TN for Surface Inflows and Using Land Use TN and TP Export Coefficients for Estimating Surface Inputs

	Nutrient Balance: FWMC		Nutrient Balance: Export coefficients	
	TP (kg/year)	TN (kg/year)	TP (kg/year)	TN (kg/year)
Inputs				
Surface water	6,564	29,572	3,125	16,343
Deeper groundwater	946	5,523	946	5,523
Atmospheric	835	17,702	835	17,702
Septic fields	483	1,069	483	1,069
Total	8,828	53,867	5,388	40,637
Outputs				
Surface water	62	1,934	62	1,934
Groundwater	0	0	0	0
Total	62	1,934	62	1,934
Nutrient retention in the lake	8,766	51,932	5326	38703
Nutrient retention as a percentage of inputs	99.3%	96.4%	98.9%	95.2%

The observation wells are located at seven “nest” sites within the watershed. The locations of the nest sites and the designation of the one well at each nest site from which a groundwater sample was collected are shown on Figure A-1. Well 1-2 is located near the natural area at the northwest end of the lake, Well 2-1 is located in a reserve area within the Summer Village of Birchcliff, Well 3-3 is located north of the Summer Village of Jarvis Bay, Well 4-1 is located immediately north of the Summer Village of Sunbreaker Cove, Well 5-2 is located northwest of the Summer Village of Birchcliff, Well 6-1 is located southwest of the Summer Village of Half Moon Bay and Well 7-1 is located south of the west end of the Summer Village of Norglenwold. Samples were collected from the seven wells (specifically the shallowest well at each nest site that contained sufficient water for sampling) on September 30, 2004. One well was re-sampled on October 21, 2004. The depths of the sampled wells range from 6.4 m to 40.52 m.

The laboratory results for the samples are presented in Table B-8 in Appendix B. The nutrient concentrations are summarized as follows:

- Total Phosphorus (TP) ranged from 0.075 to 0.55 mg/L;
- Ammonia-N ranged from non-detect (less than 0.005 mg/L) to 0.315 mg/L;
- Total Kjeldahl Nitrogen (TKN) ranged from 0.20 to 1.59 mg/L;
- Nitrite-N was detected in only three of the samples; the detected concentrations were 0.002, 0.004 and 0.59 mg/L; and
- Nitrate-N ranged from non-detect to 3.93 mg/L.

The highest concentration of Nitrate-N (3.93 mg/L) was less than the MAC of 10 mg/L as specified in the Canadian Drinking Water Quality Guidelines.

The seven wells are either surrounded by land used for agriculture (crops) or downslope from land used for crop production. Therefore, the higher concentrations of some of the nutrients for some of the wells may indicate impact from fertilizers. For nitrate, however, PFRA (1997) notes that it can be hard to differentiate between natural background levels and possible agricultural contributions.

Overall, the concentrations are low which is not unexpected in view the land use is crop production. Concentrations are higher in areas where the land use includes high-density feedlot operations and intensively irrigated soils receiving manure. As noted in Agriculture and Agri-Food Canada (1997), nitrate used in agriculture is present in nearly all groundwater underlying the principal agricultural regions of Canada, but levels are usually below the safe limit (i.e., 10 mg/L). The prairie region is generally considered to be at lower risk due to the drier climate, the low intensity of agriculture, soil characteristics (i.e., clay till) and lower use of fertilizers. PFRA (1997) concluded that although water contamination from agri-chemicals occurs to some degree in the prairies, there is no clear evidence of widespread contamination of surface water and groundwater from non-point source agricultural activities.

Estimated Nutrient Loading

Estimates of annual loads of TN and TP associated with groundwater inflow to Sylvan Lake were derived using the estimated annual discharge volume of approximately 3.4 million m³/year and the mean concentrations of TN and TP measured in the samples from the seven Alberta Environment observation wells (Table A-23). Concentrations

ranged from 0.075 mg/L to 0.55 mg/L for TP and from 0.997 mg/l to 5.57 mg/L for TN. It should be noted that the reduction of the groundwater inflow associated with the Town of Sylvan Lake's water wells (2,771 m³/d) results in an estimated reduction of nutrient loading to the lake of 281 kg/year and 1,643 kg/year of TP and TN, respectively.

A.4.1.4 Internal Loading

Internal loading refers to the release of nutrients (typically phosphorus) from the sediment to the overlying water under particular physiochemical and biological conditions at the sediment-water interface. These conditions may include: phosphorus saturated sediments; low DO conditions, elevated temperatures, reducing conditions, turbulence, biological activities of sediment biota, and iron availability. Unlike the various forms of external loading to the lake, which are more readily manageable, internal phosphorus loading is not as easily managed. Mitigation to reduce internal loading can be undertaken, as has been done recently for Pine Lake for example, but is more challenging. Remediation methods can include withdrawal of hypolimnetic water (e.g., Pine Lake, AB, Sosiak 2002) or lake aeration (e.g., Amisk Lake, AB, Prepas 1997).

Unfortunately, the type of water quality data required to estimate net internal loading to Sylvan Lake over a specified time period was not available. Specifically, there is a lack of data detailing nutrient concentrations along depth profiles, which are required to examine fluxes of nutrients from the sediments to the overlying water. The majority of water quality samples taken in Sylvan Lake were taken by depth integrated composite sampling from the euphotic zone, which precluded the calculation of the total mass of phosphorus in the lake. The single year in which depth-profile data for TP were collected over the course of the open-water season (June-September, 1996) indicated that the mass of TP actually decreased from June to September. No information is available for TN. On this basis, there was no indication that substantive internal TP loading occurred in that year. Internal loading estimates should be derived by comparing changes from May to September and data were not available that early in the open-water season.

Conversely, monthly mean concentrations of TP in the euphotic zone of Sylvan Lake in the open-water season (1983-2000) indicate a slight increase in TP in September (Figure A-15). This may reflect small amounts of internal loading but these data are not conclusive because this reflects only the euphotic zone and not the entire water column. Additionally, depth profiles of TP collected in winter and in August of 1996 indicated a notable increase in concentrations near the sediment-water interface (see Section A.2.1). Therefore, there is some indication that phosphorus may be released from sediments in Sylvan Lake under particular conditions.

Concentrations of total phosphorus measured in Sylvan Lake sediments in September 2004 were relatively low compared to other Alberta Lakes which indicated that the sediments may not be enriched at this time (Section A.3.5). However, even sediments that are not phosphorus saturated may under certain physiochemical and biological conditions release phosphorus to the water column, although this is more likely to occur with phosphorus enriched sediments.

Due to the uncertainties and lack of data required for deriving estimates of internal loading for TP and particularly TN, the nutrient balance was constructed assuming no internal loading. Additional monitoring of TP and TN along depth profiles over the open-water season could provide more conclusive information regarding the significance of

internal loading in the lake. However, accurate calculations of internal loading also require accurate estimates of external nutrient loading and any nutrient outputs.

A.4.1.5 Atmospheric Deposition

The nutrient input into Sylvan Lake via atmospheric bulk deposition was estimated from loading coefficients and the area of Sylvan Lake. The TN and TP loading coefficients measured at Narrow Lake, Alberta, by Shaw et al. (1989) were used in conjunction with a mean lake area of 41.75 km² to derive total annual loads of nutrients deposited directly onto the lake (Table A-23).

A.4.2 Nutrient Outputs from Sylvan Lake

A.4.2.1 Lake Outflow

Measurements of nutrient concentrations in the Sylvan Lake outflow (located at the south-eastern end of the lake) were insufficient for application in the nutrient balance. Therefore, outflow estimates were calculated by multiplying the average in-lake concentrations of TN and TP for the open-water season (1983-2000) by the mean annual outflow volume (2.9 million m³/year). Outflow concentrations of nutrients tend to be generally similar to those in a lake.

A.4.2.2 Natural Groundwater Outflow

The available data suggest that Sylvan Lake water flows out of the lake and into the subsurface at the southeast end but the volume of this natural outflow could be negligible (Appendix B – Section B-2.4). Consequently, a nutrient loss calculation was not made for natural groundwater outflow.

A.4.2.3 Sorption And Settling In Sediments

As discussed in Section A.1.5.1, existing data for Sylvan Lake water chemistry are insufficient to derive estimates of internal loading of TN or TP. However, overall estimates of nutrient retention in the lake were derived based on the nutrient balance as discussed below.

A.4.3 Nutrient Balance

Estimates of total phosphorus loading to Sylvan Lake indicate that by far the most significant source is from surface flows within the drainage basin (Table A-23). Drainage basin inputs of TP comprise approximately 58-74% of total inputs, depending on the estimate of surface inflow loads used (i.e., export coefficients vs. FWMC estimates). Inputs of TN are also dominated by drainage basin inflows (40-55% of total loads) but atmospheric deposition of TN is also significant (33-44% of total loads). Collectively, the nutrient balance indicates that the surrounding drainage basin is a highly significant factor contributing to the trophic status of Sylvan Lake.

Conversely, deeper groundwater, atmospheric deposition, and septic field inputs of TP to Sylvan Lake contribute approximately 25-42% of total inputs, with each source contributing approximately the same relative amounts. For TN, total loads from deeper groundwater and septic fields comprise only 12-15% of nitrogen inputs. Septic effluent loading is alone comprises from 5-9% and 2-3% of TP and TN loading, respectively.

Losses of nutrients from the lake are small, accounting for approximately 0.7-1.1% and 3.6-4.8% of total TP and TN inputs, respectively. It is also important to note that during the period considered in the nutrient balance (1983-2000), the lake outlet was discharging for a significant period. Therefore, during periods of no outflow (which represents the majority of the years for which lake level data are available), there would be no external losses of nutrients. However, given that the outflow losses comprise such a small fraction of external inputs, this pathway may not be of particular significance with respect to a long-term nutrient balance.

Sylvan Lake has a high nutrient retention (>95%) of both TN and TP (Table A-23). This is typical of lakes with small drainage area: lake area ratios and long water residence times (Kalff 2002), such as Sylvan Lake. Deep lakes with high water residence times (>25 years) reportedly retain 70-90% of TP inputs (Kalff 2002). Nutrients accumulate in the sediments of waterbodies through sorption processes, settling of particulates, and settling of phytoplankton (Kalff 2002). A comparison of estimated inputs of TP to Sylvan Lake, Gull Lake (Mitchell and LeClair 2003), and Pine Lake (Sosiak and Trew 1996) are provided in Table A-24. Gull Lake, which is characterized as meso-eutrophic and has a similar drainage area: lake area ratio as Sylvan Lake, was estimated to have a total TP loading of 12,100-20,500 kg for the years 1999 and 2000 (including internal loading). This is approximately 1.5-2 times as high as the estimates for Sylvan Lake.

A.4.4 Lake Mass Balance Model

To assist in determining the potential sensitivity of Sylvan Lake to increased nutrient loading, a mass balance water quality model was constructed using the BATHTUB (Version 6.1) model developed for the United States Army Corps of Engineers (Walker 2004). The model is an empirical water quality model used to evaluate eutrophication in lakes and reservoirs. An earlier version of the BATHTUB model (version 5.3) was applied recently for evaluating proposed mitigation activities in Pine Lake, AB (Sosiak 1997).

Model Calibration

The model was calibrated using data for the 1983-2000 period as follows:

- the mean concentrations of TP, TN, chlorophyll *a*, and Secchi disk depth measured in the euphotic zone of Sylvan Lake;
- the water balance data derived from this study (Section A.4);
- estimates of major land use types (forested/arable, urban); and,
- the nutrient balance data based on FWMC of nutrients for surface inflows (Section A.5.1).
- estimates of nutrient loading from septic effluent, groundwater and atmospheric deposition

It was desirable to use the 'average' data for this time frame in model construction for several reasons. Firstly, the information required to construct such a model (e.g., nutrient data, hydrology) was coarse and the nutrient balance was derived for the average conditions for the period of 1983-2000. Secondly, to use the model for predictive purposes, it was beneficial to construct a model of 'average' conditions, which would serve as the 'baseline' for maintenance of lake water quality.

Table A-24 Comparison between physical properties of several Alberta lakes. Data for Sylvan Lake were derived from this study and refer to the average for the period of 1956-2000

Lake	Lake Area (km ²)	Drainage Basin Area (km ²) ²	Mean Annual TP inputs (kg)				Trophic Status	TP (mg/L)	TKN/TN (mg/L)	Secchi Depth (m)	Chlorophyll a (µg/L)	Source
			Surface and Groundwater Inputs	Atmospheric	Other	Total						
Sylvan Lake	41.75	109.25	4,553-7,993	835	-	5,388-8,828	Mesotrophic	0.021	0.69	4.8	4.6	This study
Gull Lake ²	80.6	206	3,000-10,200	1600	7,500-8,700 ³	12,100-20,500	Mesotrophic-eutrophic	0.0451	1.55	2.5	8.4	Mitchell and LeClair (2003)
Pine Lake ⁴	3.89	150	729	62	1,228 ³	2019	Eutrophic	0.072	1.63	2.8	18.7	Sosiak and Trew (1996)

Notes:

- 1 Including 5.4 million m³ from diversion inflow.
- 2 TP loading estimates represent values for 1999 and 2002.
- 3 Internal loading.
- 4 1992.

² Excluding area of the lake

No internal loading of nutrients was included in the model because it could not be estimated (see Section A.5.1 for discussion).

Model calibration settings are presented in Table A-25. The model calibration factor for chlorophyll *a* was adjusted during calibration until predicted values approached observed values. The model calibration factors for TP, TN, or Secchi disk depth were not adjusted. A water runoff coefficient was derived by dividing the total surface inflow from the water balance by the drainage basin area. Then, the watershed nutrient loading was apportioned to the major land uses (arable/woodland and developed land), and concentrations were calculated.

Table A-25 BATHTUB (Version 6.1) Model Settings for the Sylvan Lake Water Quality Model

Model Type	Model Name
Phosphorus Balance	First Order
Nitrogen Balance	Bachman Vol. Load
Chlorophyll <i>a</i>	P, Linear
Secchi Depth	Vs. Chla & Turbidity
Dispersion	Constant-Numeric
P and N Calibration	Concentrations
Mass-balance Tables	Use Estimated Concentrations

Comparison between predicted and observed water quality for the calibration period is provided in Table A-26. The model closely approximated TP, chlorophyll *a*, and Secchi depth but was less successful at accurately predicting TN.

Table A-26 Comparison Between Model Predicted and Observed Water Quality for the Calibration Period (1983–2000)

	Model Calibration		Pre-development Simulation
	Observed	Model Predicted	Model Predicted
TP (mg/L)	21.3	21.0	6.6
TN (mg/L)	703	766	597
Chlorophyll <i>a</i> (µg/L)	4.3	4.1	1.3
Secchi Depth (m)	4.8	4.7	6.4

The calibrated model based on data for the 1983-2000 period was then applied in predictive simulations to evaluate the magnitude of increase in TP loads to Sylvan Lake that would be required to increase the TP concentration in the lake to "eutrophic" status. Although the lake appears to be nitrogen-limited (see Section A.2.3), predictive simulations were not based on TN for several reasons. Firstly, there are limited data describing nitrogen concentrations in Sylvan Lake. Available data for nitrogen indicate that while the total concentration is relatively high (and could be considered to represent 'eutrophic' conditions already, see Section A.2.3), the dissolved fractions of inorganic forms of nitrogen are low. In order to evaluate the effects of additional nitrogen loads on chlorophyll *a* concentrations in the lake, it would be necessary to construct a complex model that simulates the entire nitrogen cycle. As the model is based on the total

concentrations of phosphorus and nitrogen and, as such, it is too coarse to attempt this level of simulation.

Several assumptions were made in this simulation including:

- the model was based on the average conditions for the 1983-2000 period respecting lake water quality, estimated nutrient loading, and the water balance; therefore the model simulation is subject to all of the same uncertainties outlined in Section A.5 below as well as to the conditions (i.e., hydrological etc.) that occurred for that averaging period;
- internal loading to the lake was assumed to be zero;
- TN loads would increase proportionately to TP loads; and,
- "eutrophic" status was assumed to be a predicted in-lake concentration of 35 µg/L (see Section A.2.3 for discussion).

Three predictive simulations were run with the calibrated model:

1. Predictive Simulation 1: Watershed Loading Increase

Model iterations were run until the appropriate external load of phosphorus was increased sufficiently to predict a lake concentration of TP of 35 µg/L. TN loads were increased proportionately to the TP load.

2. Predictive Simulation 2: Internal Loading Increase

A second predictive simulation was undertaken to evaluate the sensitivity of the lake to internal phosphorus loading. In this case, an internal loading rate was assigned to the calibrated model and was adjusted until such time that the model predicted TP concentration reached 35 µg/L.

3. Predictive Simulation 3: Effect of Present Development

A third simulation was run to try and estimate the current impacts of existing land use and development and septic effluent are on lake water quality. To accomplish this pre-development analysis, all land in the drainage basin was specified as 'woodland' (i.e., agriculture and urban areas were converted to forest), and septic effluent was assumed to be zero. Other variables in the calibrated model remained the same.

Predictive Simulation Results

The results of the first predictive simulation indicated that TP loading to the lake would have to increase by approximately 5,500 kg/year above the average annual loading estimated for 1983-2000. This represents an approximate 62% increase above the estimated annual average loading of TP to the lake of 8,828 kg/year.

Predictive Simulation 2: Internal Loading Increase

The second predictive simulation indicated that an internal loading rate of 0.4 mg/m²/day (over the year) would cause an increase of TP in the lake to 35 µg/L. For context, the internal load of TP in Pine Lake was estimated to be 1,229 kg/year (Sosiak 1997). This would be equivalent to an annual loading rate of approximately 0.8 mg/m²/day. Estimates of internal loading for Gull Lake (7,500-8,700 kg/year, Mitchell and LeClair 2003) would be equivalent to a loading rate of 0.3 mg/m²/day over the year. Both of these lakes are

more eutrophic than Sylvan Lake (see Table A-4), and in the past, Pine Lake has had intensive blooms of blue-green algae.

Predictive Simulation 3: Effect of Present Development

The results of the third predictive simulation (i.e., the pre-development analysis) indicate that nutrient loading has doubled since European settlement of the watershed began. This increased loading from the existing land use types and septic field effluent have converted the lake from an average TP concentration of 6.6 µg/L to 21.0 µg/L. Chlorophyll *a* levels are also predicted to have been very low (approximately 1 µg/L). Therefore, these simulation results indicate that the lake would be oligotrophic if the drainage basin consisted of natural woodlands and was free of septic effluent and loading from agriculture and cottage/town development. A comparison of the pre-development analysis and current conditions is provided in Table A-26. It is important to note that the soils within the prairie region of Canada are naturally nutrient-rich (i.e., levels were relatively high prior to development) and the model may underestimate the nutrient status of Sylvan Lake prior to development.

A.4.5 Discussion

Because the predictive simulations were based on the water and nutrient balance models for the years 1983-2000, the simulations incorporate nutrient losses from the lake through the outlet channel. In the future, the lake may experience lower water levels and may not have significant outflow for extended periods of time. Therefore, the actual increased external or internal loading to the lake required to cause this predicted shift could be underestimated.

Furthermore, it is not possible to predict or estimate the point at which an increase in external nutrient loading may lead to significant internal loading. That is, an increase of less than 5,500 kg TP/year could result in conditions that would cause TP to be released from the sediments to overlying water. This could cause the sediments to shift from a net sediment sink to a net source for phosphorus. This uncertainty is particularly critical given the lake's extremely low flushing rates. Should a critical point be reached at which internal loading became significant, the effect could be maintained for a prolonged period of time even if external nutrient loading were reduced. Typically lakes with low flushing rates respond more slowly to nutrient reductions (Marsden 1989; Kalff 2002). In some cases, it may take decades for the effects of external controls on phosphorus loading to be reflected in reductions in nutrient concentrations in the water column (Kalff 2002). This is often due to the prolonged effects of internal phosphorus loading (Kalff 2002).

Additionally, it is cautioned that the predictive modeling was based on a calibration to mean TP concentrations measured over 1983-2000. Although mean TP concentrations for the open-water season for this period were fairly uniform, there is some variation from year to year. Therefore, smaller increases in loading may cause a similar increase in TP in the lake in certain years.

As the modeling exercise is based on uncertainty and assumptions, the results of the predictive simulations should be viewed with extreme caution. The intent of these simulations was to explore the relationship between nutrient loading and lake water quality, and to have a calibrated model on hand for when new data become available. It is also cautioned that the model should be validated against an independent data set. Due to

the uncertainties associated with all elements of the model, the absolute numbers derived in these exercises should be viewed with caution.

A.5 Summary and Conclusions

The following is a summary of major findings and conclusions of the materials discussed in detail in Sections A.3 to A.5 (i.e., water quality, sediment quality, and limnological assessments, water balance derivation, and nutrient balance derivation).

A.5.1 Lake Water Quality, Sediment Quality and Limnology

Major conclusions of the lake water quality, sediment quality, and limnological assessments are:

Lake Water Quality

- Sylvan Lake is alkaline, extremely insensitive to acidification (based on pH and alkalinity), very hard, contains low levels of major ions and salts, and is of high clarity;
- Thermal stratification develops in some summers and winters and DO depletion in the hypolimnion has been observed;
- Nutrient concentrations in Sylvan Lake are relatively constant over the period of record (i.e., 1983-2003) and there is no overt indication of enrichment over time;
- Concentrations of water quality parameters for which there are water quality guidelines for the protection of aquatic life are almost all below the guidelines;
- Concentrations of TP (open-water season mean 1983-2003 = 0.021 mg/L) are below the AENV guideline of 0.050 mg/L and are relatively low compared to other Alberta lakes (mean for Alberta lakes = 0.118 mg/L);
- Concentrations of TN, although measured very infrequently, are largely below the AENV guideline of 1 mg/L (one measurement exceeded the guideline over the period of record);
- The nitrogen pool is overwhelmingly dominated by organic nitrogen and inorganic forms such as ammonia and nitrate/nitrite are present in low concentrations;
- Levels of chlorophyll *a* are relatively low in Sylvan Lake (mean for the open-water season = 4.6 µg/L), compared to other Alberta (mean for Alberta lakes = 22.4 µg/L) lakes but algal blooms have been reported to develop at least as far back as the 1970's.

Lake Sediment Quality

- Lake sediment from the nearshore and offshore areas sampled in September 2004 does not appear to be enriched with phosphorus relative to concentrations previously reported for other lakes in Alberta.
- There is some evidence that phosphorus may be released from the sediments in Sylvan Lake at certain times of year (e.g., during anoxic or hypoxic conditions in the hypolimnion or low redox potential). However, the available lake monitoring data

and estimates of external nutrient loading to the lake are inadequate to derive estimates of internal loading rates in the lake.

Lake Limnology and Trophic Status

- Blue-green algae comprised a significant fraction of algal communities in late summer and early fall at the times measured;
- The trophic status of Sylvan Lake (based on the mean open-water season water quality conditions for 1983-2002) is classified as meso-eutrophic (CCME 2004) on the basis of TP (Mean = 0.021 mg/L), mesotrophic (OECD 1982) on the basis of chlorophyll *a* (Mean = 4.6 µg/L), meso-eutrophic (Wetzel 1983) to eutrophic (Nürnberg 1996) on the basis of TN (Mean = 0.715 mg/L), and oligotrophic on the basis of DIN (Mean = 0.046 mg/L, Wetzel 1983) and Secchi depth (Mean = 4.8 m, OECD 1982; Nürnberg 1996);
- The upper range of mean concentrations of TP for the open-water season (mean for open-water season of 1992 is 0.034 mg/L) approaches the boundary of meso-eutrophic and eutrophic status (i.e., 0.035 mg/L);
- There is also evidence, based on nitrogen to phosphorus ratios, that the lake may be nitrogen limited, at a minimum at certain times of the year. This may pre-dispose the lake to the development of blue-green algal blooms due to their ability to fix atmospheric nitrogen;
- Nearshore water quality monitoring conducted in September 2004 indicated that there were no overt effects of nearshore developments and/or local inflows at the time of sampling for most water quality parameters;
- Some water quality parameters (e.g., bicarbonate, alkalinity) did vary between nearshore areas examined but the reasons for these observations could not be determined.
- Fish kills have been observed on the lake and the reasons for these events have not either been determined or at a minimum documented. Dissolved oxygen depletion and/or production of algal toxins should be considered among the possible causes.

A.5.2 Tributary Streams

Major conclusions of the tributary stream assessments are:

- When flowing, the streams can be classified as eutrophic according to the stream trophic classification criteria suggested by the USEPA (2000).
- Total phosphorus and nitrogen concentrations were above the relevant Alberta water quality guidelines for the protection of aquatic life (AENV 1999). The dissolved fractions were present in similar concentrations.
- Golf Course and Northwest creeks were most likely to exhibit some prolonged flow throughout the year, and so were most likely to make the largest contribution to the nutrient budget of Sylvan Lake.
- Large spatial differences in total phosphorus and nitrogen were not evident between tributary streams based on the current dataset but the inconsistent sampling record confounded the identification of differences.

- Differences in total phosphorus and nitrogen concentrations between streams observed in March 2001, and April 2003, 2004, likely do not reflect shoreline habitat; rather they reflect the degree and nature of agricultural land use upstream. It would appear that Northwest Creek maybe be more heavily influenced by land use practices compared with the other streams.
- Elevated levels of fecal coliform and *E. coli* bacteria also periodically occurred in most streams

A.5.3 Water Balance

Major findings of the water balance constructed for Sylvan Lake include:

- Sylvan Lake water levels are remarkably stable and have fluctuated by only approximately 0.7 m between years;
- The major inputs to Sylvan Lake appear to be surface inflows associated with the six ephemeral tributary streams. Therefore, Sylvan Lake inflows are dominated by drainage from the surrounding drainage basin;
- Groundwater inflows are relatively small (12,498 m³/d without considering the effects of groundwater pumping, and 9,727 m³/d when pumping from the Town's wells are considered);
- The available data suggest that Sylvan Lake water flows out of the lake and into the subsurface its southeast end. However, the limited available data suggest the volume of this lake water outflow could be negligible;
- For large periods of time Sylvan Lake does not have a surface outflow and, consequently, the lake is characterized by very long water residence times (>100 years) and low flushing rates. Outflow has been more prevalent over the last decade.

A.5.4 Nutrient Balance

Major conclusions borne from the construction of the nutrient balance and model for Sylvan Lake include:

- Nutrient inputs to Sylvan Lake are dominated by surface loading from the surrounding drainage basin. Surface inflows (i.e., tributary streams) are estimated to contribute an annual average of approximately 74% (6,564 kg/year) of TP and 55% (29,572) of TN loads to the lake.
- Atmospheric inputs are more significant for TN than for TP, comprising approximately 33% and 9% of total inputs;
- Groundwater and septic field effluent inflow collectively contribute an estimated 16% and 12% of annual loads of TP and TN, respectively; the estimated annual loads of TP and TN for groundwater inflow are 946 kg and 5,523 kg, respectively, and the estimated annual loads for septic effluent inflow are 483 kg and 1,069 kg, respectively;
- As the lake has a highly insignificant outflow and a high residence time, the lake is characterized by high (>95%) nutrient retention rates. This means that the vast majority of nutrients entering the lake are deposited in the sediments;

- Data are insufficient to estimate the occurrence and rate of internal phosphorus loading. However, a reasonably good approximation of mean TP concentrations in the lake was obtained using a mass balance eutrophication model (BATHTUB Version 6.1) and the estimated nutrient loading derived in the nutrient balance assessment;
- The lake was predicted to be capable of assimilating an additional loading of approximately 5,500 kg TP/year and still maintaining the meso-eutrophic phosphorus status (i.e., $<35.1 \mu\text{g/L}$), based on average hydrological and chemical conditions for the 1983-2000 period. This represents an approximate 62% increase above the estimated annual average loads of TP to the lake of 8,828 kg/year. However, this simulation does not account for the potential for conditions in the lake to shift causing a net internal loading from the sediments.
- A similar effect to lake water quality could be achieved through an increase in TP loading of 5,500 kg TP/year from internal loading. This equates to an annual internal loading rate of approximately $0.4 \text{ mg TP/m}^2/\text{day}$, or about half the estimated annual internal loading rate for Pine Lake (Sosiak 1997).

A.6 Uncertainties and Data Gaps

There is inherently some scientific uncertainty associated with scientific assessments. The identification of those uncertainties and data gaps is beneficial within the framework of adaptive management as it facilitates the following:

- Confidence in the analysis conducted and the conclusions drawn from the study;
- Ensures that the study and monitoring program have scientific integrity and prevents misinterpretation of the data; and,
- A positive and effective re-evaluation of monitoring priorities to effectively direct resources for future planning and work to achieve a robust, relevant data set to be used within the context of adaptive management.

Uncertainties and data gaps identified during the course of the study are listed and prioritised in this section. Some were addressed to a certain extent by the field survey completed as part of this study, but many of these data gaps could be further addressed through longer term on-going monitoring over time as part of an adaptive management framework. It should be noted that a number of these uncertainties/data gaps are common to lake nutrient studies.

A.6.1 Water Quality and Limnology

The higher priority data gaps and uncertainties regarding Sylvan Lake water quality and limnological data are given below. Future monitoring recommendations that specifically address these data gaps are discussed in Section A.8.

- There are limited monitoring data detailing nutrient concentrations (TP and TN) across depth profiles over the open-water season. These data are required to characterize the occurrence and quantities of internal nutrient loading that may be occurring in the lake.

- Water quality data for inflowing tributaries and the lake outflow are limited. This restricts the ability to construct robust nutrient and water balances, as well as the ability to delineate areas that may be most significant sources of nutrients to the lake (i.e., relative differences of loading in the tributary streams).
- The collection of nitrogen data (TKN and TN) in Sylvan Lake has been limited to six years compared to eighteen years for total phosphorus.
- Water quality monitoring data for Sylvan Lake are available from a time frame extending from 1983 to 2003 and so only changes in water quality that occurred within this time frame could be identified. Thus, the ability to identify changes in water quality over a longer time frame (prior to 1983) that may be associated with earlier changes of land use practices in the watershed was not possible (e.g., the intensification of agricultural practices and the loss of forested land).

Several uncertainties and data gaps that are important to note in the context of the study, but are considered to be of lower priority are given below.

- The relative role of nitrogen vs. phosphorus in limiting algal growth (i.e., trophic status) is uncertain due partly to the limited monitoring data for TN.
- Additional phytoplankton data would facilitate a greater understanding regarding the composition and seasonal succession of the algal community in Sylvan Lake. Data regarding algal blooms and other events such as fish kills are also limited. Fish kill investigations following an event may provide valuable information regarding the potential cause(s).
- The collection of sedimentation rate data and/or the dating of sediment cores for Sylvan Lake would facilitate a more definitive interpretation of historical nutrient concentrations and temporal changes to the lake.

A.6.2 Groundwater Outflow

The limitations in the groundwater flow modelling work are discussed in Section B-3.6 of Appendix B. In view of the limitations, it is concluded that a reasonably good approximation of groundwater flow under natural conditions was obtained. However, there are two data gaps or limitations in regard to groundwater outflow:

- The available data suggest that Sylvan Lake water flows out of the lake and into the subsurface at the southeast end thereby recharging the surficial till deposit and perhaps the shallow bedrock. In view that the till deposit is relatively thick and likely has a very low permeability, and that a flowing well zone is present southeast of the lake, the volume of this natural lake water outflow could be negligible. However, this interpretation is based on limited data.
- Similarly, information on the effects of groundwater production from the Town of Sylvan Lake's water wells on the lake and the shallow groundwater is not available.

Considering that natural groundwater outflow may be negligible and that the Town's water wells may not be having a notable effect on the water balance of the lake (Section A.4.4), these data gaps are not considered to be significant in terms of the objectives of the study.

A.6.3 Water Balance

Overall, due to limited actual site-specific data for derivation of a Sylvan Lake water balance, most elements of the water balance were derived using surrogate data from other areas. Although a standard practice, the use of surrogates does add a significant amount of uncertainty to the water balance. The site-specific data in question relate to:

- hydrological information detailing surface inflows to the lake
- meteorological data for the lake proper (i.e., precipitation, evaporation)
- The surface outflows from the lake were estimated from site-specific hydrological information but that data set was limited in quantity and should be expanded. As discussed in Section A.6.2, there was some uncertainty concerning the occurrence and quantity of groundwater outflow. Based on limited data interpretation it was assumed to be zero.

Recommendations given in Section A.8 are aimed at reducing the aforementioned uncertainties through the acquisition of long-term site-specific data for Sylvan Lake. This information would ultimately build on the current hydrological data set for Sylvan Lake and thus increase confidence in the water balance assessment.

A.6.4 Nutrient Balance

The nutrient balance and the modeling exercise depend on the water quality data available and data derived from the water balance. Consequently, any uncertainties associated with these components are incorporated into the nutrient balance. Reducing the uncertainties associated with the water balance in particular, would increase the robustness of the nutrient balance and model. The data gaps and uncertainties regarding the Sylvan Lake nutrient balance and model are given below. Recommendations that specifically address these data gaps are discussed in Section A.8.

- Internal nutrient loading from sediments in Sylvan Lake could not be estimated because of insufficient nutrient depth profile data, and therefore was assumed to be zero.
- The calculation of surface nutrient inputs to the lake was uncertain due to limited tributary stream nutrient data and the use of surrogate discharge data.
- Additional nutrient and discharge data on the outflow channel would greatly strengthen the estimation of nutrient export from the lake via the surface outflow. The role of groundwater outflow in the nutrient balance was also uncertain as discussed in Section A.6.2 and was assumed to be zero.
- Estimates of nutrient inputs associated with septic fields and deeper groundwater would be strengthened by the collection of additional nutrient concentration data. The estimates of nutrient inputs from septic fields were based on data from a single survey.
- The model was calibrated using one data set and should be validated against a second independent data set, as is standard practice.
- The model predictions should be considered coarse estimates due to cumulative uncertainty associated with the model components.

Suggestions for future monitoring and data acquisition to reduce the major uncertainties described above are provided in Section A.8. In many cases, collection of additional data on one particular element (e.g., hydrology of inflowing tributary streams) would, by extension, reduce the uncertainties associated with other elements of this project. This is due to the inter-relation of the hydrological cycle (i.e., water balance) and the nutrient balance and model. Therefore, while uncertainties have been identified for specific study components (e.g., lake water quality, water balance, nutrient balance); targeted monitoring in the future could address more than one uncertainty at a time. This is because information is passed from one component to another cumulating in the production of the nutrient balance and model.

A.7 Implications for Watershed Planning and Development

The previous sections of this report provided an assessment of the current status of Sylvan Lake with respect to nutrients and algae as well a description of the elements of the lake's water balance and nutrient balance. The following is a discussion of the implications of the findings of this study (i.e., of the results of Sections A.3 to A.5 of this report), with respect to the maintenance of Sylvan Lake's current water quality (i.e., nutrient) status and hydrology.

A.7.1 Maintenance of the Lake's Trophic Status

Sylvan Lake is categorized as meso-eutrophic on the basis of total phosphorus (TP) concentrations (using the recently issued CCME [2004] trophic categories), oligotrophic on the basis of dissolved inorganic nitrogen concentrations, and mesotrophic on the basis of chlorophyll *a* concentrations. To be conservative, the assessment of the lake's trophic status and effects of additional nutrient loading has been largely based on TP and a current trophic condition of meso-eutrophic. The lake has very high nutrient retention (>90%) and a very long residence time. Sylvan lake stratifies at least in some years during the late summer and winter, and conditions such as low dissolved oxygen levels develop near the sediments that are conducive to releasing phosphorus from the sediment sink back into the water column (i.e., internal loading). There is some evidence that phosphorus may be released to the overlying water column although the significance of this flux is not known.

A.7.1.1 Lake's Assimilative Capacity

A calibrated model, that accounts for inputs and outputs of nutrients (i.e., a mass-balance model), was used to predict the capacity of Sylvan Lake to assimilate more phosphorus without becoming "eutrophic" (defined as a mean concentration of TP of 35 µg/L). The model prediction indicated that the lake could incur an additional 5,500 kg TP/year and remain below 35 µg TP/L (i.e., the boundary between meso-eutrophic and eutrophic). This would be equivalent to a near doubling of estimated loading associated with surface inflows or more than 10 times the current estimated loading from septic field effluent.

However, the model was constructed assuming that there is, and would not be, any internal phosphorus loading even with additional external loading. This is an important consideration, as additional nutrient loading could cause the sediments to start releasing phosphorus to the lake if the sediments became saturated and/or if increased nutrient loading lead to changes in limnological conditions (e.g., increased depletion of dissolved oxygen in the hypolimnion). The results of a sediment survey conducted in

September 2004 indicated that levels of nutrients in the sediments are relatively low and do not appear to be saturated but there is some evidence, based on historical water quality data, that the lake may experience periods where phosphorus is released from the sediments into the water. Whether internal loading is currently occurring or not, the significance is that additional external loading to the lake could create or exacerbate internal loading. The importance of this sediment flux is highly significant in many lakes, including Pine Lake where remediation efforts have been implemented to deal with this very issue (Sosiak 2002). When applying a relatively low annual internal loading rate (approximately $0.4 \text{ mg/m}^2/\text{day}$ - equivalent to about one-half the estimated rate for Pine Lake) to the BATHTUB model of Sylvan Lake, predicted TP concentrations rose to $35 \text{ } \mu\text{g/L}$.

Additionally, it is important to note that the mass-balance model is a whole-lake model and does not discriminate any potential for localized effects. That is, shoreline development, point source discharges, or additional loading of nutrients in a particular stream could have localized effects in the nearshore areas adjacent to these sources. Therefore, efforts should continually be made to minimize impacts of development of any kind along shorelines and in the drainage basin as whole in order to minimize the risks associated with these activities on nutrients in the lake. A discussion of best management practices (BMPs) which could help mitigate these impacts is provided in Section A.8.1.

To provide additional context to assist in recommendations for future management, a second model 'prediction' was made to look retrospectively at how the current level of development may have already affected the lake water quality (i.e., a pre-development case). In this case, the model was used to approximate what the lake may have looked like prior to any agricultural or urban developments of any kind in the drainage basin. When the terrestrial component of the drainage basin is assumed to consist of only woodland, as opposed to the current mix of agricultural/pasture land, woodland, and developed land, and no septic field effluent is discharged to the lake, the predicted lake conditions indicate that current developments have caused TP to rise from approximately $7 \text{ } \mu\text{g/L}$ historically to the present-day $21 \text{ } \mu\text{g/L}$ and chlorophyll *a* to rise from 1 to $4 \text{ } \mu\text{g/L}$. This suggests that the current level of development (including urbanization, agricultural activities, and septic field effluent inputs) in the drainage basin has converted the lake from an oligotrophic to a meso-eutrophic state and approximately doubled the loading of nutrients to the lake.

A.7.1.2 Sylvan Lake Sensitivity

Sylvan Lake has a very long water residence time (>100 years) because the outflow channel only flows under a high lake water level. Consequently, anything entering the lake is only slowly flushed from it. For this reason, Sylvan Lake is quite sensitive to anthropogenic activities that may increase nutrient loading. The available information is insufficient to estimate the significance of sediment fluxes of phosphorus in Sylvan Lake. Additionally, the role of internal loading of nutrients in Sylvan Lake is uncertain and it is difficult to predict at what external nutrient loading rate the sediments may become significant sources of nutrients.

Lakes with low water residence times (i.e., high flushing rates) and no internal loading often respond rapidly to nutrient management initiatives, including the well known example of Lake Washington, Seattle (US, Kalff 2002). Conversely, lakes with slow flushing rates and internal loading have been found to respond slowly to reductions of

external nutrient loading (Kalff 2002). Ultimately, this means that it is critical to take efforts to minimize external nutrient loading to Sylvan Lake to avoid creating an issue with respect to internal nutrient loading. Should an internal loading problem develop in Sylvan Lake, it would likely persist for some time even if external nutrient loading were reduced. In general, adoption of a precautionary approach is recommended for lake management in light of these particular sensitivities.

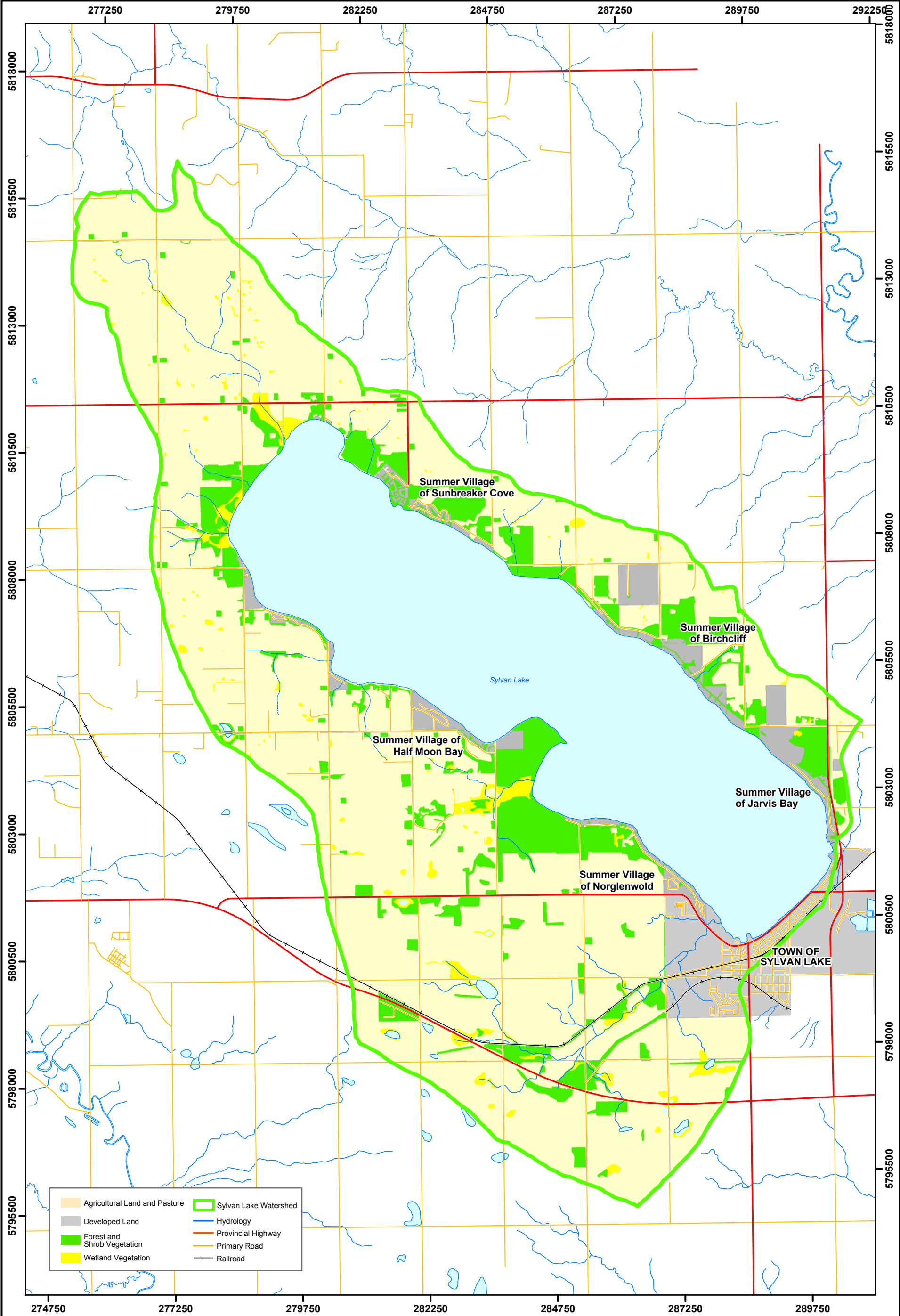
A.7.1.3 Watershed Land Use Activities and Control of Nutrient Inputs

As discussed in Section A.5.1, the majority of nutrients entering Sylvan Lake originate from the ephemeral tributary streams, with relatively small contributions from groundwater and septic field effluents. In the case of nitrogen, atmospheric loading is also quite significant. However, the latter source is not controllable and will not be discussed further.

The Sylvan Lake drainage basin is dominated by agricultural lands as illustrated in Figure A-89 and all of the streams discharging to the lake flow through agricultural areas (Table A-10). The nutrient balance results indicate that land use activities, which are primarily agricultural, are the largest source of nutrients to the lake. Because agricultural practices make up such a large portion of the land base within the watershed, future management initiatives should address nutrient loading associated with agricultural practices in the drainage basin. This does not imply that other land use activities, such as lakeshore development, are more beneficial to the lake's nutrient status, it simply indicates that at present, agriculture is the most widespread landuse activity. Because developments can also contribute nutrients to the lake, it is also recommended to limit nutrient releases associated with septic fields which are a controllable source near the lake.

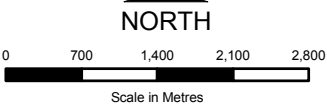
Deeper groundwater does not appear to be a major source of nutrients to the lake and the concentrations of nutrients measured in wells indicate low levels of contamination/impact. Therefore, the groundwater in the drainage basin does not appear to be substantively impacted by agricultural activities. However, all future development should proceed with consideration of minimizing impacts to groundwater quality to ensure this resource is not degraded and to minimize the introduction of nutrients to the lake.

A number of wetlands have been identified within the Sylvan Lake Watershed. As defined under the Wetlands of Canada (National Wetlands Working Group 1988), wetland types include bogs, fens, marshes, swamps or shallow water. In addition to their role in groundwater discharge, fens, and other wetlands, are important for the control and storage of surface water, and help to filter sediment, absorb nutrients, and remove chemical residues (Alberta Water Resources Commission 1993). As a result, we recommend that a 30 m "no development" setback be maintained from all wetlands within the watershed to protect their ability to reduce runoff to the lake and retain nutrients that would otherwise be discharged to the lake. This ability also makes wetlands desirable for incorporation into stormwater management systems, as discussed in Section A.8.1.1.



SYLVAN LAKE WATER QUALITY STUDY

**Land Cover Classes within
the Sylvan Lake Watershed**



Acknowledgements:
Original Drawing by AXYS Environmental
Consulting Ltd.

PREPARED BY			
			
DRAFT DATE		SCALE	
25/01/2005		1:70,000	
REVISION DATE		PROJECT	FIGURE NO.
27/06/2005		POGDS 1250	A-89
DRAWN	CHECKED	APPROVED	
CS	DC	DB	
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A.7.2 Potential Effects From Increased Groundwater Use

One of the objectives of the study was to assess the ability of the local groundwater resources to accommodate additional water use from new developments within the watershed without resulting in adverse effects to lake water quality. New developments in both Lacombe and Red Deer counties are required to be serviced by communal water and wastewater systems. Communal wastewater systems will use holding tanks with the effluent in the tanks taken to a sewage treatment facility located outside of the Sylvan Lake watershed (i.e., no return of treated sewage effluent to the subsurface within the watershed). As a result, there would be no underground discharge of effluent and, hence, no effect on the nutrient loading to the lake. There will be a loss of water in the Sylvan Lake groundwater basin and, more importantly, the effluent (i.e., pumped groundwater) will not be available for discharge into Sylvan Lake. The results of the study suggest the impact could be minor. For example, the groundwater requirements to support the addition of 3,000 year-round residents would only decrease the total inflow to the lake from 3% (based on the 2003 withdrawals by the Town of Sylvan Lake) to 4%. Regardless, this water loss should be avoided if at all possible by discharging the treated wastewater into the subsurface within the Sylvan Lake groundwater basin.

Groundwater production from any new water supply well drilled within or near the fen at the northwest end of the lake could reduce the groundwater flow available to wetland vegetation and subsequent discharge into the lake. If a water supply well is drilled in the vicinity of the fen (e.g., within 2 km), the testing program for the well should address the potential effects on groundwater supply to this wetland. This would be a requirement for obtaining a licence for a new well as specified in AENV's "Groundwater Evaluation Guideline" dated February 5, 2003 (specifically Section 2.08(k) of the Guideline).

A.8 Recommendations

Collectively, the assessment, nutrient balance, and nutrient modelling exercises conducted as components of this study indicate the lake may have some additional capacity to accommodate nutrients and still remain within the meso-eutrophic category. However, in light of the sensitivity of the lake to internal loading and the uncertainties pertaining to this issue, any further development that may contribute nutrients to the lake should be viewed as placing increasing risk on the nutrient status of the lake.

In general, future management of the lake should be based on a drainage basin-wide approach, particularly given the apparent significance of agriculture and surface flows in the nutrient balance. Any future development in the drainage basin would add incrementally to the nutrient loading to the lake and should be viewed as cumulative increasing risk to the lake trophic condition. This is particularly significant due to the potential risk of development of an internal loading issue in the slow-flushing, deep basin of Sylvan Lake.

Therefore, the development of an adaptive nutrient management strategy for the drainage basin is recommended to provide a framework for:

- Implementation of management practices and initiatives to minimize and/or reduce the current rate of nutrient loading to the lake. Some Best Management Practices (BMP) that could be considered are provided in Section 3;
- Establishing specific targets and measurement thresholds for the area reflecting the level of protection that is desired;

- Development of a monitoring program to ensure compliance with future management objectives for the lake. Some monitoring recommendations are provided in Section 3.
- Provision of an iterative framework (i.e., a tool) to assist in managing resources.

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Appendix B. Hydrogeology Baseline & Modelling Studies.

APPENDIX B

HYDROGEOLOGY BASELINE AND MODELLING STUDIES

B-1 INTRODUCTION

The purpose of the hydrogeology baseline study was to document the hydrogeological conditions in the study area. The results of the study related to the physical hydrogeological setting would form the basis for completing the groundwater modelling study. The purpose of the modelling study was to estimate the volume of groundwater flowing into Sylvan Lake. Baseline data related to the chemical hydrogeological setting would be used to estimate the groundwater component of the nutrient balance of the lake.

B-2 HYDROGEOLOGY BASELINE STUDY

The hydrogeology baseline study was completed using published and unpublished reports and data, and by undertaking two field programs to derive study-specific information. Reports reviewed and activities undertaken included:

- Review of Alberta Research Council Bulletin 31 entitled “Hydrogeology of Red Deer and Vicinity, Alberta” (Gabert, 1975);
- Review of Alberta Environment Report 1080 entitled “Stratigraphy and Hydrogeology of the Sylvan Lake Area” (AENV, 1976) prepared for the Sylvan Lake Stabilization Committee;
- Review of a B.Sc. thesis entitled “Sylvan Lake – Groundwater Interaction” (Baker, 2003);
- Processing water well drilling reports obtained from Alberta Environment’s Groundwater Information System database;
- Review of information for the Town of Sylvan Lake’s water supply wells;
- Measuring water levels in 23 observation wells installed within the Sylvan Lake watershed by Alberta Environment in 1990 and 1992, and collecting groundwater samples for chemical analysis from seven of the wells; and
- Installing, testing and sampling eight shallow monitoring wells as part of this study.

The results of the baseline study are presented below.

B-2.1 REVIEW OF AVAILABLE REPORTS

Alberta Research Council Bulletin 31 (Gabert, 1975), Alberta Environment Report 1080 (AENV, 1976) and the B.Sc. thesis (Baker, 2003) provide information on the geologic and hydrogeologic conditions within the Sylvan Lake study area. Information relevant to the current study is summarized below.

B-2.1.1 Regional Geology

The types and distributions of the surficial deposits in the Red Deer region are shown on Figure B-1. The surficial deposits in the Sylvan Lake area consist almost entirely of till (ground moraine). Minor occurrences of sand, mud and organic material (muskeg, peat and sedge bog) are present at several locations adjacent to the shoreline of the lake. Adjacent to Cygnet Lake are glaciolacustrine deposits (silt, clay and sand) in addition to organic material.

The thicknesses of the surficial deposits in the Red Deer region are shown on Figure B-2. The thickness of the till surrounding Sylvan Lake except at the southeast end ranges from 0 to 15 m. Within a linear feature extending from the southeast end of the lake to the Red Deer River valley, the till is considerably thicker with thicknesses ranging from 30 to 45 m. The till thickness to the north and south of the linear feature ranges from 15 to 30 m. The linear feature corresponds to the occurrence of a buried bedrock channel. Information from driller's logs and a borehole geophysical log from a structure testhole indicates the possible presence of basal sand and gravel along the buried channel.

The uppermost bedrock underlying the Red Deer region consists of the Tertiary-Upper Cretaceous Paskapoo Formation. The Paskapoo Formation, which primarily consists of soft, grey clayey sandstones, soft shales, and slightly indurated clays, ranges in thickness from 150 to 400 m. The upper portion of the formation is characterized by shale and siltstone units interbedded with fine- to medium-grained clayey sandstone. The lower portion is characterized by thick extensive sandstone units of fine to medium grain size alternating with thick sections of siltstones and shales.

The bedrock topography in the Red Deer region is shown on Figure B-3. The elevation of the bedrock surface beneath Sylvan Lake and at the southeast end of the lake is in the order of 915 m asl (above sea level) or less. The bedrock surface elevation adjacent to the northeast, southwest and northwest shores of the lake is approximately 945 m asl. Bedrock surface uplands occur to the northeast and southwest of the lake with a maximum elevation of about 975 m asl. The configuration of the bedrock surface shows that Sylvan Lake is situated within a buried bedrock channel, and that the channel trends in a southeasterly direction from Sylvan Lake to the Red Deer River valley.

B-2.1.2 Regional Hydrogeology

Gabert (1975) identifies two hydrostratigraphic units within the Red Deer region on the basis of the nature of permeability distributions and contrasts. The occurrences of these two units, designated as Hydrostratigraphic Unit 1 and Hydrostratigraphic Unit 2, in the Sylvan Lake area are shown on Figure B-4. Figure B-4 is Cross Section C-C' from Gabert (1975). The orientation of this cross section is shown on Figure B-3. The boundary between the two units does not coincide with geologically-defined rock unit boundaries.

The upper unit, Hydrostratigraphic Unit 1, is distinguished by a permeability generally higher than that of the underlying shale-siltstone portions of Hydrostratigraphic Unit 2. Unit 1 extends from ground surface to within the upper part of the bedrock and, thus, it includes all surficial deposits. The thickness of Unit 1 is shown on Figure B-5. Although the thickness mapping is limited in the vicinity of Sylvan Lake, the available data indicate the thickness of Unit 1 beneath and adjacent to the lake is up to 180 m. The thickness of Unit 1 within and to the south of the Town of Sylvan Lake increases significantly to a maximum of approximately 210 m.

The underlying Hydrostratigraphic Unit 2 extends from the base of Hydrostratigraphic Unit 1 down to the top of the Ardley Coal Zone. Hydrostratigraphic Unit 2 is characterized by thick, extensive layers of highly permeable sandstones alternating with thick layers of predominantly shale and siltstone with low permeability. The thickness of Unit 2 in the vicinity of Sylvan and Cygnet Lakes ranges from 180 to 210 m (Figure B-4). Within this unit in the Red Deer region are three main sandstone aquifers referred to as Sandstone Nos. 1, 2 and 3 (Gabert, 1975). Only Sandstone No. 2 occurs in the Sylvan Lake study area (Figure B-4).

The main aquifers in Hydrostratigraphic Unit 1 in the Red Deer region are sand and gravel terraces adjacent to and underlying present-day streams and lakes, sand and gravel deposits in buried preglacial valleys, and fractured sandstone lenses and shale beds in the upper bedrock deposits. With few exceptions, groundwater supplies in the region are obtained from wells completed in Unit 1. A groundwater probability map from Gabert (1975) illustrating expected water well yields in the region is shown on Figure B-6. In the vicinity of Sylvan Lake, expected well yields range from 100 imperial gallons per minute (igpm) to greater than 500 igpm (650 m³/d to greater than 3,270 m³/d).

Gabert (1975) provides hydraulic conductivity values derived from the results of bail and pumping tests conducted on wells completed in Hydrostratigraphic Units 1 and 2. The values for wells completed in Unit 1, and for wells that straddle Unit 1 and the upper portion of Unit 2, range from 6×10^{-7} m/s to 3×10^{-4} m/s. Gabert (1975) shows the average value for Unit 1 is 2×10^{-5} m/s.

Gabert (1975) presents mapping of groundwater recharge areas and discharge areas for the majority of the Red Deer region (Figure B-7). The mapping area includes the areas to the south and east of Sylvan Lake as well as the southeast end of Sylvan Lake. As shown on Figure B-7, the upland areas to the south-southwest and east-northeast of the lake are groundwater recharge areas. The lowland area between the southeast end of Sylvan Lake and the Red Deer River is a groundwater discharge area.

AENV (1976) provides mapping of the groundwater recharge and discharge areas within the Sylvan Lake watershed (Figure B-8). As shown on this figure, the groundwater divide in the vicinity of Sylvan Lake represents the perimeter of the Sylvan Lake groundwater basin. This groundwater basin generally coincides with the Sylvan Lake – Cygnet Lake watershed. The upland areas adjacent to Sylvan Lake are groundwater recharge areas. Sylvan Lake and the land immediately adjacent to the lake is a groundwater discharge area. The discharge area extends to the south of Sylvan Lake and from the southeast end of the lake to Cygnet Lake. A flowing well zone occurs in the vicinity of Cygnet Lake. Smaller flowing well zones exist near the northwest and southeast ends of Sylvan Lake.

As discussed in AENV (1976), local and intermediate flow systems are present within Hydrostratigraphic Unit 1 in the Sylvan Lake groundwater basin. The regional flow system occurs in Hydrostratigraphic Unit 2 wherein groundwater flow is horizontal in a southeasterly direction towards the Red Deer River where it discharges.

Baker (2003) shows that groundwater discharges into Sylvan Lake. The thesis also suggests there is significant groundwater flow-through in Sylvan Lake. Specifically, it is postulated that groundwater discharges into Sylvan Lake from the northwest and southwest sides, and that the lake recharges groundwater on the northeast and southeast sides. It is suggested that there is a possibility that a highly conductive layer of sandstone exists at and below the elevation of Sylvan Lake with significant quantities of groundwater flowing through it.

Two water quality types of groundwater occur in the vicinity of Sylvan Lake: a sodium-bicarbonate type and a calcium/magnesium-bicarbonate type. The groundwater is fresh with concentrations of total dissolved solids (TDS) generally less than 500 mg/L (Figure B-9).

B-2.2 WATER WELL INFORMATION

B-2.2.1 Water Well Drilling Reports

A search of Alberta Environment's Groundwater Information System database identified drilling reports for a total of 341 water wells reported to be located within the Sylvan Lake study area. A summary of the data in the reports is presented in Table B-1. These wells were given project reference numbers from 1 to 341. Drilling reports for four additional wells located outside the study area were also obtained for the construction of hydrogeologic Cross Section B-B' as discussed below. Those four wells were given project reference numbers of 501 to 504 (Table B-1). The drilling reports were obtained to assess groundwater use in the study area, prepare a hydraulic head distribution map for Hydrostratigraphic Unit 1, prepare two hydrogeologic cross sections and to assess the groundwater quality of Hydrostratigraphic Unit 1.

Groundwater Use

The drilling reports indicate the completed depths of the wells range from 3.0 to 109.7 m. Therefore, all of these wells are completed within Hydrostratigraphic Unit 1. Of the 341 wells, 298 wells (87%) are reported to be used for domestic and/or livestock watering. A total of 23 wells are used for industrial purposes, 12 wells are Alberta Environment observation wells, 5 wells have an unknown use and 3 wells are municipal wells owned by the Town of Sylvan Lake. Based on the information contained in the drilling reports for the industrial wells, it appears that the wells were temporary rig and/or camp wells drilled by oil companies.

The objective of the groundwater use review was to identify any groundwater use that would remove groundwater from the groundwater basin, thereby reducing the volume of groundwater available for discharge into Sylvan Lake. With the exception of the Town's use of its water wells as discussed below, none of the groundwater uses would remove any significant amount of groundwater from the basin. That is, groundwater consumed or utilized by the other users would be returned to the subsurface within the basin (e.g., use of septic fields, ground discharge of livestock effluent).

Hydrogeology

A hydraulic head distribution map for Hydrostratigraphic Unit 1 in the study area was prepared using data in the water well drilling reports and data for Alberta Environment's observation wells (Figure B-10). The perimeter of the Sylvan Lake groundwater basin interpreted from the hydraulic head data shown on Figure B-10 is comparable to the perimeter interpreted by Alberta Environment in 1976 (Figure B-8). Groundwater in the upland areas to the northeast, northwest and southwest of the lake flows towards and discharges into Sylvan Lake. Groundwater adjacent to the southeast end of Sylvan Lake and further to the southeast flows towards and discharges into Cygnet Lake, the Red Deer River and the streams (e.g., Sylvan Creek) in between. Groundwater northeast and southwest of the Sylvan Lake groundwater basin flows towards the Blindman and Medicine Rivers, respectively.

Two hydrogeologic cross sections designated as A-A' and B-B' were prepared (Figures B-11 and B-12) using data from the water well drilling reports supplemented with data from wells in three of Alberta Environment's seven observation well nests (discussed in Section B-2.3.1). The orientations of the cross sections are shown on Figure B-10. Cross Section A-A' trends northwest to southeast from the regional topographic high northwest of Sylvan Lake to the regional topographic low (i.e., the Red Deer River valley). Cross Section B-B' trends southwest to northeast from the valley of the Medicine River to the valley of the Blindman River.

As shown on Cross Section A-A', groundwater in the upland (recharge) area northwest of Sylvan Lake flows downward and laterally towards the lake, and laterally towards the Red Deer River. Shallow groundwater at the northwest end of the lake discharges into the lake, and shallow groundwater also seeps into the lake from beneath. The same shallow groundwater flow pattern is associated with Cygnet Lake wherein shallow groundwater flows into this lake from the sides and from beneath. Although subsurface data in the area between Sylvan and Cygnet Lakes are limited, it is likely that Sylvan Lake water flows out of the lake at the southeast end thereby recharging the surficial till deposit and perhaps the shallow bedrock. In view that the till deposit is relatively thick and likely has a very low permeability, the volume of lake water outflow could be insignificant.

There is one additional feature of note on Cross Section A-A'. The hydraulic heads in Wells 82 and 339 (both extrapolated onto the cross section) are 944 m asl and 945 m asl, respectively. These hydraulic heads are elevated in comparison to the heads in other nearby wells, indicating the completed intervals of these wells are situated near the flowing well zone (Figure B-8). This interpretation is supported by the data for the Town's water wells in that elevated hydraulic heads occur in the wells located in the main part of the Town (see Section B-2.2.3). The occurrence of the elevated hydraulic heads suggests that southeasterly groundwater flow beyond the southeast end of Sylvan Lake could be minimal and that the subsurface outflow of lake water could be insignificant.

The groundwater flow patterns northeast and southwest of Sylvan Lake (Cross Section B-B', Figure B-12) are comparable to the pattern northwest of the lake. Groundwater in the upland (recharge) areas northeast and southwest of the lake flows downward and laterally towards the lake, and discharges into the lake. A portion of the downward-moving groundwater flows deeper into the groundwater basin. Groundwater recharge occurring to the northeast of the Sylvan Lake groundwater basin flows towards the Blindman River and groundwater recharge occurring to the southwest of the Sylvan Lake basin flows towards the Medicine River.

The groundwater flow patterns shown on the two cross sections indicate the shallow groundwater in the Sylvan Lake groundwater basin, in addition to Sylvan and Cygnet Lakes, occurs within a local groundwater flow system. The deeper groundwater in the basin occurs within intermediate and regional flow systems. This interpretation is consistent with the groundwater flow systems identified in Gabert (1975) and AENV (1976).

Groundwater Quality

Groundwater quality data provided with the water well drilling reports (total of 89 lab reports) are presented in Table B-2. The data are summarized as follows:

- TDS concentrations range from 283 to 1183 mg/L and average 502 mg/L, demonstrating the groundwater is fresh; and

- fifty-four (54) of the samples were analysed for nitrate plus nitrite-nitrogen ($\text{NO}_3 + \text{NO}_2\text{-N}$); $\text{NO}_3 + \text{NO}_2\text{-N}$ was not detected in 37 of the samples; detected concentrations range from 0.02 to 0.67 mg/L, averaging 0.23 mg/L.

None of the samples was analysed for phosphorus compounds.

B-2.2.2 Licensed Groundwater Use

Further information on groundwater use in the study area was obtained from Alberta Environment in a listing of licensed water wells. A total of 145 licensed wells are located in the study area and the total maximum allowable diversion volume is 1,841,388 m³/year. A breakdown of the maximum allowable diversion volumes per year is as follows:

Town of Sylvan Lake – 1,460,477 m³
 Individuals – 196,197 m³
 Livestock Watering – 106,080 m³
 Golf courses and recreational – 30,058 m³
 “Other” and schools – 26,414 m³
 Registry – 22,162 m³

“Registry” is defined by Alberta Environment as a “traditional agricultural user”. The majority of the licensed groundwater use (79%) is for the Town’s use of its water wells. With the exception of the Town’s water wells as discussed in the next section, none of the above licensed groundwater uses would remove any significant amount of groundwater from the Sylvan Lake groundwater basin.

B-2.2.3 Town of Sylvan Lake Water Wells

The Town currently utilizes seven water wells. Five of the wells (Well #1, Well #2, Well #3, Well #5 and Well #6) are located within the main part of the Town. The other two wells (Well #9 and Well #10) are located to the north in or near the Village of Jarvis Bay.

Completion and water level data for the seven wells are presented in Table B-3 (data from Tagish Engineering Ltd. of Red Deer and from AGRA (2000)). The wells are completed in upper bedrock strata to depths ranging from 33.5 to 60.96 m. Accordingly, all seven wells are completed in Hydrostratigraphic Unit 1. Based on the highest pre-pumping water level depths, the hydraulic heads in the wells located within the main part of the Town are elevated, being in the order of 948 to 949 m asl. The hydraulic heads in Well #9 and Well #10 (937 m asl) are similar to those in other nearby wells.

Yearly water consumption data are presented in Table B-4 (data provided by Tagish Engineering). The water consumption in 2003 was 1,061,730 m³ which averages 2,908 m³/d. Based on the total population, the average per capita consumption in 2003 was 121.8 m³. The per capita consumption reflects all water uses in the Town. The average consumption per capita, excluding commercial usage, in 1994 was 0.28 m³/d (AGRA, 1995).

The majority of the groundwater pumped from the Town’s water wells eventually gets discharged into the Town’s sewage system. Sewage is piped to the sewage lagoon located northeast of the Town, next to the Outlet Channel that flows from Sylvan Lake to Cygnet Lake. Water in the lagoon is discharged into the natural surface water system (i.e., Cygnet Lake via the Outlet

Channel). Consequently, the majority of the groundwater pumped from the Town's water wells is removed from the groundwater basin via the surface water pathway.

B-2.3 FIELD PROGRAMS

The field programs for the groundwater component of the study consisted of monitoring the wells in the seven observation well nests installed by Alberta Environment in 1990 and 1992, and installing, testing and sampling eight shallow monitoring wells. The locations of the wells are shown on the base map in the main section of the report. Summaries of these two field programs are presented below.

B-2.3.1 Monitoring of Alberta Environment Observation Wells

Data for the 23 observation wells located at the seven nest sites are presented in Table B-5. Three wells are completed in the surficial deposits (sand and/or clay), two wells are completed in surficial and bedrock deposits (i.e., the well screens straddle the bedrock surface) and the remaining 18 wells are completed in sandstone strata. The maximum depth of the wells is 60.66 m and, therefore, all of the wells are completed in Hydrostratigraphic Unit 1.

As shown in Table B-5, hydraulic response tests were performed on 10 of the wells (one well completed in sandy clay, nine wells completed in sandstone strata) to obtain data for estimating hydraulic conductivity values. The hydraulic conductivity of the sandy clay deposit was estimated to be 5×10^{-5} m/s. Five values estimated for sandstone strata range from 2×10^{-6} m/s to 1×10^{-3} m/s. For four of the tests on sandstone strata, the water level response during the tests was too rapid for obtaining data, indicating the hydraulic conductivity values would be greater than 1×10^{-3} m/s.

The water levels in the observation wells were measured by Westwater on September 30 and October 1, 2004 (Table B-5). Data for several of the wells were used in preparing the two hydrogeologic cross sections presented above.

The observation wells were installed so that Alberta Environment could evaluate the level of Sylvan Lake in terms of changes in groundwater elevations in the wells. The wells were not installed for monitoring groundwater quality and, consequently, Alberta Environment has not collected groundwater samples from the wells. Limited groundwater quality data for 11 of the wells are provided in Baker (2003); the data are presented in Table B-6.

Groundwater samples for chemical analysis were collected by Westwater as part of this study. The objective of collecting the samples was to better determine the chemical quality of the bedrock groundwater in terms of nutrient parameters. The chemical quality data obtained would be used in estimating the nutrient loading to the lake from the bedrock strata in the groundwater basin.

The samples were collected from seven of the wells, specifically the shallowest well at each nest that contained sufficient water for sampling. The samples were collected on September 30, 2004 after purging at least three well volumes from each well. Five field water quality parameters (temperature, pH, conductivity, dissolved oxygen and redox potential) were measured at the time of sample collection (Table B-7). Samples from the wells were submitted to Enviro-Test Laboratories for analysis of various nutrient parameters, major water quality parameters, major ions and four miscellaneous parameters. Also submitted was a blind duplicate sample from Well 4-1 and a trip blank. Upon receipt of the lab results, it was found that the results for the primary

and duplicate samples from Well 4-1 were in poor agreement due to differences in the amounts of sediment in the sample bottles. As a result, Well 4-1 was re-sampled on October 21, 2004 for a primary and duplicate sample.

The field parameters measured in the samples on September 30, 2004 are summarized as follows:

- temperatures ranged from 4.8 to 6.6 °C;
- pH values ranged from 7.14 to 8.78;
- conductivity values ranged from 716 to 1205 µS/cm;
- dissolved oxygen concentrations ranged from 0.69 to 9.94 mg/L; and
- redox potential values ranged from -37 to +138.5 mV.

The chemical analysis results for the seven samples are presented in Table B-8. The laboratory reports issued by Enviro-Test Laboratories are provided in Attachment B-1. Of note in the results are the following nutrient concentrations:

- concentrations of Total Phosphorus range from 0.075 to 0.55 mg/L;
- concentrations of Total Dissolved Phosphorus range from 0.002 to 0.043 mg/L (average of 0.030 mg/L);
- concentrations of Ammonia-N range from non-detect (less than 0.005 mg/L) to 0.315 mg/L;
- concentrations of Total Kjeldahl Nitrogen range from 0.20 to 1.59 mg/L;
- Nitrite-N was detected in only three of the samples; the detected concentrations were 0.002, 0.004 and 0.59 mg/L; and
- concentrations of Nitrate-N range from non-detect to 3.93 mg/L; by assigning one-half of the detection limit value to the samples with non-detects, the average concentration would be 1.0 mg/L.

The TDS concentrations range from 380 to 770 mg/L (average of 480 mg/L).

B-2.3.2 Installation, Testing and Sampling of Shallow Monitoring Wells

The objective of installing shallow monitoring wells was to determine the chemical quality of the shallow groundwater adjacent to the Sylvan Lake shoreline, downslope from existing septic fields. The chemical quality data obtained would be used in estimating the nutrient loading to the lake from septic field effluent.

A reconnaissance of the Summer Villages of Half Moon Bay, Norglenwold, Birchcliff and Sunbreaker Cove was undertaken on September 4, 2004 to select sites for the monitoring wells. A representative and/or resident from each summer village accompanied the Westwater hydrogeologist. The reconnaissance was completed using maps provided by the Five Summer

Villages administrator (Ms. Myra Reiter) showing the known locations of septic fields. In consideration of access limitations, access restrictions (the wells could be installed only on village property) and proximity to known septic fields, eight sites were selected. Three sites are located in Half Moon Bay, two sites in Norglenwold and three sites in Sunbreaker Cove. All eight sites are situated on or adjacent to the beach of the lake.

Installation of the monitoring wells took place on October 6 and 7, 2004. The drilling contractor retained for the work was Mobile Augers & Research Ltd. of Calgary. The boreholes for the wells were drilled with a solid stem auger drill. The wells were completed with 51 mm ID PVC casing and screen, filter sand and bentonite grout. A flush-mount steel casing protector with a lock was installed at the top of each well. As a safety and security precaution, the tops of the wells were finished at a depth of about 10 cm below ground surface. A completion diagram for each well is provided in Attachment B-2.

The depths of the wells ranged from 2.94 to 6.15 m (Table B-9). As shown on the completion diagrams, the well boreholes encountered unsaturated surficial sand underlain by till. All but two of the boreholes were dry following drilling, demonstrating the permeability of the till was very low. The water levels measured in the wells prior to sampling on October 12 and 13, 2004 are shown in Table B-9. The water level depths ranged from 0.15 to 4.19 m below top of casing. In view of the proximity of each well to the lakeshore, a water level depth greater than about 0.5 m indicates the water level had not equilibrated. A hydraulic response test was performed on each well prior to sampling to obtain data for estimating the hydraulic conductivity of the till. The hydraulic conductivity values range from 5×10^{-10} to 3×10^{-6} m/s (Table B-9).

Groundwater samples were collected from the wells on October 12 and 13, 2004 after the wells had been purged dry. The above-noted five field water quality parameters were measured at the time of sample collection. Samples from the wells were submitted to Enviro-Test Laboratories for analysis of various nutrient parameters, major water quality parameters, major ions and four miscellaneous parameters. In addition, the samples were analysed for E. Coli and fecal coliforms. Also submitted was a blind duplicate sample from one of the wells and a trip blank. The samples were labeled MW-1 to MW-8 rather than with the actual well designation in the interest of privacy.

The field parameters measured in the samples on October 12 and 13, 2004 are presented in Table B-9. The parameter values are summarized as follows:

- temperatures ranged from 5.4 to 11.1 °C;
- pH values ranged from 6.17 to 8.80;
- conductivity values ranged from 703 to 1787 $\mu\text{S}/\text{cm}$;
- dissolved oxygen concentrations ranged from 1.93 to 13.73 mg/L; and
- redox potential values ranged from -28.1 to +134.7 mV.

The chemical analysis results for the eight samples are presented in Table B-10. The laboratory report issued by Enviro-Test Laboratories is provided in Attachment B-1. Of note in the results are the following nutrient concentrations:

- concentrations of Total Phosphorus range from 0.784 to 12.7 mg/L;
- concentrations of Total Dissolved Phosphorus range from 0.018 to 0.035 mg/L (average of 0.029 mg/L);
- concentrations of Ammonia-N range from 0.053 to 0.498 mg/L;
- concentrations of Total Kjeldahl Nitrogen range from 0.95 to 11.1 mg/L;
- Nitrite-N was detected in only four of the samples; the detected concentrations range from 0.12 to 0.28 mg/L;
- Nitrate-N was not detected in two samples (detection limit of 0.1 mg/L); the detected concentrations range from 0.2 to 9.6 mg/L; by assigning one-half of the detection limit value to the samples with non-detects, the average concentration would be 3 mg/L.

The pH values for the samples range from 7.3 to 8.1, and the TDS concentrations range from 482 to 1160 mg/L (average of 845 mg/L). E. coli was not detected in seven of the samples; the one detection was 2 CFU/100 ml. Fecal coliforms were not detected in six of the samples; the two detections were 3 CFU/100 ml and >200 CFU/100 ml.

B-2.4 Conceptual Hydrogeologic Model

Sylvan Lake is situated within a groundwater basin that generally coincides with the Sylvan Lake - Cygnet Lake watershed. The groundwater basin extends from the uplands to the northeast and southwest of Sylvan Lake, and from the upland northwest of Sylvan Lake to the Red Deer River. The upland areas of the basin are groundwater recharge areas. Sylvan Lake and the area immediately adjacent to the lake is a groundwater discharge area. The discharge area extends southeast of Sylvan Lake to the Red Deer River. A flowing well zone occurs in the vicinity of Cygnet Lake.

Groundwater in the upland (recharge) areas flows downward and laterally towards the lake. A portion of the downward-moving groundwater flows deeper into the groundwater basin. Shallow groundwater at the northwest, northeast and southwest sides of the lake discharges into the lake, and shallow groundwater also seeps into the lake from beneath. The same shallow groundwater flow pattern is associated with Cygnet Lake wherein shallow groundwater flows into this lake from the sides and from beneath. Shallow groundwater southeast of Cygnet Lake and the deeper groundwater in the basin flows in a southeasterly direction, and discharges into the Red Deer River and the streams (e.g., Sylvan Creek) in between.

Hydrogeologic data for the area between Sylvan and Cygnet Lakes are limited and, as a result, the shallow groundwater flow conditions at the southeast end of Sylvan Lake are unknown. However, the available data suggest that shallow groundwater at the southeast end of the lake flows towards Cygnet Lake, and that Sylvan Lake water flows out of the lake and into the subsurface at the southeast end thereby recharging the surficial till deposit and perhaps the shallow bedrock. The till deposit is relatively thick and likely has a very low permeability, and a flowing well zone is

present southeast of the lake. Consequently, the volume of lake water outflow into the subsurface could be negligible. Information on the effects of groundwater production from the Town of Sylvan Lake's water wells on the shallow groundwater is not available.

B-3 GROUNDWATER MODELLING STUDY

B-3.1 Model Code

The numerical model MODFLOW was used to simulate groundwater flow within the groundwater basin and, specifically, to estimate the volume of groundwater inflow to Sylvan Lake. MODFLOW is a 3-D finite difference code generally recognized as the industry standard for regional scale groundwater flow modelling. The code simulates flow by means of a block-centered finite difference approach which allows stratigraphic layers to be simulated as confined, unconfined or semi-confined. The modular nature of the code allows the user to simulate recharge, groundwater interactions with rivers and lakes, and the influence of pumping wells among other things. MODFLOW was developed by the U. S. Geological Survey (McDonald and Harbaugh, 1984) and has gained wide acceptance from regulatory agencies worldwide.

B-3.2 Model Discretization and Boundary Conditions

The hydrogeologic setting and conceptual hydrogeologic model described in Section B-2 formed the basis for the groundwater flow model. The groundwater flow model is a one-layer model consisting of Hydrostratigraphic Unit 1. The surficial deposits within Unit 1 (i.e., the ground moraine till) could not be separated from the bedrock strata due to the thinness of the deposits. The boundary of the groundwater flow model coincides with the boundary of the groundwater basin as shown on Figure B-10.

The domain of the groundwater flow model is illustrated on Figure B-13. With the exception of the Red Deer River, the perimeter of the model was assigned to be a no-flow boundary (i.e., a groundwater divide). The MODFLOW river package was used to represent the Red Deer River with a constant hydraulic head of 870 m asl. This package is used to simulate the flow between the saturated groundwater system and a permanent water feature. Within the model domain, Sylvan Lake and Cygnet Lake were also represented using the river package with constant hydraulic heads of 936.55 and 931.21 m asl, respectively. The Outlet Channel between Sylvan and Cygnet Lakes, and Sylvan Creek between Cygnet Lake and the Red Deer River were represented using the MODFLOW drain package.

The model grid consists of 256 rows and 321 columns for a total of 82,176 cells. The dimension of each grid cell is 100 m by 100 m.

B-3.3 Hydraulic Parameters

B-3.3.1 Hydraulic Conductivity and Storage Properties

The initial hydraulic conductivity values assigned to Hydrostratigraphic Unit 1 in the model ranged from 1×10^{-4} to 1×10^{-5} m/s. This range is based on the range of values of 6×10^{-7} to 3×10^{-4} m/s (average value of 2×10^{-5} m/s) in the Red Deer region as reported in Gabert (1975). The final values incorporated in the model are discussed below in the section on model calibration.

Because the model is a one-layer model, it was not necessary to assign vertical hydraulic conductivity values. The model simulations were performed for steady-state conditions and, accordingly, it was not necessary to assign a storage coefficient value. The porosity value assigned in the model was 20%.

B-3.3.2 Recharge

Groundwater recharge was distributed across the entire model domain. The initial recharge values assigned in the model varied from 4.75 mm/year in low-lying areas to 50 mm/year in the upland areas where downward hydraulic gradients are strongest. Sylvan and Cygnet Lakes were assigned a groundwater recharge of 0 mm/year. The recharge values were adjusted during model calibration as noted below.

B-3.3.3 Pumping

The majority of the water wells within the Sylvan Lake groundwater basin are used for domestic and livestock-watering purposes with relatively low pumping rates. It is likely that essentially all of this pumped groundwater remains in the groundwater basin through seepage back into the subsurface (e.g., septic fields, ground discharge of livestock effluent). The largest volume of groundwater production takes place with the Town of Sylvan Lake's water wells. Because the Town's sewage is ultimately discharged into the surface water system, the Town's pumped groundwater is removed from the groundwater basin. To account for this, pumping of groundwater from the Town's seven active water wells using the 2003 production volume was incorporated in the model without returning the pumped groundwater back into the groundwater basin.

B-3.4 Calibration

The process of model calibration involved the completion of a series of steady-state simulations in which recharge and hydraulic conductivity were adjusted until the differences between simulated and measured hydraulic heads, on average, were minimized. With respect to measured heads, Table B-11 identifies the wells from which data were used as calibration points.

The typical industry standard for model calibration is:

- The head residuals plot closely to a 45 degree line.
- The residual mean error is close to zero.
- The normalized RMS error is less than 15%.
- The correlation coefficient is 85% or greater.

These calibration criteria were met during the calibration process when the hydraulic conductivity of Hydrostratigraphic Unit 1 in the model domain was spatially varied between 2×10^{-5} and 1×10^{-4} m/s, and the recharge was spatially varied around an average of 6% of the mean annual precipitation. As shown on Figure B-14, the correlation plot of simulated vs. measured head indicates the points are fairly randomly distributed about a 45 degree line. The residual mean error is 0.85 m (i.e., close to zero), the normalized RMS error is 4.2% (i.e., less than 15%) and the correlation coefficient is 92% (i.e., greater than 85%). Thus, these model error indicators are within acceptable limits.

B-3.5 Results

B-3.5.1 Results Without Groundwater Pumping

Figure B-15 shows the simulated hydraulic head distribution within the model domain as determined with the calibrated model without pumping from the Town of Sylvan Lake's wells. Comparing this distribution to the distribution shown on Figure B-10 shows that there is a reasonably good agreement between the simulated and measured distributions.

The mass balance for the calibrated model is as follows:

- Total recharge to the groundwater basin from precipitation is 15,727 m³/d.
- Groundwater inflow to Sylvan Lake is 12,498 m³/d.
- Groundwater inflow to Cygnet Lake, the Red Deer River, the Outlet Channel and Sylvan Creek totals 3,229 m³/d.

An independent check on the groundwater inflow rate to Sylvan Lake as calculated with the model can be made with an analytical calculation using the Darcy equation. The Darcy equation is:

$$Q = K \times I \times L \times T$$

Where: Q = the groundwater inflow rate
 K = hydraulic conductivity
 I = hydraulic gradient
 L = length of flow section perpendicular to the groundwater flow direction
 T = thickness of flow section

The groundwater inflow rate (Q) to Sylvan Lake was calculated for the northeast side of the lake, the southwest side and the northwest end (groundwater inflow does not occur at the southeast end of the lake). The hydraulic conductivity in the model domain adjacent to Sylvan Lake is 2×10^{-5} m/s which is the same as the average hydraulic conductivity of Hydrostratigraphic Unit 1 as reported in Gabert (1975). The hydraulic gradients on the northeast side of the lake, the southwest side and the northwest end are 0.008, 0.038 and 0.015 m/m. The length of the northeast side of the lake, the southwest side and the northwest end are 13.5 km, 13.5 km and 3.2 km. The thickness of the flow section was assigned as the average depth of the lake (i.e., 9.6 m). Based on these parameter values, the Darcy flow rate into the lake is calculated to be 11,098 m³/d which is reasonably close to the rate of 12,498 m³/d as calculated by the model.

B-3.5.2 Results With Groundwater Pumping

One of the objectives of the project was to assess current water withdrawal rates from groundwater sources and the implications to the lake's water and nutrient balance. This objective was addressed in part by conducting a simulation with the model in which pumping from the Town of Sylvan Lake's water wells using the 2003 production volume of 1,061,730 m³ (2,908 m³/d) was included. Figure B-16 shows the simulated hydraulic head distribution within the model domain with pumping from the Town's wells. Comparing this distribution to the distribution shown on Figure B-15 shows that the Town's groundwater production would have little effect on the hydraulic head distribution. This result is not unexpected as the Town's

production of 1,061,730 m³ in 2003 is only about 0.01% of the volume of groundwater in storage within the groundwater basin (9,000,000,000 m³) as calculated by the model.

The mass balance for the calibrated model with the Town's 2003 groundwater production is as follows:

- Total recharge to the groundwater basin from precipitation is 15,727 m³/d.
- Groundwater inflow to Sylvan Lake is 9,727 m³/d.
- Groundwater inflow to Cygnet Lake, the Red Deer River, the Outlet Channel and Sylvan Creek totals 3,092 m³/d.
- Groundwater production from the Town's wells in 2003 is 2,908 m³/d.

By including the Town's 2003 production, the groundwater inflow to Sylvan Lake is reduced from 12,498 m³/d to 9,727 m³/d (a 22% reduction). This reduction is discussed further in the main report.

B-3.6 Limitations

The following limitations are noted for the groundwater flow model:

- A porous media flow model was used to represent a predominantly fractured flow system. However, given the scale of the model in relation to the fracturing and the good fit between simulated and measured hydraulic heads, this is not considered to be a significant limitation.
- In order to analyze this groundwater system on a basin scale, some local-scale detail is lost.
- There is likely considerable natural spatial variability in many of the model parameters. The model has used "best estimates" for these parameters.

Despite the limitations inherent in modelling a complex hydrogeologic system, a reasonably good approximation of groundwater flow under natural conditions was obtained. Through the calibration process it was found that the hydraulic conductivity of Hydrostratigraphic Unit 1 and groundwater recharge fell within a relatively small range of values that were in good agreement with reported values. In light of these factors, the results obtained with the groundwater flow model were considered adequate for addressing the objectives of this study.

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List of Tables

- B-1 Summary of Water Well Drilling Reports
- B-2 Chemistry Data with Water Well Drilling Reports
- B-3 Data for Town of Sylvan Lake Wells
- B-4 Yearly Water Consumption (1985 – 2003) for Town of Sylvan Lake
- B-5 AENV Observation Wells in the Sylvan Lake Area
- B-6 Historic Chemical Analysis Results for AENV Observation Wells
- B-7 Field Testing Results for AENV Observation Wells
- B-8 Chemical Analysis Results for AENV Observation Wells
- B-9 Field Testing Results for Shallow Monitoring Wells
- B-10 Chemical Analysis Results for Shallow Monitoring Wells
- B-11 Measured Heads and Simulated Heads From Model Calibration

List of Figures

- B-1 Surficial Geology of the Red Deer Region
- B-2 Thickness of Surficial Deposits in the Red Deer Region
- B-3 Bedrock Topography in the Red Deer Region
- B-4 Cross-section C-C' From Gabert (1975)
- B-5 Thickness of Hydrostratigraphic Unit 1
- B-6 Groundwater Probability Map
- B-7 Location and Distribution of Groundwater Phenomena and Recharge Areas
- B-8 Recharge /Discharge Zones
- B-9 Areal Distribution of Total Dissolved Solids in ppm
- B-10 Hydraulic Head Distribution for Hydrostratigraphic Unit 1
- B-11 Cross-section A-A'
- B-12 Cross-section B-B'
- B-13 Model Domain
- B-14 Correlation Plot and Statistical Analysis for the Calibrated Model
- B-15 Simulated Hydraulic Head Distribution Without Town Wells
- B-16 Simulated Hydraulic Head Distribution With Town Wells (2003 Pumping)

List of Attachments

- B-1 Laboratory Reports
- B-2 Completion Diagrams for Shallow Monitoring Wells

Tables

Table B-1
Summary of Water Well Drilling Reports

Project Ref. No.	AENV Well ID	Legal Location	Owner (on report)	Proposed Use	Well Elevation (m asl)	Water Requirement (m³/d)	Completion Date (dd/mm/yy)	Drilled Depth (m)	Completed Depth (m)	Screen or Perforated Intervals (m)			Depth of Seal (m)	Non-Pumping Weater Level (m)	Test Pumping Rate (m³/d)	Total Drawdown at End of Pumping (m)	Litholog Available (Y/N)	Chemistry Report Available (Y/N)	Well Yield Test Data Available (Y/N)
1	352300	NE-01-038-01-W5	Long, Bill	Domestic	936	NR	23/6/78	48.8	48.8	NR	to	NR	NR	7.3	109	NR	Y	Y	N
2	352296	SE-01-038-01-W5	Sawyer, Ted	Stock	NR	NR	31/5/74	27.7	27.7	12.2	to	27.7	17.4	8.5	54.5	19.2	Y	N	N
3	352297	SE-01-038-01-W5	C&T Res	Industrial	NR	NR	4/8/84	18.3	18.3	6.1	to	11.6	0.0	4.6	327	6.7	Y	N	Y
4	352298	NW-01-038-01-W5	Moore, Bill	Domestic	NR	NR	30/9/78	25.9	25.9	16.2	to	25.9	14.9	8.5	152.6	8.2	Y	N	Y
5	352311	NE-02-038-01-W5	Eric/Phyllis, Johanson	Domestic	945	NR	9/4/86	36.6	36.6	NR	to	NR	NR	NR	NR	NR	N	Y(3)	N
6	352312	NE-02-038-01-W5	Johanson, John	Domestic	945	NR	9/6/62	19.5	19.5	NR	to	NR	NR	6.7	54.5	12.8	Y	Y	N
7	353968	NE-02-038-01-W5	Johanson, Eric	Domestic	NR	NR	15/10/90	18.3	18.3	10.7	to	18.3	11.0	4.3	109	0.0	Y	N	N
8	352304	NW-02-038-01-W5	Feitt, Carl	Domestic	NR	NR	29/10/77	42.7	42.7	10.7	to	42.7	12.2	25.3	81.75	0.0	Y	Y	N
9	352305	NW-02-038-01-W5	Swainson, John A.	Stock	NR	NR	22/7/81	18.3	18.3	12.8	to	18.3	12.8	0.0	65.4	15.2	Y	N	N
10	491408	NW-02-038-01-W5	Swainson, John A.	Stock	NR	3.79	4/9/98	24.4	24.4	13.4	to	19.8	13.4	4.0	327	20.4	Y	N	Y
11	498563	SW-02-038-01-W5	Swainson, John A.	Stock	NR	7.57	11/6/01	24.4	24.4	18.3	to	24.4	21.0	2.7	381.5	17.1	Y	N	Y
12	352321	NE-03-038-01-W5	Comin, Erwin	Domestic	953	NR	26/11/80	18.3	18.3	NR	to	NR	NR	NR	NR	NR	N	Y(2)	N
13	352324	NE-03-038-01-W5	Comis, Erwin	Domestic	953	NR	2/12/82	35.1	35.1	28.3	to	35.1	28.3	8.5	228.9	1.5	Y	Y	N
14	352325	NE-03-038-01-W5	Comis, Erwin	Unknown	953	NR	NR	NR	NR	NR	to	NR	NR	NR	NR	NR	N	Y	N
15	352326	NE-03-038-01-W5	Yarborough, Lloyd	Unknown	953	NR	NR	NR	NR	NR	to	NR	NR	NR	NR	NR	N	Y	N
16	494613	NE-03-038-01-W5	Hanson, Wayne	Domestic	NR	1.14	30/6/99	29.0	29.0	24.1	to	29.0	24.1	7.5	98.1	5.9	Y	N	Y
17	352314	SE-03-038-01-W5	Dallaire, F.C.	Stock	936	NR	3/12/83	48.8	48.8	30.5	to	48.8	18.6	1.2	190.75	29.3	Y	N	N
18	495632	SW-03-038-01-W5	Dallaire, Frank	Domestic & Stock	NR	1.89	11/4/00	91.4	91.4	39.6 61.0	to to	42.7 73.2	38.7	15.8	19.075	90.4	Y	N	Y
19	352526	SW-13-038-01-W5	Krebs, Henry	Stock	NR	11.36	11/7/84	45.7	45.7	29.0	to	45.7	NR	1.5	43.6	44.2	Y	N	N
20	351679	NW-14-038-01-W5	Robinson, Greg	Domestic	NR	NR	20/6/90	35.1	35.1	27.4	to	35.1	21.6	5.8	147.15	0.0	Y	N	N
21	352535	NW-14-038-01-W5	Davidson, Ron	Domestic	942	NR	17/6/82	36.6	30.5	24.4	to	30.5	21.3	18.3	87.2	0.0	Y	N	N
22	352531	SW-14-038-01-W5	Johanson, Oscar	Stock	933	NR	20/6/84	50.3	50.3	32.0	to	50.3	NR	4.9	27.25	25.6	Y	N	N
23	415961	NE-15-038-01-W5	Schreuder, WM.	Domestic	NR	NR	24/9/70	24.4	24.4	NR	to	NR	NR	1.8	NR	NR	N	Y(2)	N
24	367359	NW-15-038-01-W5	Matejka, Tony	Domestic	NR	NR	16/9/92	42.7	42.7	24.4	to	42.7	24.4	9.4	136.25	27.1	Y	N	N
25	467388	NW-15-038-01-W5	Sybulka, Henry	Domestic	NR	1.32	30/7/97	42.7	42.7	30.5	to	42.7	14.9	10.4	152.6	32.3	Y	N	Y
26	469570	NW-15-038-01-W5	Hughes, David/Yvonne	Domestic	NR	1.32	7/5/98	33.5	33.5	27.4	to	33.5	23.2	11.9	65.4	0.0	Y	N	Y
27	358754	SE-15-038-01-W5	Nielsen, Les	Stock	NR	NR	13/6/91	18.3	18.3	14.0	to	17.1	11.0	0.2	283.4	18.0	Y	N	N
28	499185	NE-15-038-01-W5	Matejka Farms	Domestic	NR	1.51	27/11/97	39.6	39.6	27.4	to	39.6	24.4	7.9	599.5	32.0	Y	N	Y
29	352543	08-16-038-01-W5	Hakala, T.	Domestic	959	NR	14/7/65	NR	NR	NR	to	NR	NR	NR	NR	NR	N	Y	N
30	352544	08-16-038-01-W5	Hakala, T.	Domestic	958	NR	1/1/40	18.3	18.3	NR	to	NR	NR	4.3	NR	NR	N	y	N
31	467389	10-16-038-01-W5	Star Gas & Oil Ltd/Tricity 14	Industrial	NR	34.07	4/10/96	36.6	36.6	9.1	to	33.5	5.8	11.3	228.9	25.3	Y	N	Y
32	352547	NE-16-038-01-W5	Jensen, Ron	Domestic	963	NR	16/10/79	39.6	39.6	19.5	to	39.6	22.9	11.3	163.5	4.6	Y	N	N
33	352548	NE-16-038-01-W5	Mcmillan, Don	Domestic	960	NR	28/7/81	33.5	33.5	NR	to	NR	NR	NR	NR	NR	N	Y	N
34	352549	NE-16-038-01-W5	Mcmillan, Don	Domestic	960	NR	28/7/81	NR	NR	NR	to	NR	NR	NR	NR	NR	N	Y	N
35	352551	NE-16-038-01-W5	Strasser, Peter	Domestic	968	NR	31/3/82	53.3	53.3	27.4	to	53.3	24.4	16.8	152.6	6.1	Y	Y	N
36	352552	NE-16-038-01-W5	Hagerman, Tom	Domestic	968	NR	25/4/86	NR	NR	NR	to	NR	NR	NR	NR	NR	N	Y	N
37	350613	SE-16-038-01-W5	Hagerman, Tom	Stock	NR	NR	9/3/90	24.4	24.4	18.9	to	24.4	18.9	9.4	43.6	4.3	Y	N	Y
38	352541	SE-16-038-01-W5	Hanson, R.C.	Domestic & Stock	957	NR	23/11/72	33.5	33.5	NR	to	NR	NR	12.2	38.15	15.8	Y	Y	N
39	466295	SE-16-038-01-W5	Delage, Dennis	Domestic	NR	1.32	25/5/96	36.6	36.6	18.3	to	30.5	18.6	15.8	38.15	10.4	Y	N	Y
40	352556	SW-17-038-01-W5	Ammeter, J.	Domestic	990	NR	26/4/62	24.4	24.4	NR	to	NR	NR	6.1	54.5	17.7	Y	Y(2)	N
41	352562	NW-18-038-01-W5	Hillman, Les	Domestic	989	NR	7/8/79	42.7	42.7	25.0	to	42.7	25.0	31.1	81.75	0.0	Y	Y	N
42	352564	NW-18-038-01-W5	Hillman, Les	Domestic	992	NR	20/5/86	NR	NR	NR	to	NR	NR	NR	NR	NR	N	Y	N
43	406366	SE-18-038-01-W5	Wahl, Lucille	Domestic	NR	2.65	16/5/95	39.9	39.9	27.4	to	39.6	21.9	29.0	163.5	11.0	Y	N	Y
44	352568	05-19-038-01-W5	Hillman, H.	Domestic	981	NR	1/10/57	12.2	12.2	NR	to	NR	NR	4.6	NR	NR	Y	Y	N
45	370191	10-19-038-01-W5	Turquist, Glen	Domestic	NR	NR	9/7/93	15.2	15.2	10.7	to	15.2	8.5	0.6	136.25	11.6	Y	N	Y
46	352977	16-19-038-01-W5	StarOil & Gas	Industrial	NR	NR	27/11/90	61.0	61.0	27.4	to	54.9	26.2	27.4	43.6	33.5	Y	N	Y
47	352569	NW-19-038-01-W5	Piller, Bill	Domestic & Stock	969	NR	29/8/75	45.7	45.7	27.4	to	45.7	30.5	14.6	43.6	31.1	Y	N	N
48	352570	NW-19-038-01-W5	Seida, W.	Domestic	969	NR	23/5/67	21.3	21.3	NR	to	NR	NR	15.2	NR	NR	N	Y	N
49	352572	NW-19-038-01-W5	Simanton, Ron	Domestic	962	NR	13/2/79	30.5	30.5	NR	to	NR	NR	NR	NR	NR	N	Y	N
50	352573	NW-19-038-01-W5	Olson, John	Domestic	969	NR	11/11/83	NR	NR	NR	to	NR	NR	NR	NR	NR	N	Y	N
51	370189	NW-19-038-01-W5	Johnston, Larry	Domestic	NR	NR	29/7/93	21.3	21.3	15.2	to	21.3	10.1	11.9	81.75	1.8	Y	N	N
52	370190	NW-19-038-01-W5	Crawford, Ken	Domestic	NR	NR	16/7/93	15.2	15.2	10.7	to	14.6	7.0	1.5	136.25	10.7	Y	N	N
53	382838	NW-19-038-01-W5	Hilman, Gale	Domestic	NR	1.89	27/4/94	22.9	22.9	15.5	to	22.6	11.0	11.3	147.15	0.0	Y	N	N

NR - not reported

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Summary of Water Well Drilling Reports

Project Ref. No.	AENV Well ID	Legal Location	Owner (on report)	Proposed Use	Well Elevation (m asl)	Water Requirement (m³/d)	Completion Date (dd/mm/yy)	Drilled Depth (m)	Completed Depth (m)	Screen or Perforated Intervals (m)			Depth of Seal (m)	Non-Pumping Weater Level (m)	Test Pumping Rate (m³/d)	Total Drawdown at End of Pumping (m)	Litholog Available (Y/N)	Chemistry Report Available (Y/N)	Well Yield Test Data Available (Y/N)
54	382840	NW-19-038-01-W5	Crawford, Ken	Domestic	NR	1.89	3/5/94	16.8	16.8	9.1	to	16.8	8.8	2.1	136.25	1.5	Y	N	N
55	352565	SW-19-038-01-W5	Bechthold, George	Unknown	983	NR	10/9/71	24.4	24.4	NR	to	NR	NR	NR	NR	NR	N	Y	N
56	352577	07-20-038-01-W5	Zinn, Sheldon	Domestic & Stock	976	NR	18/4/62	37.2	37.2	NR	to	NR	NR	29.0	81.75	8.2	Y	Y	N
57	352660	NE-20-038-01-W5	Hagerman, Bruce	Domestic	981	NR	19/1/82	NR	NR	NR	to	NR	NR	NR	NR	NR	N	Y	N
58	352661	NE-20-038-01-W5	Hargerman, Tom	Domestic	981	NR	14/4/86	51.8	51.8	NR	to	NR	NR	NR	NR	NR	N	Y(2)	N
59	466296	NE-20-038-01-W5	Drews, John	Domestic	NR	7.57	23/4/96	24.4	24.4	19.8	to	24.4	17.4	14.8	272.5	9.4	Y	N	Y
60	399139	NW-20-038-01-W5	Gathercole	Domestic	NR	3.03	9/9/94	36.6	36.6	27.4	to	36.6	12.2	16.5	136.25	20.1	Y	N	Y
61	352576	SE-20-038-01-W5	Wilde, Howard	Domestic	978	NR	1/1/72	39.6	39.6	NR	to	NR	NR	NR	NR	NR	N	Y	N
62	362025	SW-20-038-01-W5	Hagerman, Tom	Domestic	NR	NR	7/11/91	21.3	21.3	15.2	to	21.3	9.8	1.5	152.6	19.8	Y	N	N
63	352668	NE-21-038-01-W5	Hagerman, Tom	Domestic	983	NR	6/7/88	59.4	59.4	47.2	to	59.4	45.4	45.4	65.4	0.3	Y	N	Y
64	365489	NE-21-038-01-W5	Hagerman, Tom	Domestic	NR	NR	19/6/92	54.9	54.9	47.2	to	54.9	46.6	43.0	136.25	11.9	Y	N	N
65	365490	NW-21-038-01-W5	Hagerman, Tom	Domestic	NR	NR	19/6/92	24.4	24.4	18.3	to	24.4	11.3	6.1	125.35	18.3	Y	N	N
66	399145	NW-21-038-01-W5	Hagerman, Tom	Domestic	NR	1.51	23/9/93	24.4	24.4	15.2	to	24.4	13.4	5.5	54.5	0.0	Y	N	Y
67	352663	SW-21-038-01-W5	Smith, H.L.	Domestic	975	NR	2/2/67	33.2	33.2	NR	to	NR	NR	22.9	NR	NR	N	Y	N
68	364635	SW-21-038-01-W5	Pearson, Rob/Debbie	Domestic & Stock	NR	1.51	30/4/92	45.7	45.7	31.4	to	45.7	28.3	28.7	32.7	13.4	Y	N	Y
69	499186	NW-21-038-01-W5	Sylvan Southland Golf Course	Domestic	NR	1.51	12/5/85	24.7	24.7	18.3	to	24.4	13.4	10.6	59.95	13.4	Y	N	Y
70	350677	NW-22-038-01-W5	Herder, Bob	Stock	NR	NR	5/3/90	54.9	54.9	45.7	to	51.8	39.6	37.8	163.5	0.3	Y	N	Y
71	353986	NW-22-038-01-W5	Herder, Bob	Domestic	975	NR	27/10/90	62.2	62.2	54.9	to	62.2	54.9	40.5	21.8	0.0	Y	N	N
72	365416	NW-23-038-01-W5	Quick, Allen/Wendy	Domestic	NR	NR	28/5/92	60.4	60.4	36.0	to	60.4	38.4	10.7	54.5	43.6	Y	N	N
73	367033	NW-23-038-01-W5	Jordi, Walter	Domestic	NR	NR	23/10/92	53.3	53.3	35.7	to	52.7	37.8	11.6	141.7	5.5	Y	N	N
74	371570	SW-23-038-01-W5	Blanchard, Jerry	Domestic	NR	NR	28/7/93	33.5	33.5	30.5	to	33.5	24.4	7.0	327	26.5	Y	N	N
75	352676	14-23-038-01-W5	Lindman, J.	Domestic	944	NR	14/7/65	NR	NR	NR	to	NR	NR	NR	NR	NR	N	Y	N
76	351636	SE-25-038-01-W5	Kirk, Russ	Domestic	NR	NR	6/10/89	47.2	47.2	39.0	to	45.7	39.0	10.4	136.25	20.1	Y	N	N
77	436620	04-26-038-01-W5	Geist, Hughy	Domestic	NR	0.38	15/11/95	29.0	29.0	22.9	to	29.0	6.1	2.1	109	0.0	Y	N	Y
78	352684	SE-26-038-01-W5	Herder, Robert	Stock	936	7.57	8/4/89	42.7	42.7	33.5	to	42.7	33.2	0.0	190.75	0.0	Y	N	Y
79	352688	SW-26-038-01-W5	Lindhome, Gordon	Industrial	942	NR	3/8/84	31.7	31.7	25.6	to	31.7	24.4	1.5	218	0.0	Y	N	Y
80	352689	SW-26-038-01-W5	Lindhome, Gordon	Domestic	942	NR	25/6/84	37.5	37.5	31.4	to	37.5	30.5	1.5	218	0.0	Y	N	N
81	491409	SW-26-038-01-W5	Mccarthey, Jim	Domestic	NR	1.14	13/8/98	36.6	36.6	22.9	to	36.6	18.3	1.2	272.5	35.4	Y	N	Y
82	496117	NE-26-038-01-W5	Conazza, Brian	Domestic	NR	2.46	2/5/00	48.8	48.8	42.7	to	48.8	42.7	5.2	436	2.7	Y	N	Y
83	352695	SE-27-038-01-W5	Taylor, Dwight	Domestic	953	NR	6/5/87	36.6	36.6	25.9	to	36.6	24.4	15.8	136.25	0.0	Y	N	N
84	407545	SE-27-038-01-W5	Spurrell, Ron	Domestic	NR	0.95	14/7/95	30.5	30.5	24.4	to	30.5	18.9	9.4	272.5	1.2	Y	N	Y
85	466297	SE-27-038-01-W5	Eskelsom, Ron	Domestic	NR	0.95	19/8/96	39.6	39.6	33.5	to	39.6	24.1	19.2	109	8.2	Y	N	Y
86	467390	SE-27-038-01-W5	Getschel, Scott	Domestic	NR	1.14	5/7/96	24.4	24.4	18.3	to	22.9	17.4	9.0	119.9	14.9	Y	N	Y
87	491410	SE-27-038-01-W5	Hyvonen, Lorne	Domestic	NR	0.95	2/2/98	36.6	36.6	25.0	to	36.6	23.8	17.6	163.5	0.0	Y	N	Y
88	352699	SW-27-038-01-W5	Mcwade, Jack	Domestic	960	NR	5/2/73	53.9	53.9	38.4	to	53.9	NR	35.1	136.25	0.0	Y	N	N
89	352700	SW-27-038-01-W5	Mcwade, Rob	Domestic	960	NR	6/6/87	42.7	42.7	27.4	to	42.7	23.8	30.8	190.75	0.0	Y	N	Y
90	495634	SE-27-038-01-W5	Blinkhorn, Pat	Domestic	NR	1.14	29/9/98	30.5	30.5	21.3	to	30.5	21.3	11.6	92.65	0.0	Y	N	Y
91	497798	SE-27-038-01-W5	Petty, Caroline	Domestic	NR	1.14	21/3/01	30.5	30.5	26.8	to	30.5	26.8	7.6	NR	7.6	Y	N	Y
92	418176	00-27-038-01-W5	Williamson, Rick	Domestic	NR	0.95	6/10/95	36.6	36.6	29.0	to	36.6	24.1	18.3	136.25	4.0	Y	N	Y
93	352704	NW-27-038-01-W5	Arlint, Bernard	Domestic & Stock	945	NR	8/4/88	47.2	47.2	39.3	to	47.2	39.3	6.4	163.5	7.6	Y	n	N
94	383760	SE-27-038-01-W5	Taylor, Tim	Domestic	NR	1.89	30/8/95	36.6	36.6	27.4	to	36.6	24.4	17.8	190.75	18.0	Y	N	Y
95	467814	SE-27-038-01-W5	Coules, John	Domestic	NR	0.95	26/6/97	30.5	30.5	21.3	to	30.5	17.7	10.0	163.5	19.8	Y	N	Y
96	354789	09-29-038-01-W5	Sylvan Lake Town of	Municipal	NR	NR	1/2/76	61.0	61.0	NR	to	NR	NR	33.5	NR	NR	N	Y(3)	N
97	353090	NE-29-038-01-W5	Sylvan Lake Town of	Municipal	965	NR	15/5/80	60.4	60.4	21.0	to	60.4	18.3	11.3	109	NR	Y	N	N
98	353095	NE-29-038-01-W5	Sylvan Lake Town of	Municipal	968	NR	31/1/83	48.8	48.8	NR	to	NR	NR	NR	NR	NR	N	Y(2)	N
99	352896	NW-29-038-01-W5	Boomer, Harry	Domestic	960	NR	8/4/81	25.9	25.9	NR	to	NR	NR	NR	NR	NR	N	Y	N
100	352890	SE-29-038-01-W5	Trottier, J.	Domestic	991	NR	1/1/54	37.8	37.8	NR	to	NR	NR	18.3	NR	NR	N	Y	N
101	352892	SW-29-038-01-W5	Boomer, L.	Domestic	977	NR	1/4/76	33.5	33.5	NR	to	NR	NR	24.4	NR	NR	N	Y(2)	N
102	350678	NW-30-038-01-W5	Freschette, Fred	Domestic	NR	NR	21/2/90	28.3	28.3	23.2	to	27.4	23.2	10.7	81.75	1.2	Y	n	Y
103	353113	NE-30-038-01-W5	Rowe, Stuart	Domestic & Stock	960	NR	18/5/88	23.2	23.2	13.7	to	22.9	11.6	9.8	65.4	0.0	Y	N	N
104	353100	SE-30-038-01-W5	Wagner, Robert	Domestic	978	NR	19/9/71	38.1	38.1	NR	to	NR	NR	12.2	0	0.0	N	Y	N
105	350614	SW-30-038-01-W5	Curran, Dick	Domestic	NR	NR	2/5/90	38.1	38.1	33.5	to	37.2	28.7	11.6	98.1	26.5	Y	N	N
106	353105	SW-30-038-01-W5	Dufffield, Mac	Domestic	968	NR	4/9/75	30.5	30.5	24.4	to	30.5	NR	8.5	65.4	11.3	Y	N	N
107	353107	SW-30-038-01-W5	Curran, Maureen	Domestic	960	NR	10/6/81	35.1	35.1	NR	to	NR	NR	NR	NR	NR	N	Y	N

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Project Ref. No.	AENV Well ID	Legal Location	Owner (on report)	Proposed Use	Well Elevation (m asl)	Water Requirement (m³/d)	Completion Date (dd/mm/yy)	Drilled Depth (m)	Completed Depth (m)	Screen or Perforated Intervals (m)			Depth of Seal (m)	Non-Pumping Weater Level (m)	Test Pumping Rate (m³/d)	Total Drawdown at End of Pumping (m)	Litholog Available (Y/N)	Chemistry Report Available (Y/N)	Well Yield Test Data Available (Y/N)
108	353109	SW-30-038-01-W5	Curran, R.T.	Domestic	968	NR	11/12/85	25.9	25.9	NR	to	NR	NR	NR	NR	NR	N	Y	N
109	353110	SW-30-038-01-W5	Hinshaw, David	Stock	968	NR	NR	NR	NR	NR	to	NR	NR	NR	NR	NR	N	Y(2)	N
110	353608	08-35-038-01-W5	Floyds Truck and Tractor	Domestic	939	NR	23/5/68	42.4	42.4	31.4	to	42.4	NR	2.4	54.4	0.0	Y	N	N
111	468010	NW-35-038-01-W5	Catco	Industrial	NR	0.26	4/12/96	42.7	42.7	33.5	to	42.7	30.8	4.1	163.2	4.0	Y	N	N
112	365418	SE-35-038-01-W5	Gogal, R.	Domestic	NR	NR	25/6/92	54.9	54.9	45.7	to	54.9	45.7	4.0	163.2	50.9	Y	N	N
113	353609	SW-35-038-01-W5	Hack, William	Domestic	933	NR	5/12/75	36.6	36.6	NR	to	NR	NR	NR	NR	NR	N	Y	N
114	353595	SE-35-038-01-W5	Don's Trailer Park	Domestic	939	NR	8/7/75	35.1	35.1	NR	to	NR	NR	10.7	109	16.8	Y	Y	N
115	357326	NE-24-038-02-W5	Ljunggren, Alvin N.	Domestic	975	NR	15/3/96	21.6	21.6	NR	to	NR	NR	15.5	NR	NR	N	Y	N
116	357327	NE-24-038-02-W5	Hillman, Allan	Domestic	975	NR	30/9/82	30.5	30.5	16.8	to	30.5	16.5	10.1	218	20.4	Y	Y	N
117	418741	NE-24-038-02-W5	Hilman, Glen	Domestic	NR	1.89	5/5/95	12.2	12.2	8.5	to	9.1	8.5	4.6	32.7	7.6	Y	N	Y
118	357339	NE-25-038-02-W5	Craven, Stewart	Domestic	976	NR	1/10/64	34.1	34.1	NR	to	NR	NR	19.5	54.5	9.1	Y	Y(2)	N
119	357329	SE-25-038-02-W5	Seven Day Adventist Church	Domestic	960	NR	26/8/75	64.6	64.6	34.1	to	64.6	29.6	21.3	109	43.3	Y	N	N
120	357331	SE-25-038-02-W5	Mannerfied, ron	Domestic & Stock	960	NR	31/8/87	51.2	51.2	27.7	to	51.2	27.7	17.7	109	6.7	Y	N	N
121	370233	SW-25-038-02-W5	Severtson, Duke	Domestic	NR	NR	29/7/93	62.5	62.5	56.4	to	62.5	35.1	19.8	81.75	39.6	Y	N	N
122	466300	SW-25-038-02-W5	Dietrich, Dennis L.	Domestic	NR	0.95	16/7/96	25.9	25.9	19.8	to	25.9	17.7	11.7	109	3.6	Y	N	Y
123	437397	SW-25-038-02-W5	Knight, Ken/Sandy	Domestic	NR	1.14	6/5/96	30.5	30.5	25.9	to	30.5	12.8	14.0	545	15.9	Y	N	Y
124	491483	SW-25-038-02-W5	Rigueldel, Rick	Domestic	NR	1.14	28/8/98	36.6	36.6	21.3	to	36.6	20.1	10.0	81.75	21.3	Y	N	Y
125	467815	NE-26-038-02-W5	Martin, Rod/Bev	Domestic	NR	1.32	29/8/97	54.9	54.9	42.7	to	54.9	42.7	21.9	65.4	32.9	Y	N	Y
126	382847	NW-26-038-02-W5	Shoulders, John	Domestic	NR	1.89	7/4/94	21.3	21.3	17.7	to	21.3	6.7	2.3	196.2	0.6	Y	N	N
127	357341	SE-26-038-02-W5	Britton, Jack	Stock	966	1.89	15/6/88	18.3	18.3	9.8	to	18.3	7.3	0.6	109	17.7	Y	N	N
128	355610	SW-26-038-02-W5	Hartigh, Garth/Janet	Domestic & Stock	NR	NR	29/11/90	38.1	38.1	25.9	to	38.1	28.7	22.6	109	6.7	Y	N	N
129	341856	NE-26-038-02-W5	Martin, Rod	Domestic & Stock	NR	NR	24/9/02	67.1	67.1	51.8	to	67.1	51.8	33.5	109	33.5	Y	N	Y
130	1060026	SE-26-038-02-W5	Klatt, Richard	Unknown	NR	NR	19/9/03	67.1	39.6	15.2	to	21.3	11.3	7.3	218	11.0	Y	N	Y
131	357509	NW-34-038-02-W5	Bath, Lee	Domestic & Stock	991	NR	25/3/82	39.6	39.6	30.5	to	39.6	30.5	17.4	98.1	5.5	Y	N	N
132	358331	SE-34-038-02-W5	Dube, Francois	Domestic	NR	NR	8/5/91	38.1	38.1	19.5	to	38.1	21.6	7.3	196.2	1.2	Y	N	N
133	357517	15-35-038-02-W5	Woima, E.	Domestic	944	NR	1/1/60	33.5	33.5	NR	to	NR	NR	13.7	16.35	0.0	N	Y	N
134	357515	NE-35-038-02-W5	Staudinger, Harvey	Domestic	978	NR	14/8/85	30.5	30.5	NR	to	NR	NR	14.6	NR	NR	N	Y(2)	N
135	410874	SE-35-038-02-W5	Severtson, Duke	Domestic	NR	1.14	25/8/95	36.6	36.6	25.9	to	36.6	25.0	11.0	136.25	25.6	Y	N	N
136	357513	SW-35-038-02-W5	Dube, Francois	Domestic	991	NR	30/9/75	36.6	36.6	21.3	to	36.6	22.3	10.7	136.25	4.6	Y	N	Y
137	358428	NE-36-038-02-W5	Jarvis, Ralph	Stock	NR	NR	30/3/90	67.1	67.1	36.6	to	67.1	34.4	39.9	16.35	0.0	Y	N	N
138	351680	NW-36-038-02-W5	Schlachter, Bill	Domestic & Stock	NR	NR	6/7/90	48.8	48.8	36.6	to	45.7	27.7	32.0	98.1	0.0	Y	N	N
139	466303	NW-36-038-02-W5	Schlachter, Miram	Domestic	NR	1.89	26/4/96	42.7	42.7	30.5	to	42.7	27.4	21.3	163.5	33.5	Y	N	Y
140	357518	SE-36-038-02-W5	Boehr, Lewis	Domestic	981	NR	22/8/75	39.6	39.6	24.4	to	39.6	25.3	19.8	136.25	12.2	Y	Y	N
141	357520	SE-36-038-02-W5	Brzak, Wayne	Domestic & Stock	981	NR	7/4/89	38.1	38.1	24.4	to	38.1	23.2	21.6	81.75	16.5	Y	N	N
142	272174	NE-17-038-28-W4	Fraser, Gregg	Domestic	NR	1.51	11/7/95	76.2	76.2	61.0	to	76.2	60.7	25.0	54.5	51.2	Y	N	Y
143	97008	SE-17-038-28-W4	Blakely, E.W.	Domestic & Stock	NR	NR	6/12/74	61.0	61.0	51.2	to	61.0	51.2	16.8	136.25	0.0	Y	N	Y
144	97036	NE-29-038-28-W4	Wenger, Ken	Domestic	NR	NR	16/6/87	54.9	54.9	32.0	to	54.9	29.9	26.3	65.4	NR	Y	N	N
145	237629	SE-29-038-28-W4	Schritt, H.G.	Domestic & Stock	NR	7.57	20/11/93	57.9	57.9	48.8	to	57.9	51.2	12.2	136.25	14.0	Y	N	Y
146	99659	04-29-038-28-W4	Yarbrough#231	Domestic	NR	NR	NR	19.8	19.8	NR	to	NR	NR	6.1	NR	NR	N	Y	N
147	99662	NE-29-038-28-W4	Mcafee, J.	Domestic	962	NR	29/7/63	39.6	39.6	NR	to	NR	NR	19.8	109	19.8	N	Y	N
148	99658	SE-29-038-28-W4	Harvey, Ross	Stock	937	NR	16/9/67	34.1	34.1	29.6	to	34.1	NR	11.3	136.25	1.5	Y	N	Y
149	282183	SE-29-038-28-W4	Harvey, Ross	Domestic	NR	NR	NR	48.8	48.8	NR	to	NR	NR	NR	NR	NR	N	Y	N
150	286562	SE-29-038-28-W4	Gyori, Paul	Domestic	NR	1.32	18/6/97	18.3	18.3	12.2	to	18.3	14.9	11.0	81.75	0.0	Y	N	Y
151	288654	SE-29-038-28-W4	Lapointe, Marcel	Domestic	NR	1.51	13/5/97	39.6	39.6	30.5	to	39.6	30.5	21.0	218	17.1	Y	N	Y
152	150513	SW-29-038-28-W4	Harvey, Ross	Domestic	NR	NR	8/2/90	42.7	42.7	30.5	to	42.7	32.9	8.5	163.5	0.0	Y	N	N
153	99661	NE-29-038-28-W4	Smith, Bruce	Domestic	NR	NR	NR	NR	NR	NR	to	NR	NR	NR	NR	NR	N	Y	N
154	282152	SE-29-038-28-W4	Harvey, Ross	Stock	NR	NR	12/9/73	39.6	39.6	NR	to	NR	NR	12.5	109	NR	Y	Y	N
155	357551	NW-02-039-01-W5	Van Doesburg H.	Domestic & Stock	960	NR	13/5/82	82.3	82.3	53.3	to	82.3	51.8	38.1	33	41.1	Y	N	N
156	377679	SE-02-039-01-W5	Ellerby, T.	Domestic & Stock	NR	0.50	15/10/93	52.4	52.4	34.1	to	52.4	36.3	17.1	130	17.1	Y	N	N
157	357546	SW-02-039-01-W5	Morigeau, D.	Domestic & Stock	972	NR	2/6/82	36.6	36.6	24.4	to	33.5	0.6	19.5	70	1.2	Y	N	N
158	407874	13-10-039-01-W5	Lidston, Richard	Domestic	NR	0.57	7/7/95	55.5	55.5	47.9	to	55.5	19.2	45.7	54.5	2.1	Y	N	Y
159	358100	NE-10-039-01-W5	Lyons, Fred	Domestic	975	NR	25/6/73	86.3	86.3	47.9	to	55.5	0.0	55.8	81.75	0.0	Y	N	N
160	386217	NW-10-039-01-W5	Duschanak, Kevin	Domestic	NR	1.51	12/7/94	91.4	91.4	67.1	to	91.4	63.4	49.7	54.5	41.8	Y	N	Y
161	399208	NW-10-039-01-W5	Whymark, Colin	Domestic	NR	1.51	16/9/94	61.0	61.0	39.6	to	61.0	37.2	49.3	81.75	11.6	Y	N	Y

NR - not reported

Table B-1
Summary of Water Well Drilling Reports

Project Ref. No.	AENV Well ID	Legal Location	Owner (on report)	Proposed Use	Well Elevation (m asl)	Water Requirement (m³/d)	Completion Date (dd/mm/yy)	Drilled Depth (m)	Completed Depth (m)	Screen or Perforated Intervals (m)			Depth of Seal (m)	Non-Pumping Weater Level (m)	Test Pumping Rate (m³/d)	Total Drawdown at End of Pumping (m)	Litholog Available (Y/N)	Chemistry Report Available (Y/N)	Well Yield Test Data Available (Y/N)
162	406374	NW-10-039-01-W5	Germann, Chris	Domestic	NR	1.51	24/4/95	61.0	57.9	42.7	to	57.9	43.3	47.2	81.75	13.7	Y	N	Y
163	406377	NW-10-039-01-W5	Potts, Gary	Domestic	NR	1.14	22/2/95	76.2	76.2	64.0	to	76.2	60.4	46.3	43.6	29.9	Y	N	Y
164	406680	NW-10-039-01-W5	Anserson, Floyd	Domestic	NR	0.95	30/5/95	103.6	103.6	67.1	to	103.6	48.5	46.0	65.4	0.0	Y	N	N
165	411443	NW-10-039-01-W5	Moylan, Joy/Martin, Clayton	Domestic	NR	1.51	8/6/95	64.3	64.3	48.8	to	64.3	43.3	51.7	81.75	11.3	Y	N	Y
166	467426	NW-10-039-01-W5	Balough, Doug/Barb	Domestic	NR	1.51	24/7/96	79.2	79.2	64.0	to	79.2	64.6	47.9	65.4	0.0	Y	N	Y
167	467427	NW-10-039-01-W5	Watters, Dan	Domestic	NR	1.51	3/6/96	62.5	61.0	48.8	to	61.0	49.4	48.8	245.25	0.0	Y	N	Y
168	469623	NW-10-039-01-W5	Whymark, Colin	Domestic	NR	1.14	30/5/97	61.0	61.0	48.8	to	61.0	42.1	50.9	54.5	0.0	Y	N	N
169	491508	NW-10-039-01-W5	Kit, Bruce	Domestic	NR	1.14	7/10/97	54.9	54.9	45.7	to	54.9	42.1	47.9	65.4	6.1	Y	N	N
170	493082	NW-10-039-01-W5	Tiedeman, Dwight	Domestic	NR	1.51	15/6/99	73.2	73.2	65.5	to	73.2	65.5	48.8	54.5	24.4	Y	N	Y
171	494619	NW-10-039-01-W5	Martin, Rob/Bev	Domestic	NR	1.14	30/8/99	73.2	73.2	61.0	to	73.2	61.6	48.8	163.5	24.4	Y	N	Y
172	358094	NW-10-039-01-W5	Mattson, R.	Stock	968	NR	16/10/74	30.2	30.2	21.3	to	27.4	15.2	12.5	109	12.5	Y	N	Y
173	495648	SE-10-039-01-W5	Hagerman, Tom	Domestic	NR	1.14	19/7/99	42.7	42.7	37.8	to	42.7	36.6	24.4	163.5	0.0	Y	N	Y
174	495649	NW-10-039-01-W5	Hill, Jim	Domestic & Stock	NR	1.89	21/4/99	61.0	61.0	51.8	to	61.0	45.7	41.8	81.75	19.2	Y	N	Y
175	496121	NW-10-039-01-W5	Porttin, Garry	Domestic	NR	2.65	14/6/99	79.2	79.2	73.2	to	79.2	61.0	50.6	109	10.1	Y	N	Y
176	340520	NE-10-039-01-W5	Gyori, Ross/Magill, Aleatha	Domestic & Stock	NR	NR	31/5/02	67.1	67.1	54.9	to	62.5	54.9	57.9	152.6	0.0	Y	N	Y
177	418027	14-10-039-01-W5	Wiynt, Jes	Domestic	NR	0.57	21/9/95	57.0	57.0	50.9	to	57.0	3.7	48.8	54.5	0.0	Y	N	Y
178	367366	NW-10-039-01-W5	Deschenses, kevin	Domestic	NR	NR	21/9/92	70.1	70.1	61.0	to	70.1	60.4	46.3	163.5	17.7	Y	N	N
179	406375	NW-10-039-01-W5	Evans, Dick	Domestic	NR	1.51	1/5/95	80.2	80.2	61.0	to	79.2	60.7	47.9	54.5	32.0	Y	N	Y
180	466315	NW-10-039-01-W5	Shomeczko, Bill/Sharon	Domestic	NR	1.14	14/6/96	67.1	67.1	54.9	to	61.0	54.6	45.7	163.5	21.3	Y	N	Y
181	491507	NW-10-039-01-W5	Wheaton, Larry	Domestic	NR	1.14	6/7/98	56.7	56.7	45.7	to	56.7	45.7	36.3	43.6	18.3	Y	N	Y
182	350620	NE-16-039-01-W5	Tatlock, R.	Domestic	NR	NR	29/3/90	42.7	42.7	36.6	to	42.7	29.9	28.7	152.32	3.4	Y	N	Y
183	380533	NE-16-039-01-W5	Luttmer, R.	Domestic	NR	0.26	9/6/95	73.2	73.2	59.4	to	73.2	42.7	50.0	27.2	23.1	Y	N	Y
184	359298	NW-16-039-01-W5	Holm, E.	Domestic & Stock	998	NR	6/5/76	70.4	70.4	56.7	to	70.4	35.1	56.4	136	0.0	Y	N	N
185	495650	SE-16-039-01-W5	Safronovich, R.	Domestic	NR	0.86	3/12/99	97.5	97.5	48.8	to	54.9	23.5	38.4	380	38.4	Y	N	Y
186	340521	NW-16-039-01-W5	Holm, E. (Sylvan Farm)	Domestic	NR	0.26	26/3/02	73.2	73.2	61.0	to	73.2	51.2	59.7	163.2	13.4	Y	N	Y
187	467429	SE-20-039-01-W5	Wilson, F.	Domestic	NR	0.39	28/10/96	109.7	109.7	91.4	to	73.2	43.6	85.3	163.2	15.2	Y	N	Y
188	361917	SW-20-039-01-W5	Nelson, J.	Stock	983	0.86	21/9/79	20.4	20.4	15.2	to	20.1	NR	11.6	190.4	0.0	Y	N	N
189	341100	SW-20-039-01-W5	Pardy, K.	Domestic	NR	0.26	18/6/02	58.5	58.5	43.3	to	58.5	40.5	18.6	54.4	39.9	Y	N	Y
190	341884	SW-20-039-01-W5	Pardy, K.	Domestic	NR	NR	27/8/02	42.7	42.7	37.2	to	42.7	37.2	10.4	190	32.3	Y	N	Y
191	468804	NW-30-039-01-W5	Szasz, B.	Domestic	NR	0.43	30/6/99	79.2	79.2	73.2	to	79.2	61.0	66.1	54.4	0.1	Y	N	Y
192	361999	SW-30-039-01-W5	Nelson, F.	Domestic	975	NR	26/8/77	51.8	51.8	39.0	to	51.8	31.1	35.0	86	16.8	Y	N	N
193	362302	NE-01-039-02-W5	Walker, Jim	Domestic	945	1.14	4/1/84	41.1	41.1	26.5	to	39.6	0.0	5.8	27.25	15.5	Y	N	N
194	362304	NE-01-039-02-W5	Pegcau, Marie	Domestic	945	NR	19/10/86	22.9	22.9	17.7	to	22.9	17.4	7.0	109	15.8	Y	N	N
195	366083	NE-01-039-02-W5	Alta Env #2696E	Observation	NR	NR	7/8/92	36.3	36.3	35.4	to	36.3	34.1	27.9	5.45	0.0	Y	N	N
196	366085	NE-01-039-02-W5	Alta Env #2698E	Observation	NR	NR	8/8/92	10.4	10.4	9.4	to	10.4	8.5	7.9	0.545	0.0	Y	N	N
197	362283	SE-01-039-02-W5	Stevenson, H.G.	Domestic	981	NR	5/6/69	54.9	54.9	19.8	to	54.9	NR	29.0	32.7	0.0	Y	N	N
198	362286	SW-01-039-02-W5	Rourke, Doug	Domestic	983	NR	14/5/79	27.4	27.4	24.4	to	27.4	18.3	10.7	163.5	0.0	Y	N	N
199	362301	NE-01-039-02-W5	Muir, R.C.	Domestic	945	NR	29/10/79	13.7	13.7	7.6	to	13.7	5.8	7.6	163.5	0.0	Y	N	N
200	469629	NE-02-039-02-W5	Nielsen, Dan	Domestic & Stock	NR	4.54	28/8/97	48.8	48.8	36.6	to	42.7	36.3	14.0	81.75	33.8	Y	N	Y
201	362306	SE-02-039-02-W5	Kathol, Howard	Stock	975	NR	4/12/73	33.2	33.2	17.7	to	33.2	NR	16.8	136.25	0.0	Y	N	N
202	360006	SE-02-039-02-W5	Kathol, Howard	Domestic	NR	NR	31/8/67	27.4	27.4	11.3	to	27.4	NR	18.9	87.2	0.0	Y	N	Y
203	469625	SE-02-039-02-W5	Williams, Michelle	Domestic	NR	1.32	22/6/98	42.7	42.7	24.4	to	42.7	25.6	18.0	65.4	24.7	Y	N	Y
204	469627	SE-02-039-02-W5	Knudsen, Al	Domestic	NR	1.14	8/6/98	29.0	29.0	22.9	to	29.0	5.5	22.8	38.15	0.0	Y	N	Y
205	491515	SE-02-039-02-W5	Kriekle, John	Domestic	NR	1.14	21/10/97	45.7	45.7	39.6	to	45.7	21.9	18.9	32.7	26.5	Y	N	Y
206	362310	SW-02-039-02-W5	Deschamps, Peter	Domestic & Stock	991	NR	19/9/88	30.5	30.5	24.4	to	30.5	18.9	19.2	109	11.3	Y	N	N
207	362314	NE-02-039-02-W5	Hawkings, Frances J.	Domestic & Stock	937	NR	21/11/86	49.7	49.7	32.9	to	49.7	32.9	17.1	59.95	25.9	Y	N	N
208	469626	SE-02-039-02-W5	Lord, Gerard	Domestic	NR	1.14	7/6/98	29.0	29.0	16.8	to	29.0	5.5	11.7	81.75	0.0	Y	N	Y
209	362308	SW-02-039-02-W5	Deschamps, Peter	Domestic	991	NR	14/9/81	42.4	42.4	19.2	to	42.4	19.2	9.3	136.25	29.0	Y	N	N
210	362326	NE-03-039-02-W5	Mattson, Roy	Domestic & Stock	991	NR	28/8/89	42.7	42.7	33.5	to	42.7	30.5	31.9	81.75	6.1	Y	N	Y
211	362317	SE-03-039-02-W5	Draker, Dolores	Domestic & Stock	990	NR	12/11/80	36.6	36.6	32.0	to	36.6	32.0	13.7	185.3	0.0	Y	N	N
212	494823	SE-03-039-02-W5	Draper, Randy	Domestic	NR	2.65	3/5/99	44.2	44.2	41.1	to	44.2	24.4	31.1	109	2.4	Y	N	Y
213	362357	SE-09-039-02-W5	Bell, David	Domestic	986	NR	17/8/81	24.4	24.4	12.2	to	21.3	11.9	9.6	136.25	NR	Y	N	Y
214	366317	SE-10-039-02-W5	Alta Env #2620E	Observation	NR	NR	6/8/92	60.7	60.7	59.7	to	60.7	58.2	34.9	5.45	NR	Y	N	N
215	351108	SW-10-039-02-W5	Mattson, Roy	Stock	NR	NR	18/3/90	79.2	79.2	61.0	to	79.2	57.9	50.9	109	1.5	Y	N	Y

NR - not reported

Table B-1
Summary of Water Well Drilling Reports

Project Ref. No.	AENV Well ID	Legal Location	Owner (on report)	Proposed Use	Well Elevation (m asl)	Water Requirement (m³/d)	Completion Date (dd/mm/yy)	Drilled Depth (m)	Completed Depth (m)	Screen or Perforated Intervals (m)			Depth of Seal (m)	Non-Pumping Weater Level (m)	Test Pumping Rate (m³/d)	Total Drawdown at End of Pumping (m)	Litholog Available (Y/N)	Chemistry Report Available (Y/N)	Well Yield Test Data Available (Y/N)
216	366086	SE-10-039-02-W5	Alta Env #2620E	Observation	NR	NR	9/8/92	36.3	36.3	35.4	to	36.3	34.4	30.1	5.45	NR	Y	N	N
217	406578	NE-10-039-02-W5	Eli Murto Trust	Domestic	NR	NR	14/11/94	65.5	65.5	39.6	to	57.9	37.8	34.7	190.75	30.8	Y	N	Y
218	362363	SE-10-039-02-W5	Canadian Jorex Ltd.	Industrial	981	NR	16/4/85	43.0	43.0	36.6	to	43.0	32.9	32.0	136.25	11.0	Y	N	Y
219	366087	SE-10-039-02-W5	Alta Env #2620E	Observation	NR	NR	6/8/92	24.1	24.1	24.1	to	24.1	22.3	15.5	10.9	NR	Y	N	N
220	362365	08-10-039-02-W5	Canadian Jorex Ltd.	Industrial	975	NR	7/3/85	61.9	61.9	32.9	to	61.9	NR	32.9	81.75	0.0	Y	N	Y
221	362367	08-10-039-02-W5	Canadian Jorex Ltd.	Industrial	981	NR	7/5/85	61.9	61.9	32.0	to	61.9	32.0	32.0	54.5	22.9	Y	N	N
222	352024	SW-10-039-02-W5	Mattson, Roy	Stock	NR	NR	18/2/90	79.2	79.2	61.0	to	79.2	57.9	50.9	109	1.5	Y	N	Y
223	362432	10-12-039-02-W5	Pembina, Res Ltd.	Industrial	930	NR	31/8/82	19.8	19.8	15.2	to	19.8	0.9	8.8	54.5	11.0	Y	N	N
224	362430	14-12-039-02-W5	Summitt Res/Atco 55	Industrial	939	NR	10/10/84	73.2	73.2	61.0	to	73.2	12.2	12.2	81.75	NR	Y	N	N
225	362426	SW-12-039-02-W5	Gullon, Priscella/Bob	Stock	939	0.76	14/10/87	29.9	29.9	23.8	to	29.9	18.6	5.5	109	1.2	Y	N	N
226	362440	SW-14-039-02-W5	Boy Scouts of Can	Domestic	945	NR	24/11/83	49.7	49.7	45.1	to	49.7	45.1	32.0	163.5	8.5	Y	N	N
227	468542	04-15-039-02-W5	Newtrino res	Industrial	NR	3.79	30/6/97	42.7	42.7	30.5	to	42.7	6.1	7.9	381.5	0.0	Y	N	Y
228	469631	04-15-039-02-W5	Newtrino res	Industrial	NR	3.79	10/4/97	54.9	54.9	42.7	to	54.9	54.9	30.5	545	0.0	Y	N	Y
229	362449	06-15-039-02-W5	Can Jorex	Industrial	945	NR	12/6/85	62.2	62.2	37.5	to	61.9	37.2	28.7	763	33.5	Y	N	Y
230	362459	NW-15-039-02-W5	Bahai Summer Camp	Domestic	940	NR	13/12/77	37.5	37.5	25.3	to	37.5	27.1	8.5	152.6	1.5	Y	N	N
231	491519	NW-15-039-02-W5	Bahai Summer Camp	Domestic	NR	2.27	28/7/97	27.4	27.4	15.2	to	27.4	14.6	14.3	163.5	12.8	Y	N	Y
232	362442	SE-15-039-02-W5	Parson, W.B.	Domestic	960	NR	12/5/66	43.0	43.0	18.6	to	43.0	15.5	27.4	81.75	0.0	Y	N	N
233	491518	SE-15-039-02-W5	Anderson, Julin	Domestic	NR	1.51	10/11/97	24.4	24.4	15.2	to	24.4	11.6	11.3	109	11.6	Y	N	Y
234	469630	SW-15-039-02-W5	Bahai Summer Camp	Domestic	NR	1.51	16/7/96	27.4	27.4	15.2	to	26.5	15.2	18.0	81.75	8.8	Y	N	Y
235	465652	NW-15-039-02-W5	Bahai Summer Camp	Domestic	NR	1.89	26/7/99	22.9	22.9	15.2	to	22.9	12.2	14.3	81.75	0.0	Y	N	Y
236	355292	16-16-039-02-W5	Badger Drlg	Industrial	NR	NR	13/8/88	30.5	30.5	6.1	to	12.2	6.1	4.6	109	25.9	Y	N	N
237	355293	16-16-039-02-W5	Badger Drlg	Industrial	NR	NR	13/8/98	48.8	48.8	30.5	to	36.6	12.2	18.3	136.25	30.5	Y	N	Y
238	469632	NE-16-039-02-W5	Murto, Fred	Domestic	NR	1.51	27/11/97	32.3	32.3	26.8	to	32.3	26.8	14.3	109	0.3	Y	N	Y
239	362465	SE-16-039-02-W5	Mattson, Roy	Domestic & Stock	975	3.03	23/4/86	54.9	54.9	36.6	to	54.9	28.0	39.0	38.15	15.8	Y	N	N
240	405605	NW-16-039-02-W5	Smith, Larry	Domestic	NR	1.89	7/12/94	39.6	39.6	30.5	to	38.4	29.9	30.5	81.75	8.4	Y	N	Y
241	362479	SE-17-039-02-W5	Murto, Fred	Domestic & Stock	975	NR	22/8/89	67.1	67.1	59.4	to	67.1	57.9	50.5	119.9	9.5	Y	N	Y
242	350622	NW-19-039-02-W5	Murto, Fred	Domestic & Stock	NR	NR	23/3/90	29.0	29.0	22.9	to	29.0	19.8	14.6	76.3	6.7	Y	N	Y
243	362495	SW-19-039-02-W5	Nelson, Ed	Domestic	966	NR	3/8/88	30.5	30.5	18.3	to	24.4	20.4	12.5	54.5	3.0	Y	N	N
244	468022	09-20-039-02-W5	Dominion Expl/Cactus14	Industrial	NR	11.36	8/1/97	42.7	42.7	30.5	to	36.6	6.1	12.2	218	30.5	Y	N	N
245	409002	15-20-039-02-W5	Larsen, Dave	Domestic	NR	1.51	15/9/95	30.5	30.5	12.2	to	29.0	3.4	19.8	163.5	1.5	Y	N	Y
246	468023	16-20-039-02-W5	Poco/Cactus27#Rig	Industrial	NR	11.36	8/1/97	42.7	42.7	30.5	to	36.6	6.1	14.0	218	28.7	Y	N	Y
247	365225	SE-20-039-02-W5	Nelson, Art	Domestic	NR	NR	11/6/92	30.5	30.5	24.4	to	29.6	12.2	19.2	109	11.3	Y	N	N
248	468543	10-20-039-02-W5	Bow Can	Industrial	NR	1.89	3/9/97	73.2	73.2	39.6	to	45.7	24.4	27.4	490.5	0.0	Y	N	Y
										67.1	to	73.2							
249	418028	01-21-039-02-W5	Verbitsky, Larry	Domestic	NR	0.09	25/9/95	33.5	33.5	21.3	to	33.5	6.7	18.3	54.5	0.0	Y	N	Y
250	494620	NW-21-039-02-W5	Steene, Gordon	Domestic	NR	0.57	26/7/99	28.3	28.3	19.8	to	28.3	14.6	12.2	65.4	9.1	Y	N	Y
251	362530	SE-21-039-02-W5	Bloomfield, Carol/Bill	Domestic	945	NR	24/6/88	43.6	43.6	37.5	to	43.6	37.5	20.4	163.5	0.0	Y	N	N
252	364710	SE-21-039-02-W5	Deer Run Homes	Domestic	NR	NR	7/10/91	42.7	42.7	39.6	to	42.7	38.4	21.9	436	20.7	Y	N	N
253	366318	SE-21-039-02-W5	Hanham, Chris	Domestic	NR	NR	31/7/92	36.6	36.6	30.5	to	36.6	26.5	15.8	272.5	20.7	Y	N	N
254	491520	SE-21-039-02-W5	Sundelf, Wayne	Domestic	NR	1.06	22/7/98	36.6	36.6	32.0	to	36.6	30.2	14.3	436	0.0	Y	N	Y
255	362533	SW-21-039-02-W5	Palm, Bill	Domestic & Stock	960	NR	7/7/88	30.5	30.5	18.9	to	30.5	18.9	16.8	98.1	4.6	Y	N	N
256	409236	SW-21-039-02-W5	Camp Kuricakos	Domestic	NR	0.76	13/9/95	30.5	30.5	13.7	to	29.0	12.5	13.7	163.5	6.1	Y	N	Y
257	491521	SW-21-039-02-W5	Palm, Gregg	Domestic	NR	3.79	26/6/98	24.4	24.4	19.8	to	24.4	18.0	15.8	119.9	8.5	Y	N	Y
258	352967	01-25-039-02-W5	Alta Env #2620E	Observation	NR	NR	29/10/90	40.5	40.5	39.6	to	40.5	36.9	36.9	0	0.0	Y	N	N
259	352968	01-25-039-02-W5	Alta Env #2620E	Observation	NR	NR	28/10/90	66.8	51.8	50.3	to	51.2	48.5	36.6	0	0.0	Y	N	N
260	396645	NE-25-039-02-W5	Wilson, F.	Domestic	NR	0.17	26/10/94	79.2	79.2	54.9	to	79.2	43.0	54.9	136	21.3	Y	N	Y
261	365585	SE-25-039-02-W5	Culshaw, D.	Domestic & Stock	NR	NR	30/7/92	70.1	70.1	54.9	to	70.1	49.7	44.8	109	13.1	Y	N	Y
262	351682	NW-25-039-02-W5	Scott, R.	Domestic & Stock	NR	NR	27/6/90	64.0	64.0	57.9	to	64.0	47.2	50.3	108	0.0	Y	N	N
263	366544	SE-29-039-02-W5	Johson, Walter	Domestic	NR	NR	17/10/92	30.5	30.5	18.3	to	30.5	19.5	7.6	163.5	22.9	Y	N	N
264	1060227	SE-29-039-02-W5	Layton, Frank	Domestic	NR	NR	3/5/03	36.6	36.6	24.4	to	30.5	18.9	12.5	436	8.8	Y	N	Y
265	1060228	SE-29-039-02-W5	Layton, Frank	Domestic	NR	NR	23/5/03	36.6	36.6	24.4	to	30.5	21.0	15.2	436	7.0	Y	N	Y
266	491558	06-30-039-02-W5	Nocen/Union Pacific#Rig	Industrial	NR	11.36	21/5/98	51.2	51.2	24.4	to	48.8	11.0	4.3	218	46.9	Y	N	N
267	468544	14-30-039-02-W5	Ben Can Oil Co	Industrial	NR	1.14	23/4/97	48.8	48.8	42.7	to	48.8	6.1	6.1	381.5	0.0	Y	N	Y
268	359679	NW-30-039-02-W5	Erickson, Phyllis	Domestic & Stock	NR	NR	7/8/91	27.4	27.4	22.9	to	27.4	18.6	14.3	81.75	13.1	Y	N	N

NR - not reported

Table B-1
Summary of Water Well Drilling Reports

Project Ref. No.	AENV Well ID	Legal Location	Owner (on report)	Proposed Use	Well Elevation (m asl)	Water Requirement (m ³ /d)	Completion Date (dd/mm/yy)	Drilled Depth (m)	Completed Depth (m)	Screen or Perforated Intervals (m)			Depth of Seal (m)	Non-Pumping Weater Level (m)	Test Pumping Rate (m ³ /d)	Total Drawdown at End of Pumping (m)	Litholog Available (Y/N)	Chemistry Report Available (Y/N)	Well Yield Test Data Available (Y/N)
269	466321	SE-30-039-02-W5	Schafers, Dwayne	Domestic	NR	1.14	15/3/96	51.8	51.8	39.6	to	51.8	30.5	37.3	54.5	1.1	Y	N	Y
270	1060163	SW-30-039-02-W5	Moor, Jerry	Stock	NR	NR	3/10/03	30.5	30.5	16.8	to	24.4	10.4	12.2	163.5	7.6	Y	N	Y
271	467431	NE-31-039-02-W5	Ackerman, K.	Domestic	NR	0.34	12/8/96	41.1	41.1	25.9	to	41.1	24.4	25.9	40	14.9	Y	N	Y
272	386225	SE-31-039-02-W5	Engman, G.I	Domestic	NR	0.51	3/8/94	42.7	42.7	30.5	to	42.7	18.0	27.4	54.4	15.2	Y	N	Y
273	352619	01-32-039-02-W5	Alta Env #2620E	Observation	NR	NR	12/10/90	33.5	33.5	32.6	to	33.5	31.1	8.5	NR	NR	Y	N	N
274	352623	01-32-039-02-W5	Alta Env #2620E	Observation	NR	NR	12/10/90	19.2	19.2	18.3	to	19.2	15.8	8.8	NR	NR	Y	N	N
275	352624	01-32-039-02-W5	Alta Env #2620E	Observation	NR	NR	12/10/90	6.4	6.4	5.5	to	6.4	4.3	3.7	NR	NR	Y	N	N
276	352966	01-32-039-02-W5	Alta Env #2620E	Observation	NR	NR	9/11/90	32.9	32.9	31.4	to	32.9	27.1	9.4	NR	NR	Y	N	N
277	362663	SW-32-039-02-W5	Zaleski, Bill	Domestic	945	NR	2/8/77	53.3	53.3	35.1	to	53.3	27.1	35.1	82	3.0	Y	N	N
278	352625	01-32-039-02-W5	Alta Env #2620E	Observation	NR	NR	12/10/90	3.0	3.0	0.6	to	3.0	NR	2.7	NR	NR	Y	N	N
279	350623	SE-32-039-02-W5	Shoettler, R.	Stock	NR	NR	28/2/90	36.6	36.6	27.4	to	36.6	23.5	14.5	152.32	17.5	Y	N	Y
280	362669	NW-33-039-02-W5	Mottus, W.	Domestic	NR	NR	31/7/84	18.3	18.3	12.2	to	18.3	10.4	7.6	11	1.5	Y	N	N
281	406356	NW-33-039-02-W5	Sabados, A.	Domestic	NR	0.30	8/6/95	19.2	19.2	10.4	to	19.2	10.4	8.2	218	11.0	Y	N	Y
282	341885	SW-33-039-02-W5	Degroat, R.	Domestic	NR	NR	13/11/02	24.4	24.4	16.8	to	24.4	16.8	9.6	408	1.7	Y	N	Y
283	418385	NW-33-039-02-W5	Vig, Dean	Domestic	NR	NR	1/7/79	76.2	76.2	NR	to	NR	NR	NR	NR	NR	N	Y	N
284	406357	03-35-039-02-W5	Dominion Expl/artisan	Industrial	NR	0.69	8/6/95	67.1	54.9	36.6	to	54.9	3.0	45.7	190	21.3	Y	N	Y
285	362728	NW-35-039-02-W5	Brattgerg, E.	Domestic & Stock	991	NR	5/11/74	64.0	64.0	29.3	to	64.0	29.3	38.1	114	12.2	Y	N	N
286	362729	NW-35-039-02-W5	Brattgerg, E.	Stock	1006	NR	12/6/80	61.0	61.0	53.9	to	61.0	32.3	42.7	109	9.1	Y	N	N
287	362734	NE-35-039-02-W5	Millar, D.	Stock	1006	NR	30/5/80	56.7	56.7	51.2	to	54.3	44.5	25.9	33	29.0	Y	N	Y
288	362730	NW-35-039-02-W5	Brattgerg, E.	Domestic & Stock	1006	NR	9/6/80	71.6	71.6	46.0	to	71.6	36.9	50.3	109	6.1	Y	N	N
289	429669	NW-36-039-03-W5	Stopsen, Jean/Ed	Domestic & Stock	NR	NR	8/3/88	35.1	35.1	25.3	to	35.1	25.3	16.2	98.1	5.2	Y	N	N
290	429666	SE-36-039-03-W5	Saari, Ken	Domestic & Stock	NR	NR	27/5/85	41.1	41.1	24.1	to	41.1	24.1	15.2	163.5	9.8	Y	N	N
291	437826	NE-05-040-02-W5	Kathol, Howard	Stock	NR	NR	20/6/88	32.0	32.0	25.9	to	32.0	21.9	7.3	163.5	24.1	Y	Y	N
292	437819	NW-05-040-02-W5	Berg, Don	Domestic & Stock	NR	NR	21/9/88	36.6	36.6	29.0	to	36.6	18.3	14.0	98.1	22.6	Y	N	N
293	437802	SE-05-040-02-W5	Psikla, Joe	Domestic & Stock	NR	3.79	5/11/88	30.5	30.5	18.0	to	30.5	19.2	9.1	109	9.1	Y	N	N
294	478915	SW-05-040-02-W5	Herregodsts, ron	Domestic	NR	NR	NR	19.8	19.8	NR	to	NR	NR	4.6	NR	NR	N	Y	N
295	437826	NE-05-040-02-W5	Kathol, Howard	Stock	NR	NR	20/6/88	32.0	32.0	25.9	to	32.0	21.9	7.3	163.5	24.7	Y	N	N
296	437815	NW-05-040-02-W5	Berg, Don	Domestic & Stock	NR	NR	21/9/88	36.6	36.6	29.0	to	36.6	28.7	14.0	98.1	22.6	Y	N	N
297	437802	SE-05-040-02-W5	Psikla, Joe	Domestic & Stock	NR	3.79	5/11/88	30.5	30.5	18.0	to	30.5	19.2	9.1	109	9.1	Y	N	N
298	437849	04-06-040-02-W5	Psikla, Louis/Joe	Domestic & Stock	NR	NR	24/6/69	30.5	30.5	NR	to	NR	NR	4.3	NR	NR	N	Y(2)	N
299	437962	13-06-040-02-W5	Liikala, Ed	Domestic & Stock	NR	NR	26/8/69	64.0	64.0	NR	to	NR	NR	57.9	NR	NR	N	Y	N
300	469677	NE-06-040-02-W5	Anderson, Greg	Stock	NR	3.79	14/5/98	42.7	42.7	12.2	to	42.7	11.0	29.0	109	2.4	Y	N	Y
301	437958	NW-06-040-02-W5	Likala, Russ	Domestic & Stock	NR	NR	9/12/83	64.0	64.0	22.6	to	64.0	22.6	24.4	152.6	17.1	Y	N	N
302	350683	SW-06-040-02-W5	Psikla Bros	Stock	NR	NR	8/3/90	30.8	30.8	17.4	to	30.8	17.4	10.7	81.75	1.5	Y	N	N
303	499636	SW-06-040-02-W5	Brink, Harvey	Stock	NR	1.89	11/12/01	36.6	36.6	22.9	to	30.5	22.9	16.8	114.45	13.7	Y	N	Y
304	1060333	SW-06-040-02-W5	Macinek, Murray	Domestic	NR	3.79	29/1/02	48.8	48.8	30.5	to	42.7	25.9	10.7	98.1	38.1	Y	N	Y
305	401235	NW-07-040-02-W5	Moos, Clarence	Domestic & Stock	NR	7.57	8/2/95	24.4	24.4	9.1	to	24.4	9.4	10.7	218	12.2	Y	N	Y
306	437699	SW-07-040-02-W5	Meyers, Ray	Domestic	NR	NR	22/10/70	47.2	47.2	41.1	to	47.2	NR	39.6	81.75	0.0	Y	N	N
307	437969	SW-07-040-02-W5	Folvik, Dennis	Domestic	NR	NR	6/12/84	NR	NR	NR	to	NR	NR	NR	NR	NR	N	Y	N
308	438455	02-18-040-02-W5	Ponto, fred	Domestic & Stock	NR	NR	26/8/69	36.6	36.6	0.0	to	NR	NR	21.3	NR	NR	N	Y	N
309	438460	SW-18-040-02-W5	Tolonen, Rodney	Domestic	1015	NR	7/10/76	36.6	36.6	14.6	to	36.6	18.6	21.3	43.6	15.2	Y	N	N
310	438446	SE-18-040-02-W5	Shewkenek, Terry	Domestic	NR	NR	29/11/83	44.5	44.5	21.9	to	44.5	23.2	18.3	190.75	13.1	Y	N	N
311	438481	NE-19-040-02-W5	Bergerson, Dave	Domestic	NR	NR	4/1/90	30.5	30.5	NR	to	NR	NR	NR	NR	NR	N	Y	N
312	350626	SE-19-040-02-W5	Johnson, Orville	Stock	NR	NR	30/3/90	48.8	48.8	42.7	to	48.8	32.0	33.5	109	15.2	Y	N	N
313	438473	SW-19-040-02-W5	Rangen, A.Q.N. #Spring	Domestic	NR	NR	11/9/73	NR	NR	NR	to	NR	NR	NR	NR	NR	N	Y	N
314	478916	NW-19-040-02-W5	Booth, Bernard	Domestic	NR	NR	1/4/84	NR	NR	NR	to	NR	NR	NR	NR	NR	N	Y	N
315	478917	14-19-040-02-W5	Arc	Unknown	NR	NR	NR	NR	NR	NR	to	NR	NR	NR	NR	NR	N	Y	N
316	438482	NE-19-040-02-W5	Olson, Len	Domestic	975	NR	9/7/81	54.9	54.9	38.7	to	54.9	38.4	29.0	152.6	1.5	Y	N	N
317	466354	10-01-040-03-W5	Gulf/Cactus	Industrial	NR	37.85	12/7/96	48.8	48.8	30.5	to	48.8	10.1	6.7	207.1	37.2	Y	N	Y
318	353991	NE-01-040-03-W5	Wickins, Tom	Domestic & Stock	NR	NR	8/7/82	45.7	45.7	30.5	to	45.7	30.8	18.9	109	23.8	Y	N	N
319	437059	NE-01-040-03-W5	Wilkins, T.C.	Domestic	998	NR	17/11/75	44.2	44.2	NR	to	NR	NR	NR	NR	NR	N	Y	N
320	437058	NW-01-040-03-W5	Smith, T.G.	Domestic & Stock	NR	NR	NR	NR	NR	NR	to	NR	NR	NR	NR	NR	N	Y	N
321	437834	04-13-040-03-W5	Mackenzie, Simon	Domestic & Stock	NR	NR	1/1/32	20.1	20.1	NR	to	NR	NR	13.4	NR	NR	N	Y	N
322	437836	06-13-040-03-W5	Gulf Can Ltd	Domestic	NR	NR	4/12/85	NR	NR	NR	to	NR	NR	NR	NR	NR	N	Y	N

NR - not reported

Table B-1
Summary of Water Well Drilling Reports

Project Ref. No.	AENV Well ID	Legal Location	Owner (on report)	Proposed Use	Well Elevation (m asl)	Water Requirement (m³/d)	Completion Date (dd/mm/yy)	Drilled Depth (m)	Completed Depth (m)	Screen or Perforated Intervals (m)		Depth of Seal (m)	Non-Pumping Weater Level (m)	Test Pumping Rate (m³/d)	Total Drawdown at End of Pumping (m)	Litholog Available (Y/N)	Chemistry Report Available (Y/N)	Well Yield Test Data Available (Y/N)	
323	437843	NW-13-040-03-W5	Brattgerg, E.	Domestic	NR	NR	7/8/84	18.3	18.3	NR	to	NR	NR	NR	NR	NR	N	Y	N
324	437844	NW-13-040-03-W5	Hunt, Chris	Domestic	NR	NR	19/9/84	NR	NR	NR	to	NR	NR	NR	NR	NR	N	Y	N
325	437847	NW-13-040-03-W5	Bauer, Tony	Domestic	NR	NR	20/3/86	NR	NR	NR	to	NR	NR	NR	NR	NR			
326	437854	SE-14-040-03-W5	Stenvig, Martin	Stock	NR	NR	4/8/73	25.9	25.9	15.8	to	25.9	NR	4.3	218	9.4	Y	N	Y
327	438419	13-23-040-03-W5	Patapoff, William	Domestic	NR	NR	16/6/69	51.5	51.5	NR	to	NR	NR	9.1	NR	NR	N	Y	N
328	438435	15-23-040-03-W5	Kalev, H.	Domestic & Stock	NR	NR	12/6/69	60.4	60.4	NR	to	NR	NR	36.6	NR	NR	N	Y	N
329	351655	NE-23-040-03-W5	Kalev Farms	Domestic	NR	NR	16/1/90	61.0	61.0	48.8	to	61.0	48.2	42.7	109	18.3	Y	N	N
330	493102	NE-23-040-03-W5	Kaleu, Brian	Domestic	NR	2.65	27/7/99	61.0	61.0	30.5 42.7	to	36.6 61.0	28.3	50.3	109	7.6	Y	N	Y
331	466356	SE-23-040-03-W5	Nygaard, Bernice	Domestic	NR	0.95	15/5/96	35.1	35.1	24.4	to	32.0	22.9	18.3	109	7.6	Y	Y	N
332	438410	SE-23-040-03-W5	Iverson, wayne	Domestic & Stock	NR	NR	10/3/89	36.6	36.6	17.4	to	36.6	17.4	19.8	65.4	32.9	Y	N	N
333	1060028	SE-23-040-03-W5	Vollmin, Val	Domestic & Stock	NR	NR	20/10/03	61.0	61.0	48.8	to	54.9	18.6	45.7	218	6.1	Y	N	Y
334	438444	NE-24-040-03-W5	Armstrong, P.	Domestic	NR	NR	13/11/73	21.3	21.3	NR	to	NR	NR	NR	NR	NR	N	Y	N
335	356225	NW-25-040-03-W5	Reid, George	Domestic	NR	NR	23/4/91	109.7	109.7	79.2	to	109.7	34.7	86.3	81.75	NR	Y	N	N
336	438450	SW-25-040-03-W5	Paul, Ed	Stock	NR	NR	16/11/79	27.4	27.4	22.9	to	27.4	12.8	20.1	43.6	2.7	Y	N	N
337	370192	01-25-040-03-W5	Crestar/Cactus1	Industrial	NR	NR	24/8/93	48.8	48.8	42.7	to	48.8	9.1	38.1	218	10.7	Y	N	N
338	350298	SW-25-040-03-W5	Armstrong, Max	Stock	NR	NR	1/3/90	47.2	47.2	18.3 36.6	to	24.4 47.2	12.2	36.6	163.5	10.7	Y	N	N
339	497799	NE-34-038-01-W5	Delta Land Corp.	Domestic	NR	1.36	23/4/01	42.7	42.7	24.4	to	42.7	30.0	1.2	654.1	23.2	Y	N	Y
340	96923	NE-09-038-28-W4	Halvorson, Glenn	Domestic	NR	1.36	13/7/87	53.3	53.3	44.5	to	53.3	19.8	24.4	26.2	51.8	Y	Y	N
341	258849	NE-03-038-28-W4	Graham, Danny	Domestic	NR	1.36	24/8/95	48.8	48.8	38.7	to	48.8	38.7	17.7	327	0.0	Y	N	N
501	361982	SW-27-039-01-W5	Buit, John	Domestic	930	NR	19/6/80	59.4	59.4	24.4	to	59.4	24.7	27.4	76.3	23.5	Y	N	N
502	357353	02-28-038-02-W5	Stinn, LaVerne	Domestic	983	NR	1/1/45	15.8	15.8	6.1	to	15.8	NR	7.6	NR	NR	Y	Y	N
503	355898	NW-17-038-02-W5	Hambly, Terry	Stock	936	NR	16/7/79	30.5	30.5	14.6	to	30.5	14.6	10.7	21.6	19.8	Y	N	N
504	369532	NE-05-038-02-45	Layek, Elmer	Domestic	NR	NR	28/6/93	73.2	73.2	14.9	to	73.2	14.6	10.7	21.6	62.5	Y	N	N

NR - not reported

Table B-2
Chemistry Data with Water Well Drilling Reports

Project Ref. No.	AENV Well ID	LSD	Sec	Tp	Rg	Mer	Proposed Use	Well Elevation (m asl)	Sampling Date (dd/mm/yy)	Sampling Depth (m)	Ion Balance	Total Alkalinity (mg/L)	TDS (mg/L)	Conductivity (µs/cm)	pH	SiO2	Calcium (Ca) (mg/L)	Chloride (Cl) (mg/L)	Sodium (Na) (mg/L)	NO ₂ + NO ₃ (mg/L)	Iron (Fe) (mg/L)	Bicarbonate (HCO ₃) (mg/L)	Carbonate (CO ₃) (mg/L)	Magnesium (Mg) (mg/L)	Nitrate-N (mg/L)	Potassium (mg/L)	Sulphate (mg/L)	Total Hardness (mg/L)	
1	352300	NE	1	38	1	5	Domestic	936	NR	48.8	0.96	464.00	509.00	872.00	8.90	6.40	2.99	3.00	210.00	0.09	9.38	519.83	22.00	1.000768*	0.0504*	1.21	10.99	8.00	
5	352311	NE	2	38	1	5	Domestic	945	15/1/86	36.6	1.01	479.00	571.00	939.00	8.80	7.00	0.998*	1.0011*	240.00	0.0144*	0.02*	548.82	18.00	1.000768*	0.0504*	0.71	39.97	5*	
5	352311	NE	2	38	1	5	Domestic	945	NR	36.6	0.87	485.00	544.00	942.00	8.90	6.60	0.998*	1.0011*	210.00	0.0144*	0.02*	532.82	29.00	1.000768*	0.0504*	0.71	39.97	5*	
5	352311	NE	2	38	1	5	Domestic	945	NR	36.6		365.00	486.00	710.00	8.29		35.83	1.00	115.00					19.72	0.00		53.97	171.00	
6	352312	NE	2	38	1	5	Domestic	945	NR	19.5			536.00				36.93	4.00	105.00		0.10	423.86		24.02			63.69	191.00	
8	352304	NW	2	38	1	5	Domestic	NR	29/10/77	42.7	1.07	309.00	315.00	565.00	8.20	9.80	39.92	2.00	63.00	0.0284*	0.89	375.88		23.02	0.0994*	2.43	9.9936*	194.00	
12	352321	NE	3	38	1	5	Domestic	953	26/11/80	18.3	0.90	397.00	464.00	811.00	8.60	7.00	8.98	2.00	165.00	0.0144*	0.05	469.85	7.00	5.00	0.0504*	0.71	43.97	43.00	
12	352322	NE	3	38	1	5	Domestic	953	1/6/82	18.3	0.97	380.00	436.00	764.00	8.40	7.00	5.99	2.00	171.00	0.0144*	0.03	453.85	5.001*	2.00	0.0504*	1.21	24.98	23.00	
13	352324	NE	3	38	1	5	Domestic	953	9/2/83	35.1	0.94	457.00	546.00	927.00	9.40	6.70	0.998*	1.0011*	218.00	0.0144*	0.13	454.85	50.00	1.000768*	0.0504*	0.71	49.97	6.00	
14	352325	NE	3	38	1	5	Unknown	953	NR	BR		430.00	558.00	840.00	8.71		1.80	2.00	213.60		0.22			0.30			65.96	6.00	
15	352326	NE	3	38	1	5	Unknown	953	NR	BR		465.00	634.00	930.00	8.61		2.10	1.00	239.10		0.06			0.30			88.94	7.00	
23	415961	NE	15	38	1	5	Domestic	NR	24/9/70	24.4		479.00	678.00	1000.00				4.00			0.02						70.95	35.00	
23	415961	NE	15	38	1	5	Domestic	NR	NR	24.4		479.00	672.00					2.00									67.96	19.00	
29	352543	8	16	38	1	5	Domestic	959	14/7/65	BR			280.00		8.20		26.95	4.00	42.00		0.10	273.91	15.00	27.02			14.99	179.00	
30	352544	8	16	38	1	5	Domestic	958	14/7/65	18.3			304.00		8.50		12.97	4.00	71.00		0.10	243.92	33.00	19.02			5.00	111.00	
33	352548	NE	16	38	1	5	Domestic	960	28/7/81	33.5	0.87	381.00	446.00	742.00	8.30	6.40	46.91	2.00	84.00	0.02	0.30	464.85		22.02	0.0504*	0.20145*	31.96	208.00	
34	352549	NE	16	38	1	5	Domestic	960	28/7/81	BR	0.91	372.00	398.00	715.00	8.20	6.70	59.88	2.00	43.00	0.12	0.03	453.85		32.03	0.0504*	2.52	33.98	279.00	
35	352551	NE	16	38	1	5	Domestic	968	24/11/82	53.3	0.95	386.00	468.00	800.00	9.00	6.40	0.998*	1.0011*	188.00	0.0144*	0.14	415.86	27.00	1.000768*	0.0504*	0.60	44.97	5*	
36	352552	NE	16	38	1	5	Domestic	968	25/4/86	BR	1.03	333.00	364.00	639.00	8.20	8.00	59.88	1.0011*	46.00	0.36	0.02*	405.87		29.02	0.0504*	1.82	20.99	269.00	
38	352541	SE	16	38	1	5	Domestic & Stock	957	15/7/73	33.5		519.00	880.00	1010.00	8.80		3.99	1.00	236.01		0.40	525.83	51.00	2.00		0.81	58.96	18.00	
40	352556	SW	17	38	1	5	Domestic	990	14/7/65	24.4			568.00		8.20		20.96	12.02	72.00		0.25	287.91	15.00	22.02			19.99	143.00	
40	352556	SW	17	38	1	5	Domestic	990	30/6/70	24.4		398.00	548.00	730.00				8.01			0.16						49.97	46.00	
41	352562	NW	18	38	1	5	Domestic	989	7/8/79	42.7	0.98	517.00	631.00	998.00	8.70	6.80	0.998*	3.00	258.00	0.0144*	5.12	594.80	17.00	1.000768*	0.0504*	1.62	55.96	5*	
42	352564	NW	18	38	1	5	Domestic	992	20/5/86	BR	0.98	459.00	607.00	1003.00	8.70	6.50	0.998*	1.0011*	245.00	0.11	0.11	512.83	23.00	1.000768*	0.0504*	0.51	81.95	5*	
44	352568	5	19	38	1	5	Domestic	981	14/7/65	12.2			388.00		8.10		50.90	12.02	76.00		0.10	379.88	15.00	17.01			8.00	197.00	
48	352570	NW	19	38	1	5	Domestic	969	23/5/67	21.3		424.00	520.00					4.00			1.50						57.96	355.00	
49	352572	NW	19	38	1	5	Domestic	962	13/2/79	30.5		466.00	530.00	905.00	8.90	6.80	0.998*	1.0011*	223.00	0.0144*	0.11	523.83	21.00	1.000768*	0.0504*	0.51	23.99	5*	
50	352573	NW	19	38	1	5	Domestic	969	11/11/83	BR	0.88	473.00	527.00	917.00	8.90	6.30	0.998*	1.0011*	205.00	0.0144*	0.07	517.83	29.00	1.000768*	0.0504*	0.60	34.98	5*	
55	352565	SW	19	38	1	5	NR	983	10/9/71	24.4		365.00	520.00	760.00	7.70		21.96	8.01						15.01			34.98	115.00	
56	352577	7	20	38	1	5	Domestic & Stock	976	18/4/62	37.2			384.00		7.40		47.90	16.02	66.99		2.60	341.89	0.00	18.02				34.98	194.00
57	352660	NE	20	38	1	5	Domestic	981	19/1/82	BR		312.00	366.00		8.40		63.87	7.01	28.00	0.09	0.1*	377.88	84.00	33.03		2.02	42.97	295.00	
58	352661	NE	20	38	1	5	Domestic	981	14/4/86	51.8	0.98	419.00	484.00	824.00	8.70	7.80	6.99	1.0011*	190.00	0.0144*	0.02*	463.85	23.00	3.00	0.0504*	1.01	29.98	30.00	
58	352661	NE	20	38	1	5	Domestic	981	19/1/82	51.8		360.00	455.00		8.40		30.94	5.01	131.00	0.09	0.1*	436.86	2.00	13.01		2.02	52.97	130.00	
61	352576	SE	20	38	1	5	Domestic	978	11/1/67	39.6	0.99	289.00	283.00	550.00	8.20		52.89	3.00	17.00	0.31	1.07	351.88		30.02	0.0994*	2.43	9.9936*	254.00	
67	352663	SW	21	38	1	5	Domestic	975	2/2/67	33.2		370.00	568.00					4.00			0.34						80.95	250.00	
75	352676	14	23	38	1	5	Domestic	944	14/7/65	BR			648.00		8.10		10.98	8.01	236.00		0.20	477.84	38.00	1.000768*				73.95	35.00
96	354789	9	29	38	1	5	Municipal	NR	31/1/80	61.0	0.99	378.00	422.00	732.00	7.90	9.20	62.87	2.00	73.00	0.02	0.17	460.85		23.02	0.0504*	2.43	31.98	250.00	
96	354789	9	29	38	1	5	Municipal	NR	26/4/82	61.0	0.95	380.00	433.00	728.00	8.10	9.00	52.89	2.00	90.00	0.0144*	0.24	462.85		18.02	0.0504*	2.12	39.97	206.00	
96	354789	9	29	38	1	5	Municipal	NR	NR	61.0	0.93	391.00	411.00	747.00	8.10	9.60	56.89	1.0011*	70.00	0.0144*	0.23	476.84		22.02	0.0504*	2.22	23.99	232.00	
98	353095	NE	29	38	1	5	Municipal	968	31/1/83	48.8	0.92	362.00	380.00	670.00	8.40	9.50	42.91	1.0011*	90.00	0.0144*	0.20	439.86	5.001*	12.01	0.0504*	1.92	14.99	157.00	
98	353095	NE	29	38	1	5	Municipal	968	6/1/86	48.8	1.01	373.00	405.00	696.00	8.00	9.60	47.90	1.0011*	102.00	0.0144*	0.18	454.85		12.01	0.0504*	2.12	15.99	169.00	
99	352896	NW	29	38	1	5	Domestic	960	8/4/81	25.9	0.96	355.00	369.00	667.00	8.10	11.70	63.87	2.00	33.00	0.0144*	0.84	432.86		32.03	0.0504*	2.02	22.99	291.00	
100	352890	SE	29	38	1	5	Domestic	991	29/1/76	37.8	0.98	434.00	563.00	940.00	8.00		10.98	7.01	213.00	0.0284*	0.1*	528.83		4.00	0.0994*	1.62	65.97	41.00	
101	352892	SW	29	38	1	5	Domestic	977	12/6/77	33.5		386.00	396.00	720.00	8.30	10.90	63.87	1.0011*	59.00	0.0284*	0.05*	466.85	5.001*	27.02	0.0994*	2.43	9.9936*	272.00	
101	352892	SW	29	38	1	5	Domestic	977	16/10/81	33.5	0.86	317.00	304.00	623.00	8.00	13.00	24.95	1.0011*	42.00	0.17	0.02*	385.87		31.03	0.0504*	2.22	9.9936*	190.00	
104	353100	SE	30	38	1	5	Domestic	978	16/9/71	38.1		410.00	560.00	800.00	8.70		7.98	1.0011*			0.80			3.00			79.95	35.00	
107	353107	SW	30	38	1	5	Domestic	960	10/6/81	35.1	1.02	452.00	548.00	887.00	8.80	7.40	3.99	1.0011*	227.00	0.0144*	0.07	515.83	17.00	1.000768*	0.0504*	0.60	42.97	13.00	
108	353109	SW	30	38	1	5	Domestic	968	11/12/85	25.9	1.03	459.00	554.00	914.00	8.90	7.00	0.998*	1.0011*	235.00	0.0144*	0.02*	505.84	26.00	1.000768*	0.0504*	0.60	39.97	5*	
109	353110	SW	30	38	1	5	Stock																						

Table B-2
Chemistry Data with Water Well Drilling Reports

Project Ref. No.	AENV Well ID	LSD	Sec	Tp	Rg	Mer	Proposed Use	Well Elevation (m asl)	Sampling Date (dd/mm/yy)	Sampling Depth (m)	Ion Balance	Total Alkalinity (mg/L)	TDS (mg/L)	Conductivity (µs/cm)	pH	SiO2	Calcium (Ca) (mg/L)	Chloride (Cl) (mg/L)	Sodium (Na) (mg/L)	NO ₂ + NO ₃ (mg/L)	Iron (Fe) (mg/L)	Bicarbonate (HCO ₃) (mg/L)	Carbonate (CO ₃) (mg/L)	Magnesium (Mg) (mg/L)	Nitrate-N (mg/L)	Potassium (mg/L)	Sulphate (mg/L)	Total Hardness (mg/L)
133	357517	15	35	38	2	5	Domestic	944	15/7/65	33.5			476.00		8.50		4.99	4.00	183.00		0.20	399.87	28.00	1.000768*			32.98	17.00
134	357515	NE	35	38	2	5	Domestic	978	14/8/85	30.5	1.04	395.00	513.00	837.00	8.90	7.00	0.998*	1.0011*	215.00	0.0144*	0.02*	431.86	24.00	1.000768*	0.0504*	0.51	57.96	5*
134	357515	NE	35	38	2	5	Domestic	978	NR	30.5	0.97	393.00	505.00	862.00	9.10	7.50	0.998*	1.0011*	202.00	0.0144*	0.02*	413.00	32.00	1.000768*	0.0504*	0.51	63.96	5*
140	357518	SE	36	38	2	5	Domestic	981	22/8/75	39.6	0.83	465.00	527.00	800.00	8.70		0.998*	1.0011*	194.00	0.0284*	0.1*	532.82	17.00	1.000768*	0.0994*	2.22	51.97	1*
146	99659	4	29	38	28	4	Domestic	NR	NR	19.8			484.00				2.00	4.00			0.1*	477.86	38.00	8.00			17.99	38.00
147	99662	NE	29	38	28	4	Domestic	962	29/7/63	39.6			768.00		8.60		2.99	8.01			0.1*	477.86	38.00	1.000768*			29.98	12.00
149	282183	SE	29	38	28	4	Domestic	NR	NR	48.8	0.93	448.00	500.00	852.00	8.50	8.00	2.99	1.0011*	198.00	0.0144*	0.07	528.83	8.00	1.000768*	0.0504*	1.21	26.98	12.00
153	99661	NE	29	38	28	4	Domestic	NR	22/6/84	BR	0.96	419.00	463.00	791.00	8.60	5.60	0.998*	1.0011*	190.00	0.0144*	0.02*	481.84	14.00	1.000768*	0.0504*	0.91	17.99	5*
154	282152	SE	29	38	28	4	Stock	NR	NR	39.6	0.95	447.00	504.00	873.00	8.60	8.30	4.99	1.0011*	200.00	0.0144*	0.23	524.83	10.00	1.000768*	0.0504*	1.21	26.98	18.00
283	418385	NW	33	39	2	5	Domestic	NR	6/6/80	76.2	1.03	414.00	540.00	904.00	8.90	7.10	0.998*	2.00	225.00	0.0284*	0.13	467.85	18.00	1.000768*	0.0994*	0.51	62.96	5*
294	478915	SW	5	40	2	5	Domestic	NR	NR	19.8	0.99	328.00	414.00	900.00	7.00		39.92	8.01	70.00	0.0284*	1.00	399.87		34.03	0.0994*	4.35	55.96	237.00
296	437815	NW	5	40	2	5	Domestic & Stock	NR	4/9/86	36.6	0.98	388.00	396.00	731.00	7.50	13.10	75.85	1.0011*	27.00	0.0144*	0.51	472.85		37.03	0.0504*	2.32	19.99	342.00
298	437849	4	6	40	2	5	Domestic & Stock	NR	24/6/69	30.5		402.00	468.00		8.20		31.94	4.00	145.00			401.87	0.00	9.81		0.40	20.99	120.00
298	437849	4	6	40	2	5	Domestic & Stock	NR	15/9/82	30.5	0.93	396.00	424.00	748.00	7.90	10.80	37.92	1.0011*	114.00	0.0144*	0.79	482.84		11.01	0.0504*	1.82	19.99	140.00
299	437962	13	6	40	2	5	Domestic & Stock	NR	26/8/69	64.0		472.00	680.00		8.70		2.10	4.00	260.00			443.85	28.00	0.30		0.40	99.94	7.00
307	437969	SW	7	40	2	5	Domestic	NR	6/12/84	BR	1.01	406.00	471.00	758.00	7.90	7.80	42.91	2.00	127.00	0.13	0.02*	494.84		16.01	0.0504*	1.41	35.98	173.00
308	438455	2	18	40	2	5	Domestic & Stock	NR	26/8/69	36.6		554.00	642.00		7.95		8.78	3.00	228.00		0.05*	553.82	0.00	1.20		0.81	15.99	27.00
311	438481	NE	19	40	2	5	Domestic	NR	4/1/80	30.5	0.99	387.00	487.00	811.00	8.90	8.70	0.998*	4.00	200.00	0.0144*	0.12	444.85	13.00	2.00	0.0504*	0.71	46.97	9.00
313	438473	SW	19	40	2	5	Domestic	NR	11/9/73	BR	0.91	329.00	348.00	550.00	7.40		58.88	1.0011*	34.00		0.1*	401.87		25.02	0.0994*	1.31	27.98	250.00
314	478916	NW	19	40	2	5	Domestic	NR	1/4/84	BR	0.96	338.00	345.00	645.00	7.90	11.8/	65.87	1.0011*	10.00	0.08	0.02*	411.86		39.03	0.0504*	2.22	22.99	325.00
315	478917	14	19	40	2	5	Unknown	NR	NR	BR		337.00	424.00		8.10		73.85	4.00			0.05*	397.87	6.00	42.03			17.99	358.00
319	437059	NE	1	40	3	5	Domestic	998	17/11/75	44.2	0.86	497.00	614.00	900.00	8.50		13.97	5.00	207.00	0.11	0.1*	588.80	8.00	6.00	0.40	1.11	80.95	60.00
320	437058	NW	1	40	3	5	Domestic & Stock	NR	NR	BR		320.00	392.00	730.00	8.39		34.83		43.80		0.16			41.23				190.00
321	437834	4	13	40	3	5	Domestic & Stock	NR	26/4/69	20.1		283.00	322.00		7.60		69.86	5.50	22.50		0.05*	282.90		21.21		3.33	9.39	262.00
322	437836	6	13	40	3	5	Domestic	NR	4/12/85	SD	1.02	356.00	383.00	653.00	8.20	12.00	74.85	1.0011*	48.99	0.0144*	2.36	433.86		22.02	0.0504*	1.82	19.99	278.00
323	437843	NW	13	40	3	5	Domestic	NR	7/8/84	18.3	1.01	378.00	409.00	692.00	7.90	9.70	96.80	1.0011*	8.00	0.67	0.02*	460.85		38.03	0.0504*	2.42	25.98	398.00
324	437844	NW	13	40	3	5	Domestic	NR	19/9/84	SD	1.03	379.00	414.00	719.00	7.60	10.00	103.79	1.0011*	11.00	0.67	0.02*	461.84		34.03	0.0504*	2.42	23.98	399.00
325	437847	NW	13	40	3	5	Domestic	NR	20/3/86	SD	0.86	356.00	363.00	607.00	8.00	10.20	68.86	1.0011*	9.00	0.63	0.02*	433.86		34.03	0.0504*	2.42	23.98	312.00
327	438419	13	23	40	3	5	Domestic	NR	16/6/69	51.5		376.00	424.00		7.90		37.92	4.00	117.99			375.88		17.41		0.81	14.99	167.00
328	438435	15	23	40	3	5	Domestic & Stock	NR	12/6/69	60.4		374.00	464.00		8.30		11.98	7.01	178.99			373.88		4.30		1.72	39.97	48.00
334	438444	NE	24	40	3	5	Domestic	NR	13/11/73	21.3		411.00	398.00	800.00	7.30		57.88	4.00	18.00		1.20	500.83		57.04	0.0994*	2.43	9.9936*	377.00

*indicates concentration less than
NR - not reported
SD - surficial deposits
BR - bedrock deposits

Table B-3
Data for Town of Sylvan Lake Wells

	Well #1	Well #2	Well #3	Well #5	Well #6	Well #9	Well #10
Approximate Ground Elevation (+/- 2 m) (m asl)	958	951	983	959	960	958	961
Total Depth (m)	57.15	56.4	60.96	59.74	59.74	33.5	41.2
Well Intake (m)	15.00 - 57.15	11.58 - 54.87	15.24 - 60.0	19.20 - 59.74	21.00 - 59.74	26.5 - 33.5	31.1 - 41.2
Pump Intake (m)	28.65	46.02	47.7	53.9	37.80	28.65	46.02
Pre-pumping Water Level Upon Completion of Well (m)	--	7.62 (1980)	--	14.3 (1985)	11.29 (1980)	21.42 (1996)	25.54 (1996)
Pre-pumping Water Level (m)	18.35 (Sept. 1995)	12.01 (Sept. 1995)	39.00 (Sept. 1995)	18.44 (Sept. 1995)	17.80 (Sept. 1995)	21.47 (Sept. 1999)	25.32 (Sept. 1999)
Pre-pumping Water Level Dec. 1999 (m)	9.00	3.20	34.44	10.52	10.56	--	--
Pre-pumping Water Level Nov. 2004 (m)	17.05	13.20	40.77	22.16	18.28	24.87	24.08
Approximate Pumping Water Level (m)	--	--	--	24.25	--	26.5	30.8
Highest Pre-pump Water Level (m asl) (from above water level depths)	949	948	949	949	949	937	937

Source: Tagish Engineering and AGRA (2000)

Table B-4**Yearly Water Consumption (1985 - 2003) for Town of Sylvan Lake**

Year	Water Consumption (m³)	Population	Average Consumption (m³/person)	Average Day (m³/day)	Peak Summer Day (m³/day)
1985	459,227				
1986	476,415	3,937	121.0		
1987	498,981				
1988	554,732				
1989	629,790				
1990	603,315				
1991	564,954	4,240	133.2		
1992	770,346				
1993	615,826				
1994	648,663				
1995	565,743				
1996	590,046	5,178	114.0		
1997	674,316				
1998	733,087				
1999	764,655				
2000	851,846				
2001	946,119	7,493	126.3		
2002	1,006,846	8,066	124.8		
2003	1,061,730	8,717	121.8	2,908	5,236

* Source: Tagish Engineering (2004)

Table B-5
AENV Observation Wells in the Sylvan Lake Area

Well Designation (AENV)	Well Designation (this study)	Legal Location	Area	Ground Elevation (m asl)	Top of Pipe Elevation (m asl)	Bottom Elevation (m asl)	Completion Interval (m bgs)	Aquifer Type	Hydraulic Conductivity (m/s)	Historical Water Level Depths (m btoc)		Fall 2004 Water Level Depths* (m btoc)
										Range	Average	
1_2607E	Well 1-1	01-32-039-02-W5	Northwest End of Lake	945.30	946.56	942.49	0.61 - 3.05	Sand / Clay		0.54 - 3.04	1.85	3.63
1_2606E	Well 1-2	01-32-039-02-W5		945.70	946.38	939.05	5.49 - 6.40	Sandstone	Instant	2.93 - 4.71	3.84	5.24
1_2605E	Well 1-3	01-32-039-02-W5		945.70	946.14	926.12	18.29 - 19.20	Sandstone	6 x 10-4	7.38 - 8.56	8.33	6.99
1_2604E	Well 1-4	01-32-039-02-W5		945.84	945.98	911.60	32.61 - 33.53	Sandstone	4 x 10-4	7.12 - 8.21	8.38	8.92
2_2611E	Well 2-1	01-19-039-01-W5	Birchcliff	941.60	942.27	935.09	0.61 - 6.40	Sandy clay		1.01 - 4.76	3.68	5.87
2_2610E	Well 2-2	01-19-039-01-W5		941.36	942.05	929.73	10.67 - 11.58	Sandstone	1 x 10-3	3.85 - 4.83	4.50	5.65
2_2609E	Well 2-3	01-19-039-01-W5		941.36	941.99	915.35	24.99 - 25.91	Sandstone		4.13 - 4.75	4.44	5.54
3_2615E	Well 3-1	15-09-039-01-W5	Jarvis Bay	963.50	964.06	957.71	1.22 - 5.49	Sandy Clay / Siltstone		4.97 - 5.73	5.63	6.06
3_2614E	Well 3-2	15-09-039-01-W5		963.05	963.67	944.08	17.98 - 18.90	Sandstone		4.72 - 5.19	17.83	19.57
3_2613E	Well 3-3	15-09-039-01-W5		962.97	963.69	933.00	28.96 - 29.87	Sandstone	Instant	25.82 - 27.36	26.15	27.18
3_2612E	Well 3-4	15-09-039-01-W5		963.50	963.50	927.18	35.36 - 36.27	Sandstone	2 x 10-3	26.34 - 27.08	26.68	27.78
4_2618E	Well 4-1	13-26-039-05-W5	Sunbreaker Cove	952.37	953.09	946.70	0.91 - 5.49	Sandy Clay	5 x 10-5	0.40 - 2.15	1.30	2.32
4_2617E	Well 4-2	13-26-039-05-W5		952.17	952.85	928.20	22.86 - 23.77	Sandstone		14.94 - 15.68	15.33	16.36
4_2616E	Well 4-3	13-26-039-05-W5		952.04	952.69	909.77	41.15 - 42.06	Sandstone	Instant	14.95 - 15.53	15.23	16.11
5_2621E	Well 5-1	01-25-039-02-W5	Between Sunbreaker Cove and Birchcliff	973.00	973.60	968.00	1.22 - 4.88	Clay / Shale		4.05 - 4.92	4.73	(dry)
5_2620E	Well 5-2	01-25-039-02-W5		972.00	973.47	931.00	39.62 - 40.54	Sandstone		35.76 - 36.26	35.08	36.97
5_2619E	Well 5-3	01-25-039-02-W5		972.80	973.38	921.00	50.29 - 51.21	Sandstone		35.64 - 36.24	35.89	36.85
6_2694E	Well 6-1	08-10-039-02-W5	South of Half Moon Bay	974.14	974.81	950.00	23.16 - 24.08	Sandstone		14.50 - 15.69	15.16	16.74
6_2693E	Well 6-2	08-10-039-02-W5		974.21	974.90	938.00	35.36 - 36.27	Sandstone	Instant	29.46 -31.05	30.61	31.17
6_2692E	Well 6-3	08-10-039-02-W5		973.55	974.31	913.00	59.74 - 60.66	Sandstone	2 x 10-6	34.06 - 34.45	34.27	33.65
7_2698E	Well 7-1	09-01-039-02-W5	Norglenwold	968.97	969.51	959.50	9.45 - 10.36	Sandstone		7.07 - 8.83	8.01	8.70
7_2697E	Well 7-2	09-01-039-02-W5		969.06	969.69	951.80	17.07 - 17.98	Sandstone		7.47 - 9.60	8.32	9.20
7_2696E	Well 7-3	09-01-039-02-W5		969.07	969.75	931.80	35.36 - 36.27	Sandstone		27.24 - 29.60	28.91	29.92

m asl - metres above sea level
m bgs - metres below ground surface
Instant - water level response too rapid for measurements
m btoc - metres below top of casing
* measured on September 30 and October 1, 2004

Table B-6
Historic Chemical Analysis Results for AENV Observation Wells

Well	Parameters																						
	Lab						Field								Lab								
	pH	EC μS/cm	TDS mg/L	DO mg/L	Alk mg/L	HCO ₃ mg/L	T °C	pH	EC μS/cm	DO mg/L	Eh mV	Alk mg/L	HCO ₃ mg/L	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Na+K mg/L	Mn mg/L	Fe mg/L		SO ₄ mg/L	Cl mg/L
																					HCO ₃ mg/L		
6-3	8.56	780	567	N/A	400	244	N/A	N/A	N/A	N/A	N/A	N/A		1.0	2.0	0.8	191	191.8	N/A	0.62	466	22.0	7
6-2	7.71	690	397	N/A	334	203.7	N/A	N/A	N/A	N/A	N/A	N/A		38.0	13.0	104	2.0	106	N/A	0.02	407	24.0	13
6-1	8.18	750	469	N/A	358	218.4	N/A	N/A	N/A	N/A	N/A	N/A		12.0	6.0	168	1.0	169	N/A	1.58	437	50.0	15
7-3	8.92	940	544	N/A	440	268.4	N/A	N/A	N/A	N/A	N/A	N/A		3.0	0.6	223	0.4	223.4	N/A	1.00	481	48.0	3
7-2	8.63	850	494	N/A	407	248.3	N/A	N/A	N/A	N/A	N/A	N/A		3.0	0.6	202	0.4	202.4	N/A	0.18	469	36.0	8
7-1	7.83	720	397	N/A	348	212.3	N/A	N/A	N/A	N/A	N/A	N/A		44.0	28.0	74.0	3.0	77	N/A	0.13	425	24.0	15
1-5	8.90	956	588	0.1	428	261.1	N/A	8.95	900	N/A	-165	342	208.6	1.0	0.2	242	0.6	242.6	0.004	0.01	457	86.5	0.8
1-3	8.23	752	436	0.2	411	250.7	5.0	7.48	813	N/A	-140	230	140.3	43.5	31.2	83.4	2.1	85.5	0.023	0.01	501	27.6	1.4
1-2	8.12	724	418	6.6	388	236.7	5.4	7.21	688	N/A	-0.45	420	256.2	59.6	35.1	51.9	2.0	53.9	0.004	0.01	473	27.8	2.7
2-3	8.44	848	517	0.1	434	264.7	5.6	8.05	871	N/A	-210	337	205.6	10.9	6.2	192	1.4	193.4	0.011	0.01	508	45.6	0.5
2-2	8.05	827	463	0.1	385	234.9	4.9	7.23	863	N/A	-70	117	108	81.8	43.2	25.7	2.9	28.6	0.042	0.01	470	23.3	28.9

Source: Baker (2003)

Table B-7**Field Testing Results for AENV Observation Wells**

Parameter	30-Sep-04 Well 1-2	30-Sep-04 Well 2-1	30-Sep-04 Well 3-3	30-Sep-04 Well 4-1	30-Sep-04 Well 5-2	30-Sep-04 Well 6-1	30-Sep-04 Well 7-1
Water Level (m btoc)	6.88	5.90	27.18	2.32	36.97	16.74	8.70
Well Depth (m bgs)	5.24	7.18	31.92	6.03	42.45	25.07	11.78
Temperature (°C)	4.8	5.0	6.6	6.2	5.6	5.6	5.7
pH	7.51	7.14	7.40	7.28	8.78	7.72	7.57
Conductivity (µS/cm)	786	1205	716	743	858	716	716
Dissolved Oxygen (mg/L)	6.21	9.94	4.67	2.56	2.65	5.29	0.69
Redox Potential (mV)	138.5	137.5	126.7	-58.4	59.1	-65	-37
Northing (m) NAD 83	5808334	5805168	5803122	5808218	5806710	5802688	5801048
Easting (m) NAD 83	687739	695946	698841	691086	694320	691131	694564

m btoc - metres below top of casing

m bgs - metres below ground surface

Table B-8
Chemical Analysis Results for AENV Observation Wells

Chemical Analysis Results for AENV Observation Wells										
Parameters	Units	30-Sep-04	30-Sep-04	30-Sep-04	21-Oct-04	30-Sep-04	30-Sep-04	30-Sep-04	21-Oct-04 Duplicate	Trip Blank
		Well 1-2	Well 2-1	Well 3-3	Well 4-1	Well 5-2	Well 6-1	Well 7-1	Well 4-1	
Nutrients										
Total Phosphorus	mg/L	0.075	0.55	0.379	0.405	0.108	0.305	0.123	0.356	0.002
Total Dissolved Phosphorus	mg/L	0.002	0.04	0.004	0.043	0.014	0.103	0.007	0.037	<0.001
Ammonia - N	mg/L	0.008	0.042	<0.005	0.047	0.068	0.102	0.315	0.051	<0.005
Total Kjeldahl Nitrogen	mg/L	0.20	1.59	0.40	1.21	0.29	0.28	0.44	0.94	<0.05
Nitrite - N	mg/L	<0.002	0.059	<0.002	<0.05	<0.002	0.004	0.002	<0.05	<0.002
Nitrate - N	mg/L	0.868	3.93	1.22	<0.1	0.023	0.835	<0.006	<0.1	<0.006
Nitrate + Nitrite - N	mg/L	0.868	3.98	1.22	0.027	0.024	0.839	<0.006	0.057	<0.006
Major Water Quality Parameters										
pH	pH	7.8	7.8	7.9	7.8	8.7	7.9	7.9	7.8	5.9
Conductivity	µS/cm	671	993	628	740	823	596	674	742	1.4
Total Dissolved Solids	mg/L	430	770	420	380	540	400	420	410	10
Total Alkalinity (as CaCO ₃)	mg/L	378	584	364	400	415	333	358	402	<5
Hardness (as CaCO ₃)	mg/L	295	676	332	395	30	295	246	401	<1
Ion Balance	%	98.1	99.4	96.4	99.4	112	96.2	93.4	101	low TDS
Major Ions										
Calcium	mg/L	62.8	150	53.2	88.2	6.6	59.5	49.8	89	<0.5
Magnesium	mg/L	33.6	73.1	48.3	42.5	3.2	35.6	29.6	43.4	<0.1
Sodium	mg/L	48	10	23	13	226	27	61	13	<1
Potassium	mg/L	2.0	2.8	2.6	2.1	1.5	2.5	2.6	2.2	<0.1
Carbonate	mg/L	<5	<5	<5	<5	23	<5	<5	<5	<5
Bicarbonate	mg/L	461	712	444	488	459	407	437	490	<5
Sulfate	mg/L	25.1	83.8	12.1	26	48.4	16.0	18.8	24.1	<0.5
Chloride	mg/L	2	14	13	1	2	13	23	1	<1
Fluoride	mg/L	0.13	0.20	0.13	0.24	0.13	0.11	<0.05	0.22	<0.05
Hydroxide	mg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5
Miscellaneous										
Dissolved Iron	mg/L	<0.06	<0.06	<0.06	0.37	<0.06	<0.06	<0.06	0.41	<0.06
Dissolved Manganese	mg/L	<0.01	0.17	<0.01	0.09	<0.01	0.04	0.06	0.07	<0.01
Silica (as SiO ₂)	mg/L	9.9	13.6	8.5	11.2	17.3	7.9	10.4	11.9	<0.1
Dissolved Organic Carbon	mg/L	4	9	13	8	3	4	4	9	1

Table B-9

Field Testing Results for Shallow Monitoring Wells

Parameter	12/13-Oct-04 S1	12/13-Oct-04 S2	12/13-Oct-04 S3	12/13-Oct-04 N1	12/13-Oct-04 N2	12/13-Oct-04 Lake (N2)	12/13-Oct-04 H1	12/13-Oct-04 H2	12/13-Oct-04 H3
Ground Elevation (m asl)	936.87	937.88	937.07	940.61	936.92	--	937.25	937.21	937.28
Water Level (m btoc)*	0.42	1.33	0.70	4.19	0.15	--	0.68	3.53	2.52
Well Depth (m bgs)	6.05	6.15	2.94	5.29	5.97	--	4.45	4.46	2.98
Hydraulic Conductivity (m/s)	5×10^{-7}	3×10^{-8}	3×10^{-6}	2×10^{-7}	6×10^{-9}	--	4×10^{-7}	5×10^{-10}	3×10^{-9}
Temperature (°C)	9.8	7.7	11.10	6.7	7.1	3.4	8.8	5.4	7.8
pH	6.17	7.16	6.91	7.40	7.81	8.80	7.14	6.92	7.24
Conductivity (µS/cm)	901	1526	1258	1144	1574	703	1660	1016	1787
Dissolved Oxygen (mg/L)	1.93	4.00	3.91	5.20	5.92	13.73	4.38	9.95	8.31
Redox Potential (mV)	-28.1	127.4	50.4	40.1	54	88.7	126.2	134.7	131.1
Northing (m) NAD 83	5807640	5807659	5807761	5800415	5801643	--	5803160	5803191	5803226
Easting (m) NAD 83	691305	691153	690836	696790	694519	--	692819	692538	692480

m btoc - metres below top of casing

m bgs - metres below ground surface

* - measured on October 21, 2004

Table B-10

Chemical Analysis Results for Shallow Monitoring Wells

Parameters	Units	MW-1	MW-2	MW-3	MW-4	MW-5	MW-6	MW-7	MW-8	Trip Blank	MW-4 (Duplicate)
Nutrients											
Total Phosphorus	mg/L	2.78	1.99	2.11	1.61	12.7	0.784	3.51	1.65	0.003	3.09
Total Dissolved Phosphorus	mg/L	0.018	0.027	0.026	0.018	0.02	0.019	0.035	0.027	0.002	0.021
Ammonia - N	mg/L	0.065	0.161	0.098	0.068	0.498	0.053	0.087	0.300	<0.005	0.097
Total Kjeldahl Nitrogen	mg/L	2.21	2.93	1.66	6.29	11.1	0.95	5.33	5.50	<0.05	9.69
Nitrite - N	mg/L	<0.05	0.28	0.22	<0.05	0.12	<0.05	0.28	<0.05	<0.05	<0.05
Nitrate - N	mg/L	9.6	0.8	0.7	7.8	0.2	<0.1	4.9	<0.1	<0.1	7.8
Nitrate + Nitrite - N	mg/L	9.1	1.1	0.9	7.8	0.3	<0.1	4.8	<0.1	<0.1	7.8
Major Water Quality Parameters											
pH	pH	7.5	7.8	8.0	7.6	8.1	7.7	7.5	7.3	7.1	7.6
Conductivity	µS/cm	1560	1810	1560	1040	1540	831	1470	1140	2.6	1020
Total Dissolved Solids	mg/L	950	1230	-	660	1800	510	1000	740	<10	640
TDS (Calculated)	mg/L	943	1160	1036	622	948	482	864	706	<1	616
Total Alkalinity (as CaCO ₃)	mg/L	655	527	584	445	666	423	722	616	<5	445
Hardness (as CaCO ₃)	mg/L	771	557	641	518	140	355	744	517	<1	516
Ion Balance	%	102	104	103	101	102	102	104	101	Low TDS	100
Major Ions											
Calcium	mg/L	186	136	156	142	35.8	69.7	161	127	<0.5	140
Magnesium	mg/L	74.5	52.7	61.0	39.8	12.2	44.0	83.0	48.6	<0.1	40.4
Sodium	mg/L	67	214	139	34	328	58	62	80	<1	33
Potassium	mg/L	4.2	5.8	5.9	5.0	3.8	3.7	5.3	8.5	<0.1	4.6
Carbonate	mg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Bicarbonate	mg/L	799	644	712	543	812	516	881	752	<5	544
Sulfate	mg/L	101	407	287	47.5	161	48.3	63.5	64.1	<0.5	44.3
Chloride	mg/L	75	26	28	52	6	4	33	8	<1	52
Fluoride	mg/L	0.21	0.15	0.14	0.18	0.25	0.15	0.16	0.21	<0.05	0.18
Hydroxide	mg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Miscellaneous											
Dissolved Iron	mg/L	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
Dissolved Manganese	mg/L	0.20	0.08	<0.01	<0.01	0.08	0.08	0.51	0.77	<0.01	<0.01
Silica (as SiO ₂)	mg/L	14.3	10.2	12.2	10.8	10.8	9.4	13.5	12.5	<0.1	11.5
Dissolved Organic Carbon	mg/L	17	21	15	21	11	22	15	29	1	9
MF - E.Coli	CFU/100mL	2	<1	<1	<1	<1	<1	<1	<1	-	<1
MF - Fecal Coliforms	CFU/100mL	3	<1	<1	>200	<1	<1	<1	<1	<0.1	>200

Table B-11**Measured Heads and Simulated Heads From Model Calibration**

Well Location (UTM)		Measured Head (m asl)	Simulated Head (m asl)
Northing (m)	Easting (m)		
5809563	279357	937.46	936.74
5805967	287376	936.92	937.67
5803814	290152	936.82	937.22
5808997	283026	936.81	937.00
5807666	285814	936.91	937.14
5803347	282352	939.28	941.52
5801998	285567	940.16	940.10
5810552	275324	974.00	977.42
5809271	276901	951.00	954.84
5806821	277194	966.00	954.20
5812013	279063	968.00	965.15
5803438	280315	966.00	968.23
5797989	284669	960.00	963.30
5801614	285146	953.00	946.59
5797532	285452	965.00	963.50
5795486	286186	958.00	964.42
5795067	286570	967.00	964.31
5805949	287799	950.00	940.48
5797305	290741	935.00	936.55
5796818	292748	933.00	933.02
5800054	292884	933.00	931.22
5798027	293200	936.00	931.71
5798429	293217	933.00	931.47
5799635	293268	937.00	931.22
5801264	293318	934.00	938.71
5797959	294823	934.00	931.21
5797838	297757	928.00	928.79
5794585	298025	921.00	925.49
5800544	281530	973.00	971.07
5795295	290656	950.00	942.78
5798251	287932	953.00	952.90

Figures

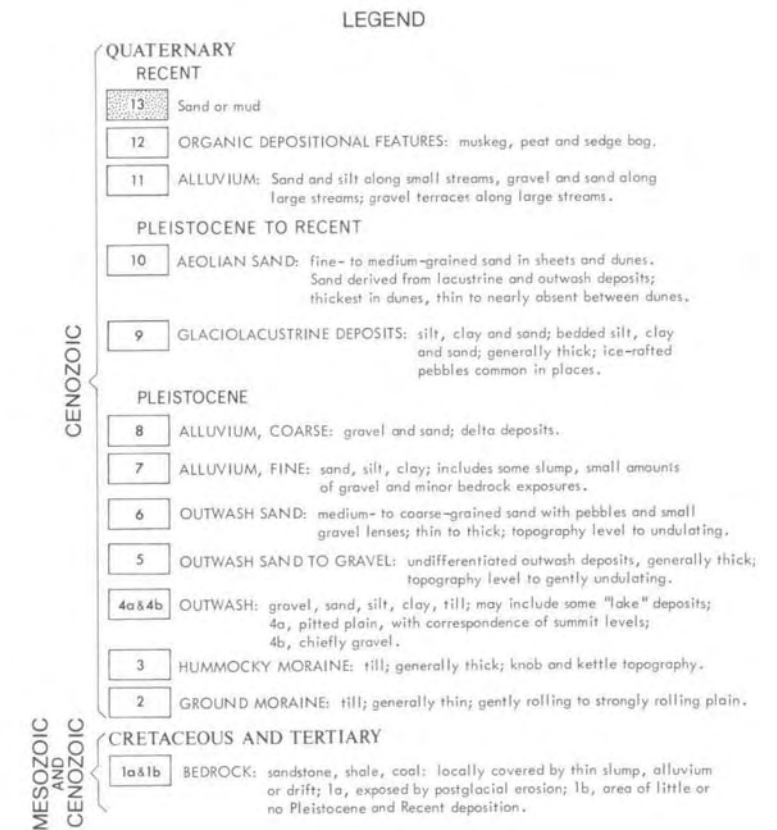
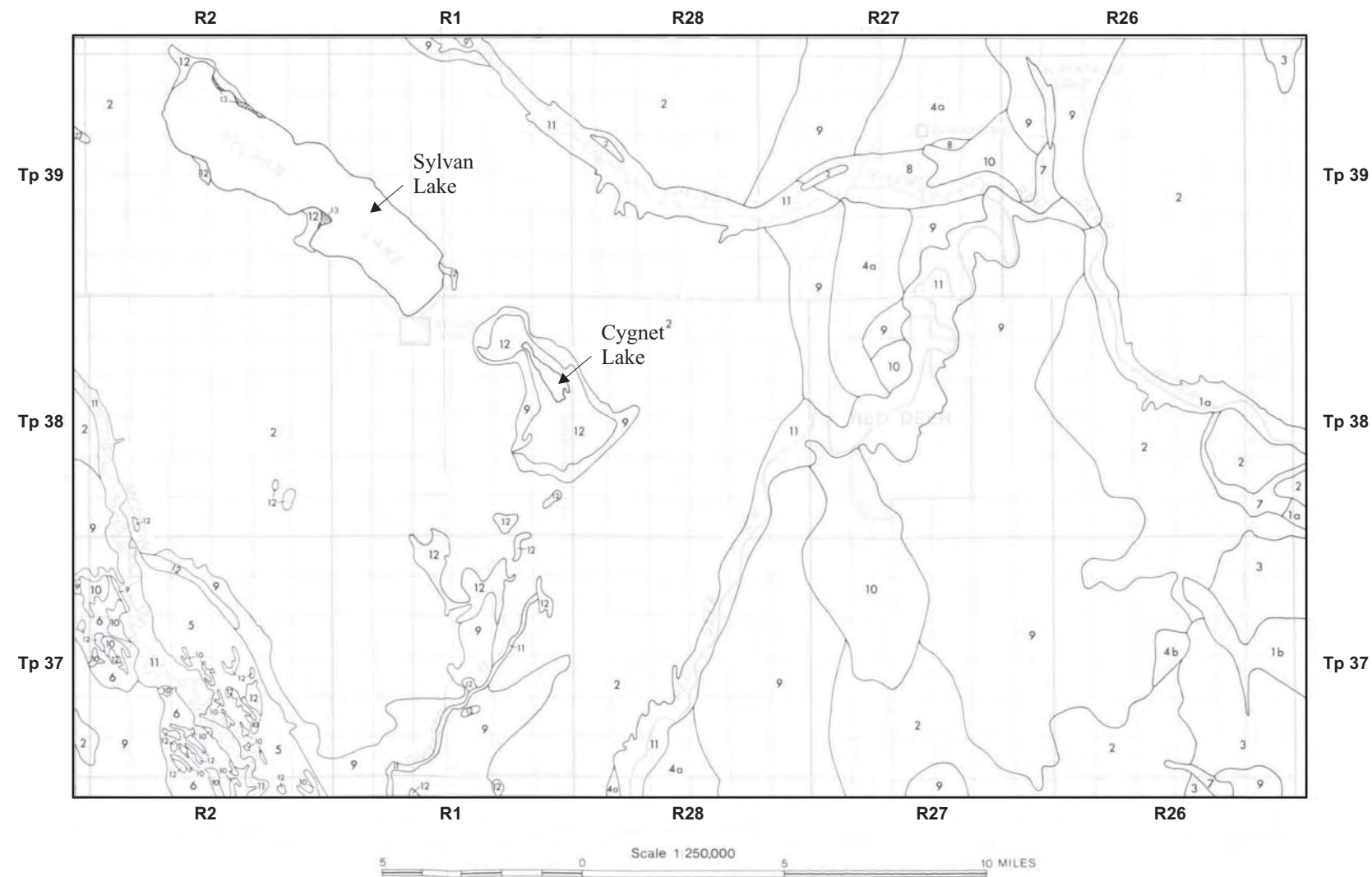


Figure B-1
Surficial Geology of the Red Deer Region
 (from Gabert 1975)



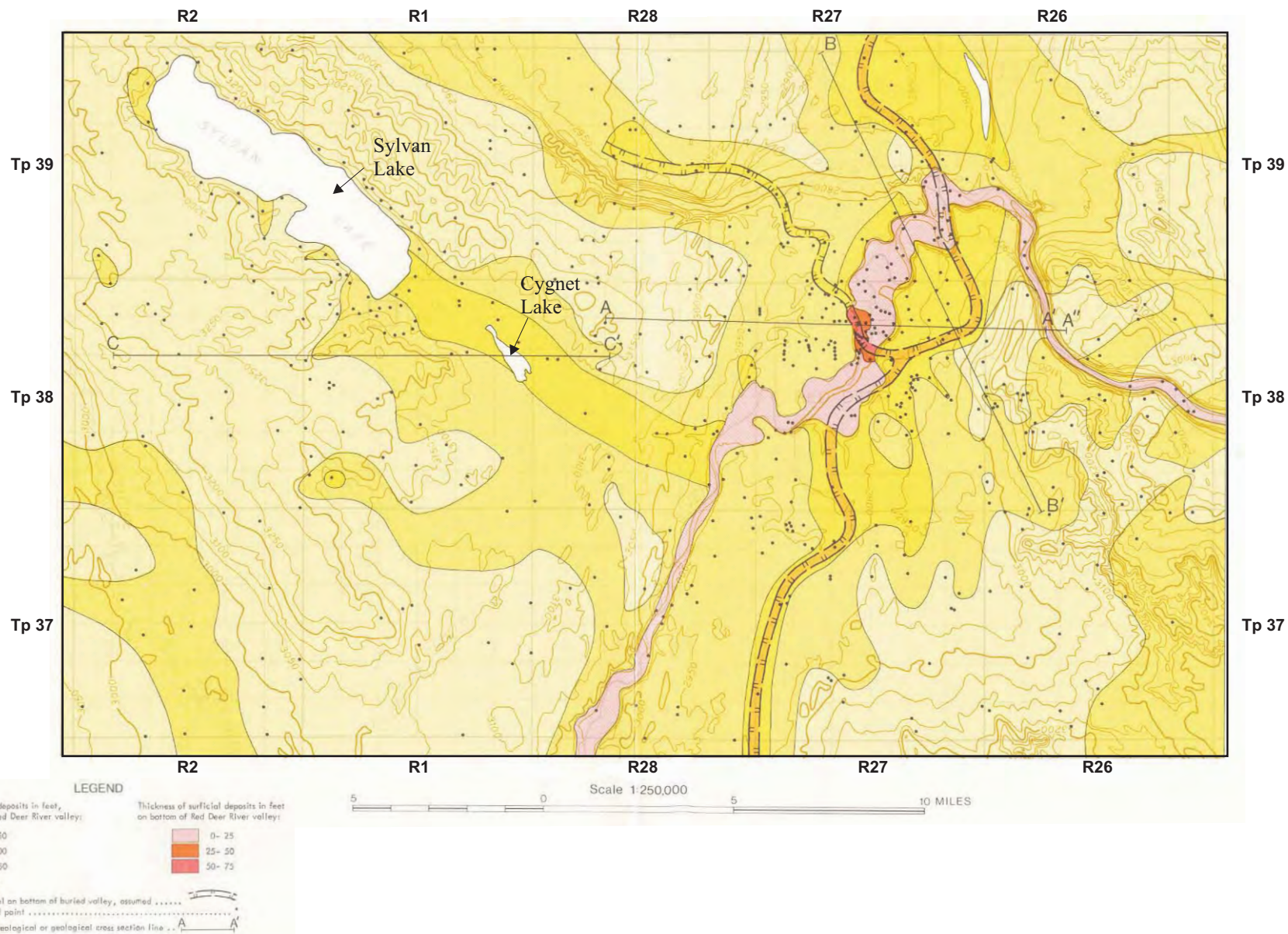


Figure B-2
Thickness of Surficial Deposits
In the Red Deer Region
(From Gabert 1975)



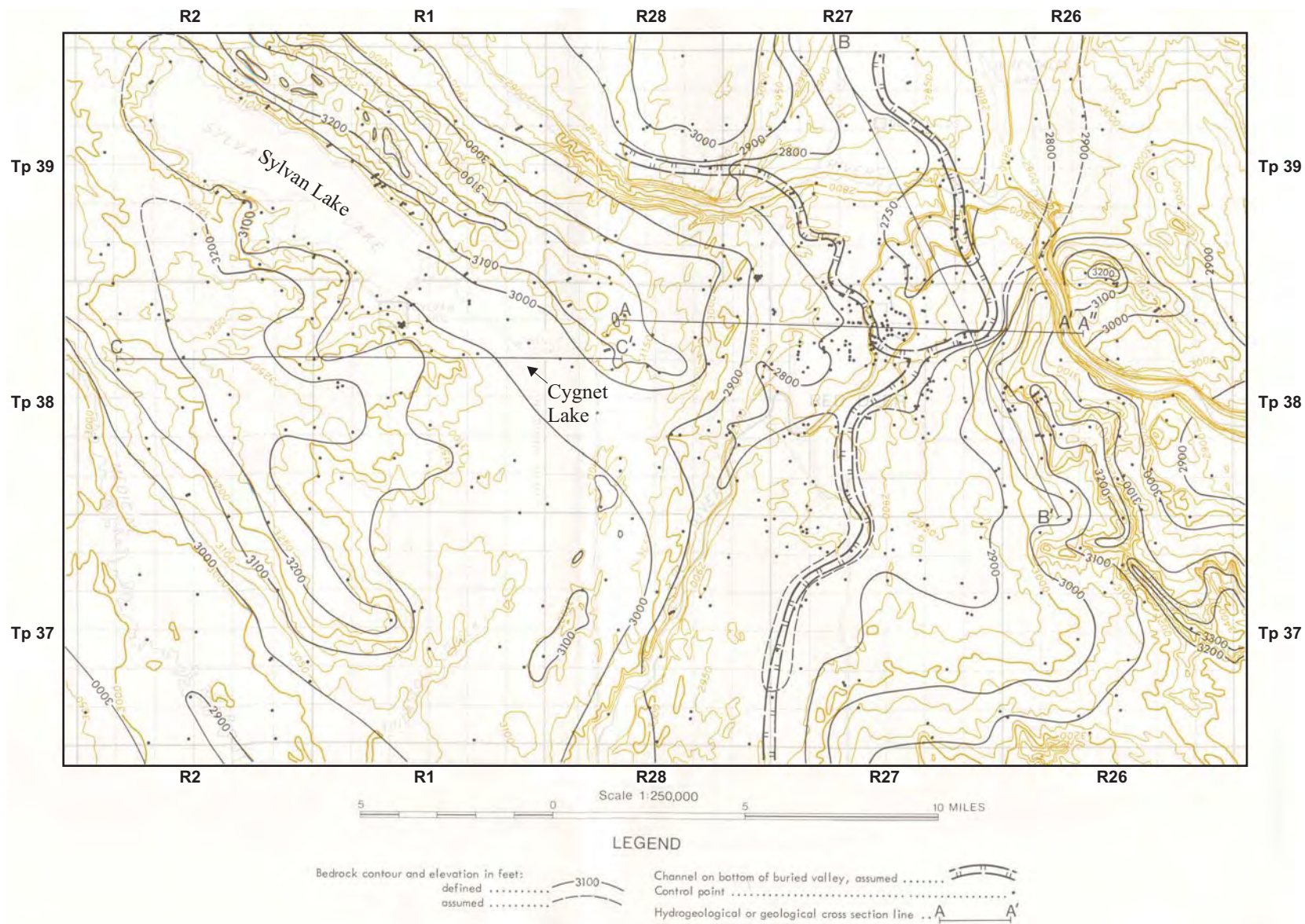


Figure B-3
Bedrock Topography in the Red Deer Region
 (from Gabert 1975)



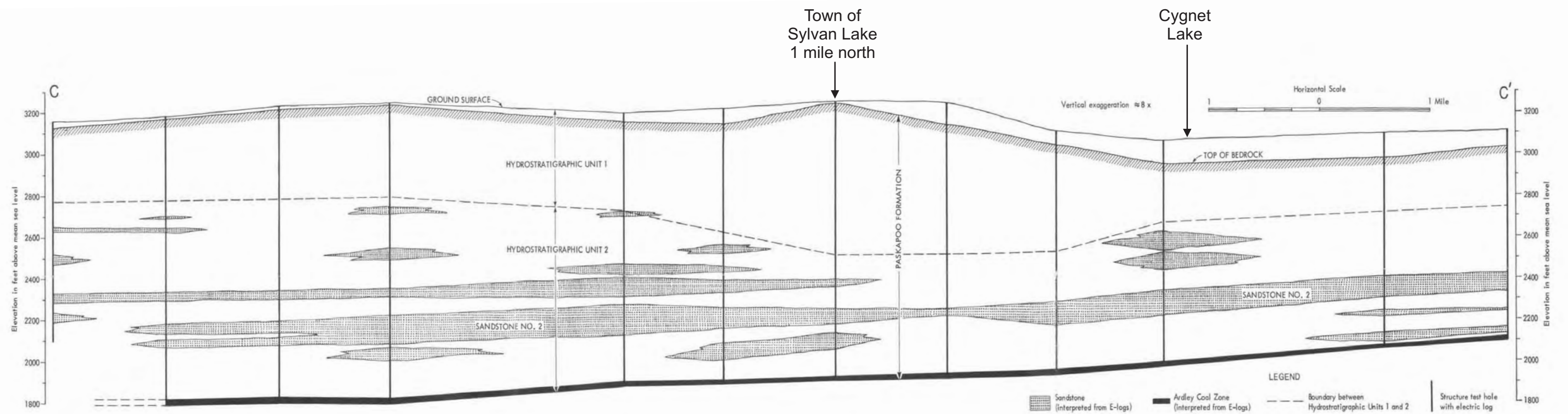


Figure B-4
Cross-section C-C' from Gabert (1975)

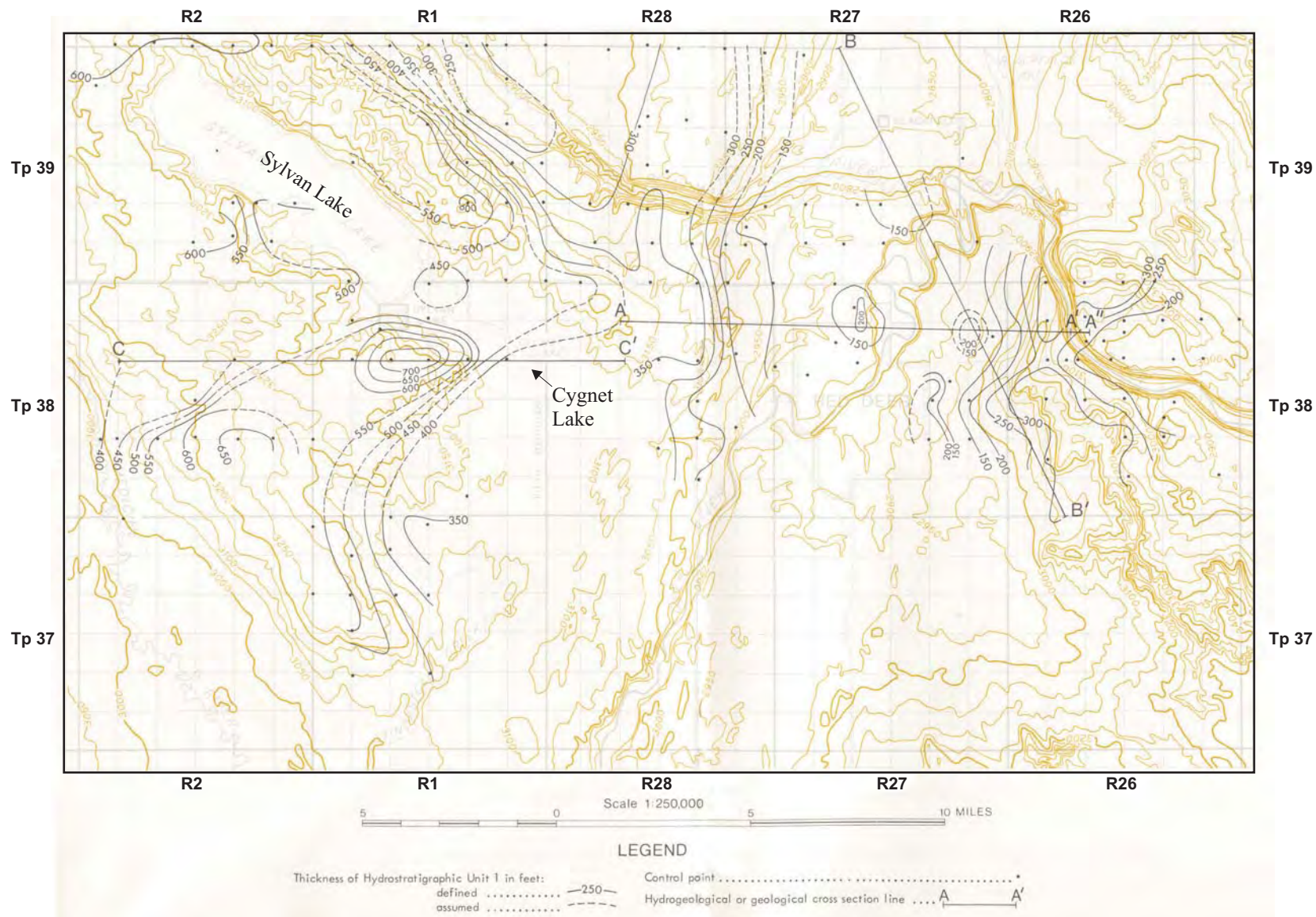


Figure B-5
Thickness of Hydrostratigraphic Unit 1
(From Gabert 1975)



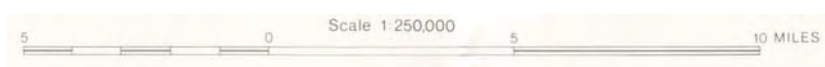
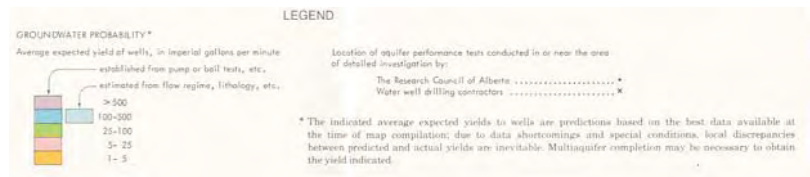
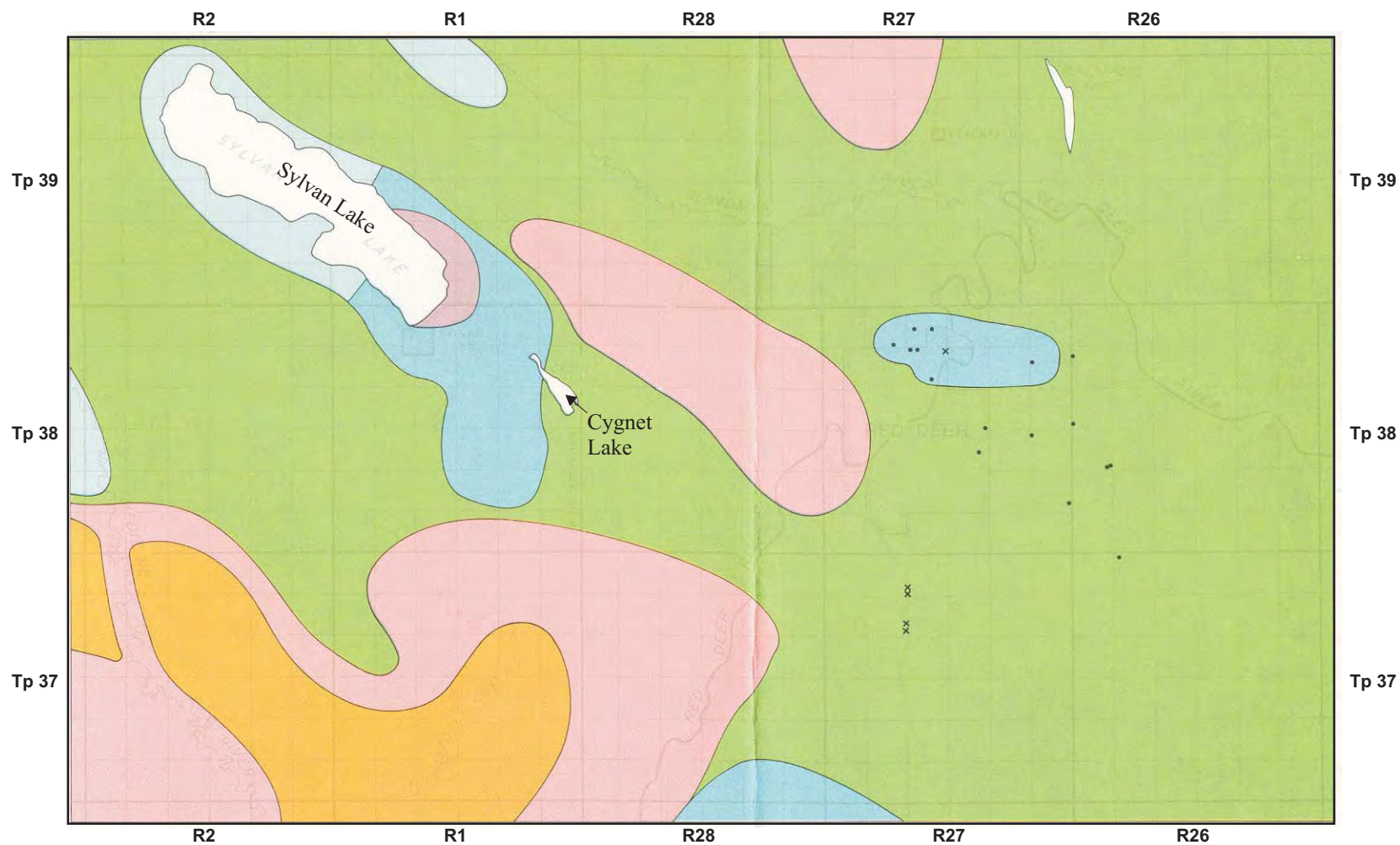
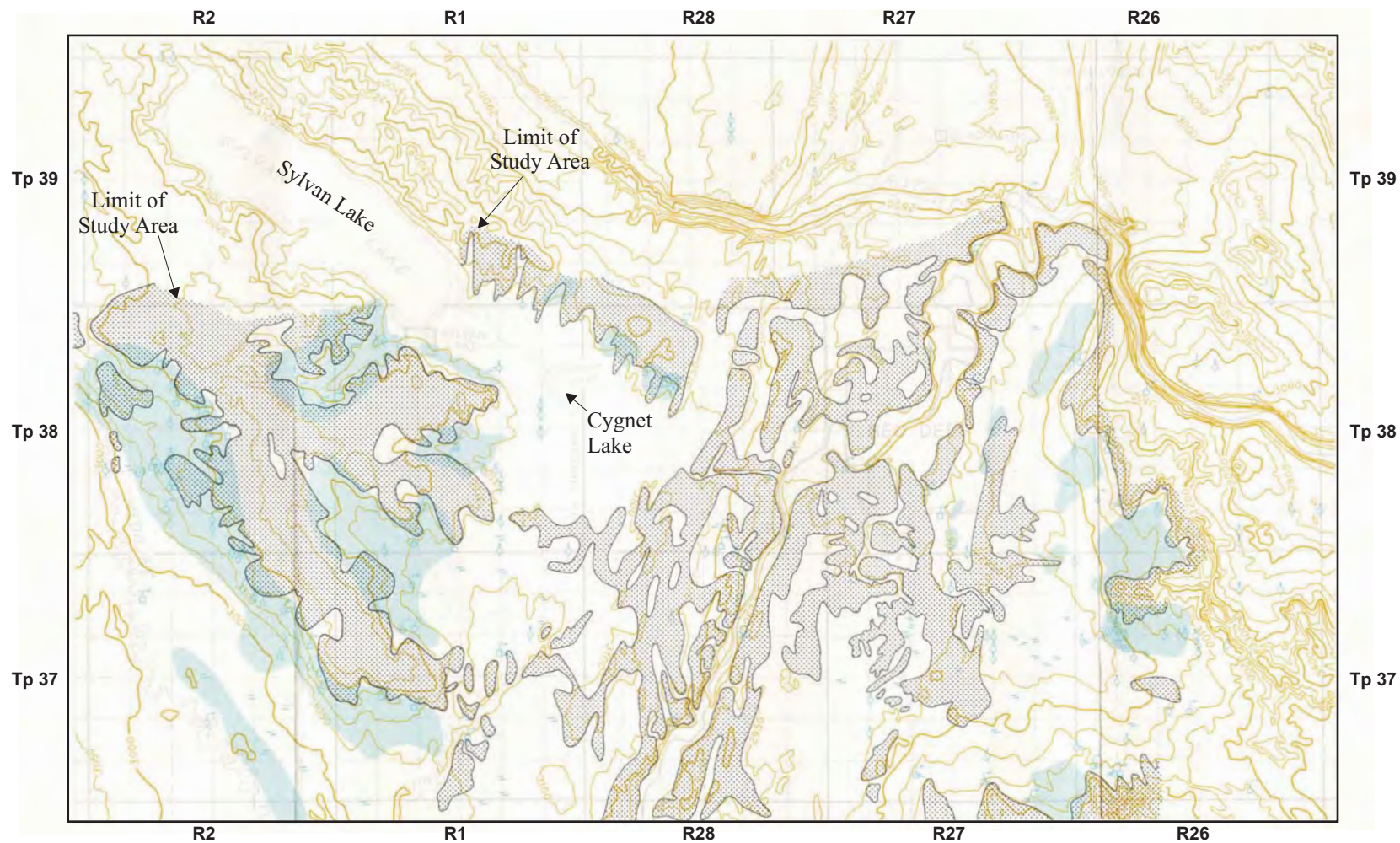


Figure B-6
Groundwater Probability Map
(From Gabert 1975)





LEGEND

Spring	Recharge area (groundwater moving away from the water table)
Seepage	
Soaphole	Area of proposed test drilling for a large groundwater supply
Flowing seismic shot hole	
Salt precipitates	

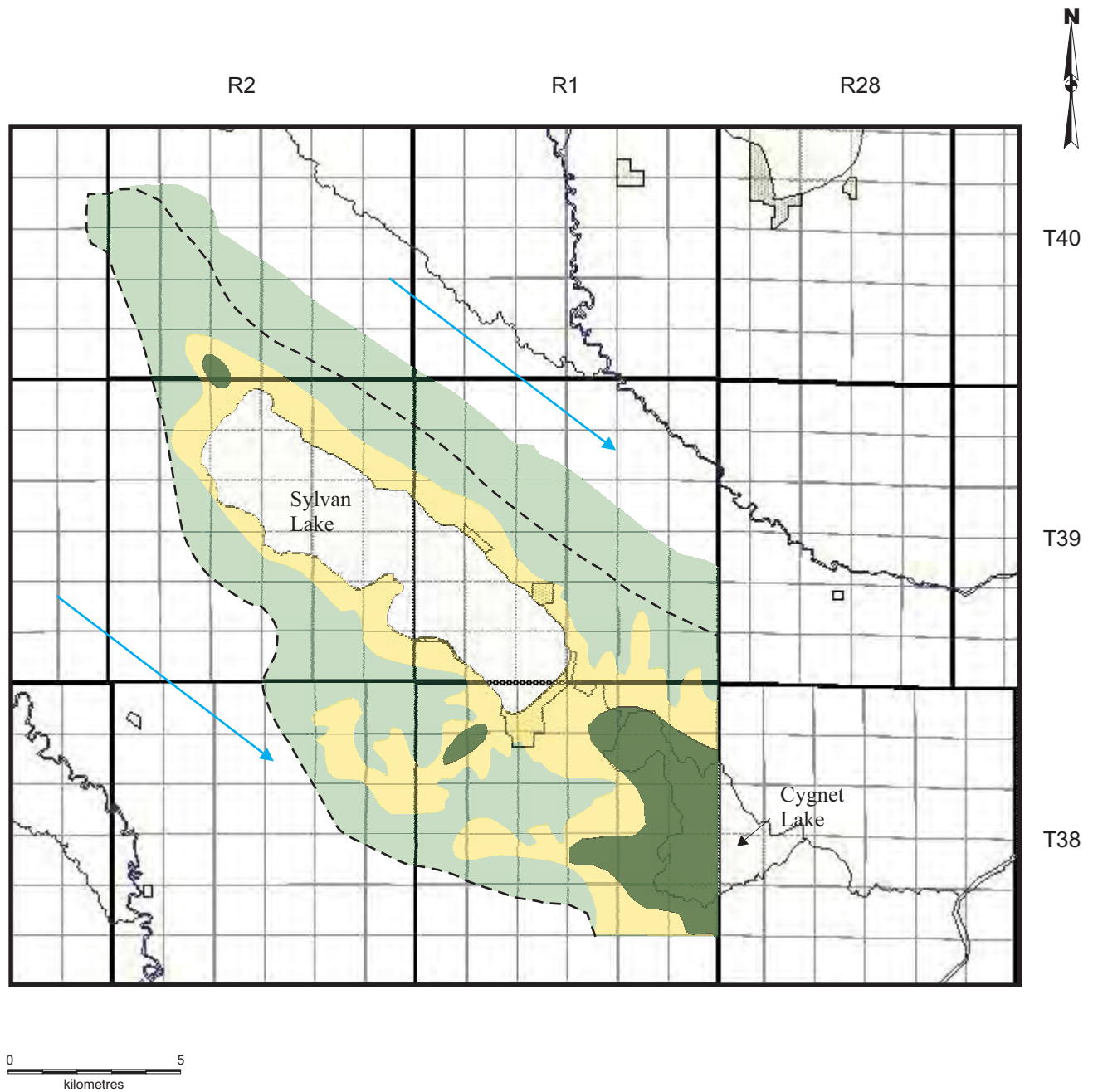
Note: Areas between stipple, designated as recharge areas, are considered discharge areas (groundwater is moving toward the water table).

Scale 1:250,000

5 0 5 10 MILES

Figure B-7
Location and Distribution of
Groundwater Phenomena and Recharge Areas
(from Gabert 1975)





LEGEND

- Groundwater and Surface Water Divide
- Groundwater Recharge Area
- Groundwater Discharge Area
- Flowing Well Zone
- Direction of Regional Groundwater Flow

Figure B-8
Recharge/Discharge Zones
(from Alberta Environment 1976)



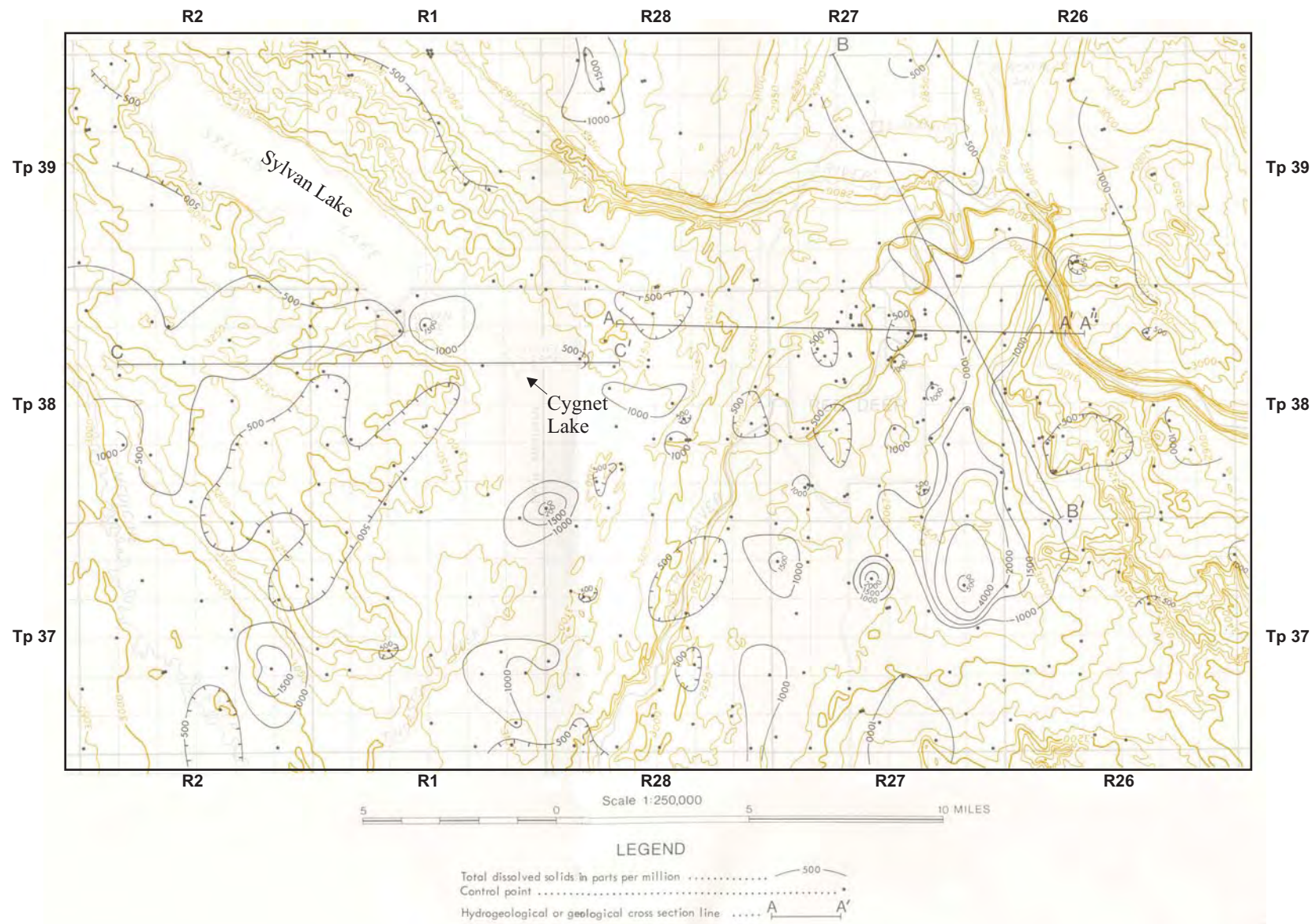
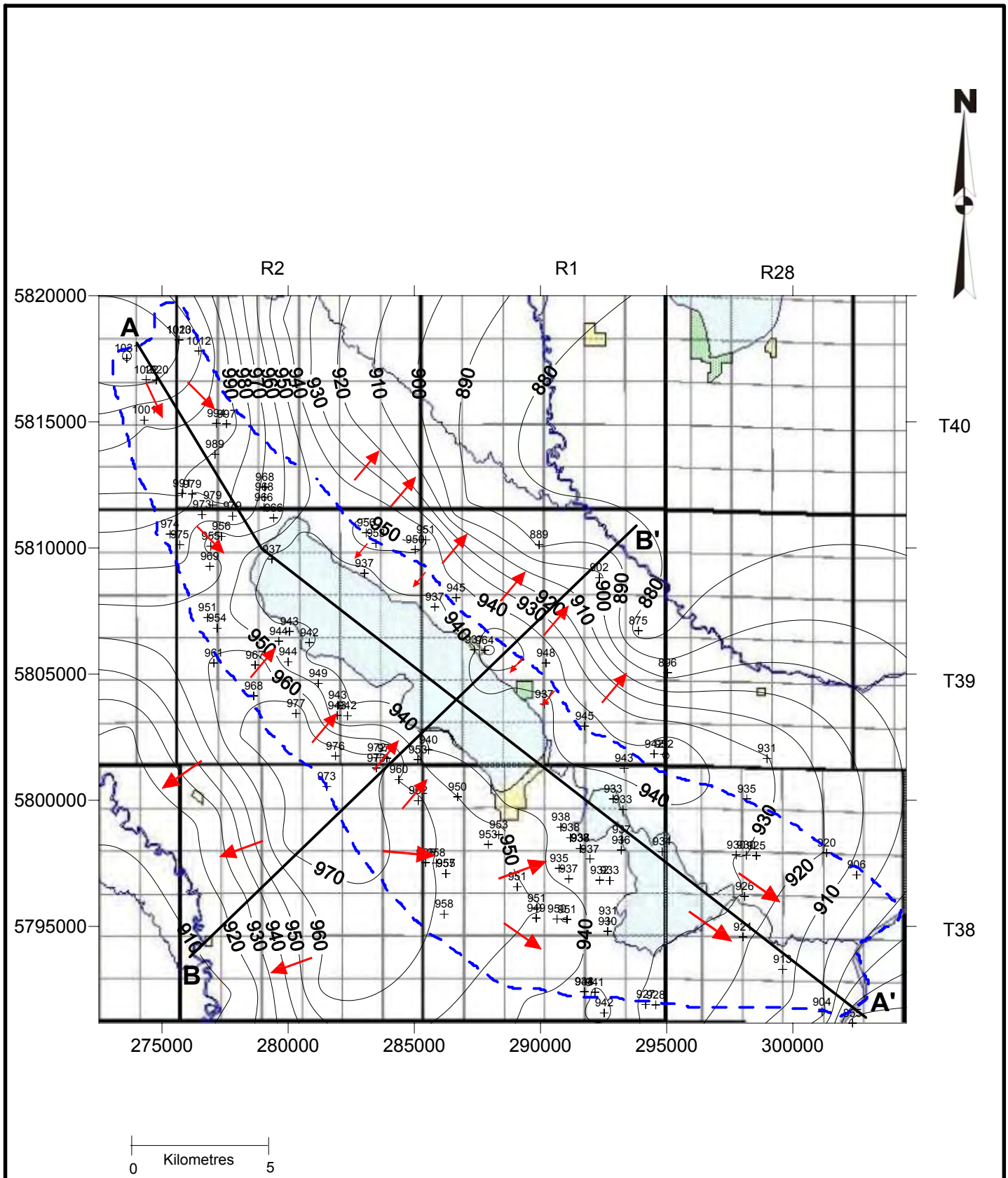


Figure B-9
Areal Distribution of Total Dissolved Solids
in ppm
(From Gabert 1975)



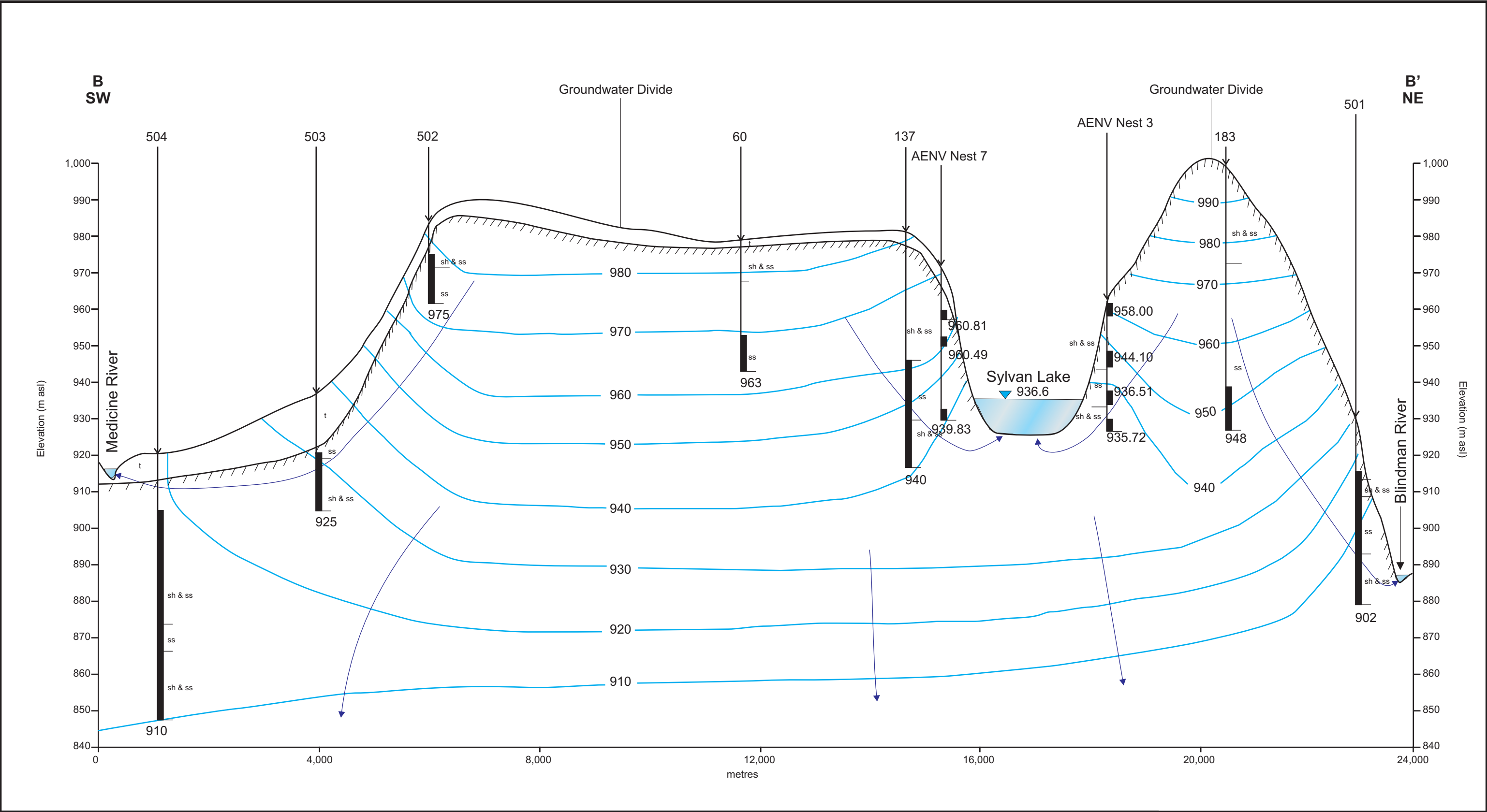


LEGEND

- Hydraulic Head Contour (m asl)
- - - Groundwater Basin
- Groundwater Flow Direction

Figure B-10
Hydraulic Head Distribution for
Hydrostratigraphic Unit 1





LEGEND

- t Till
- ss Sandstone
- sh Shale
- Bedrock Surface
- Equipotential Line (m asl)
- Direction of Groundwater Flow

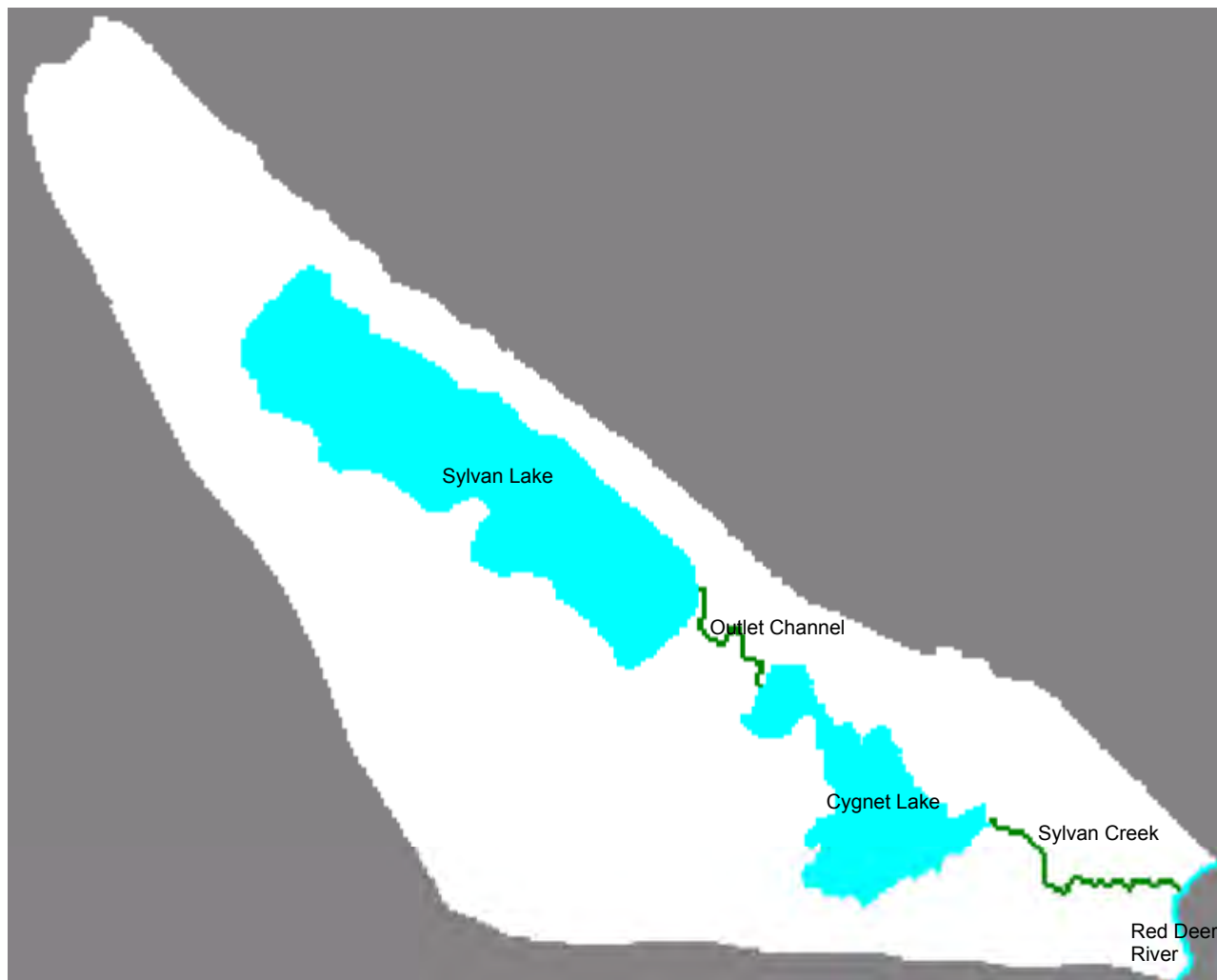
137 ← Project Ref. No.

Screen or Perforated Pipe

940 ← Hydraulic Head (m asl)

Figure B-12
Cross-section B-B'



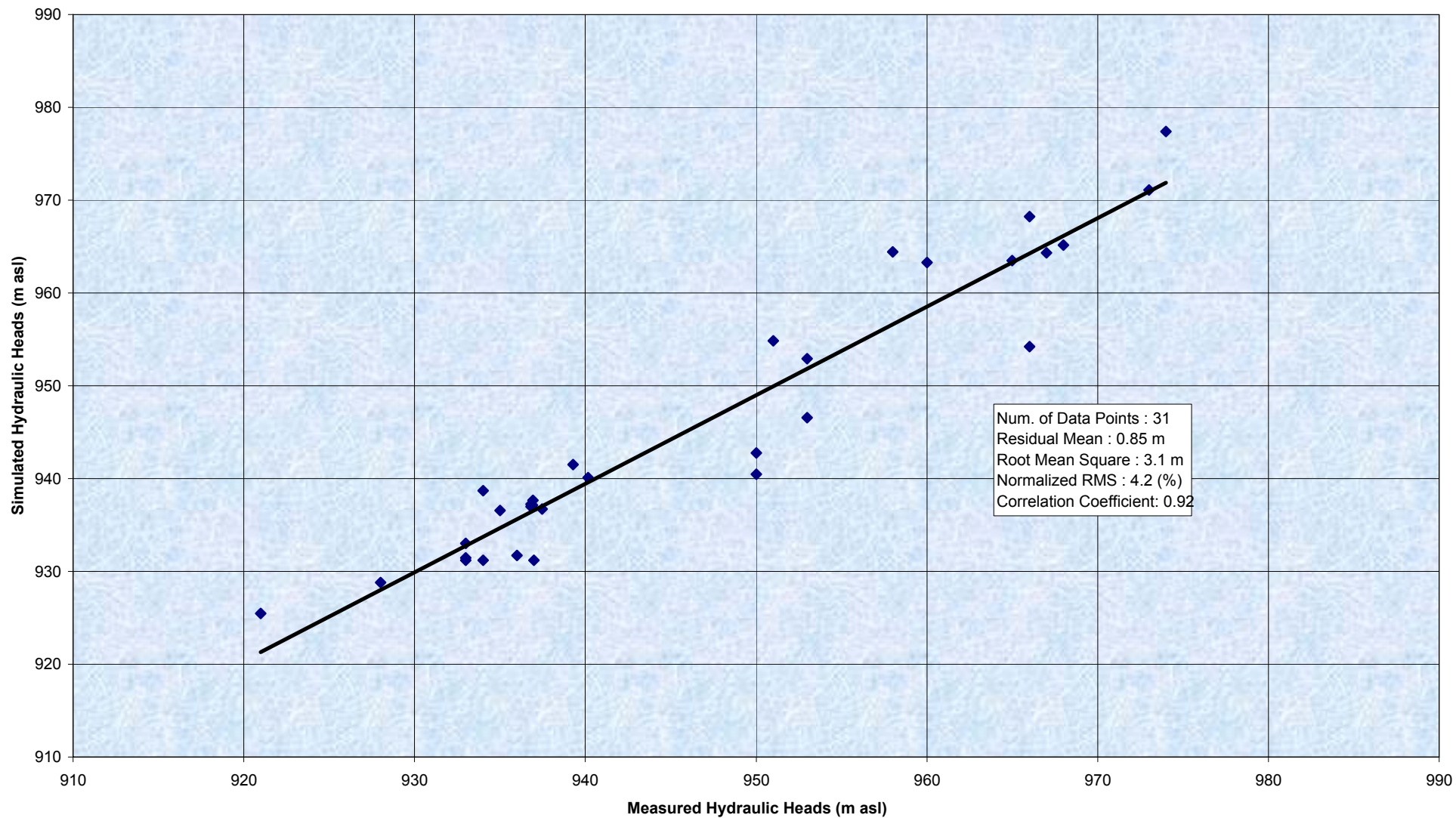


LEGEND

	Active Cells		Creek
	Inactive Cells		Lake or River

**Figure B-13
Model Domain**

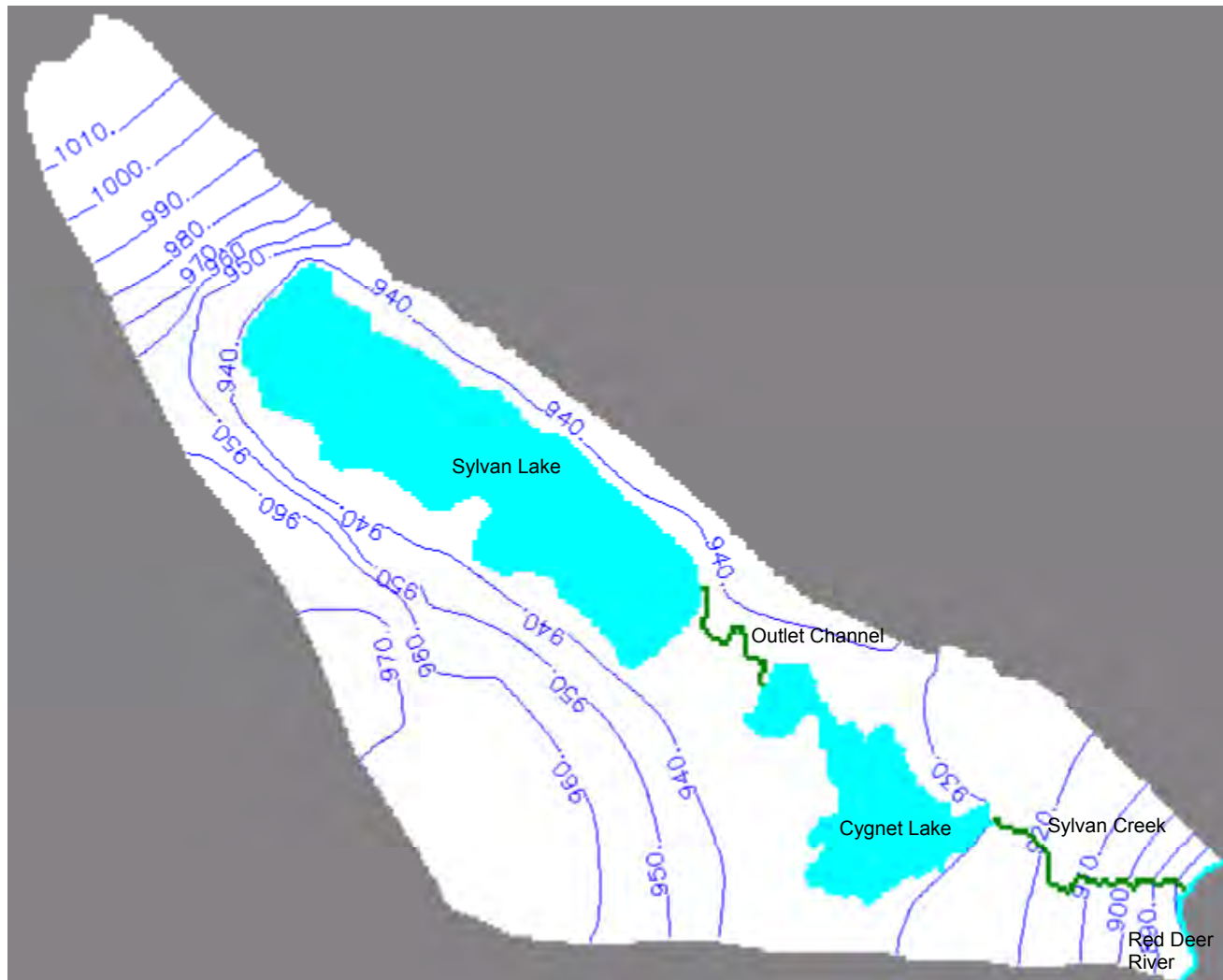




Legend

Figure B-14
Correlation Plot and Statistical Analysis
for the Calibrated Model



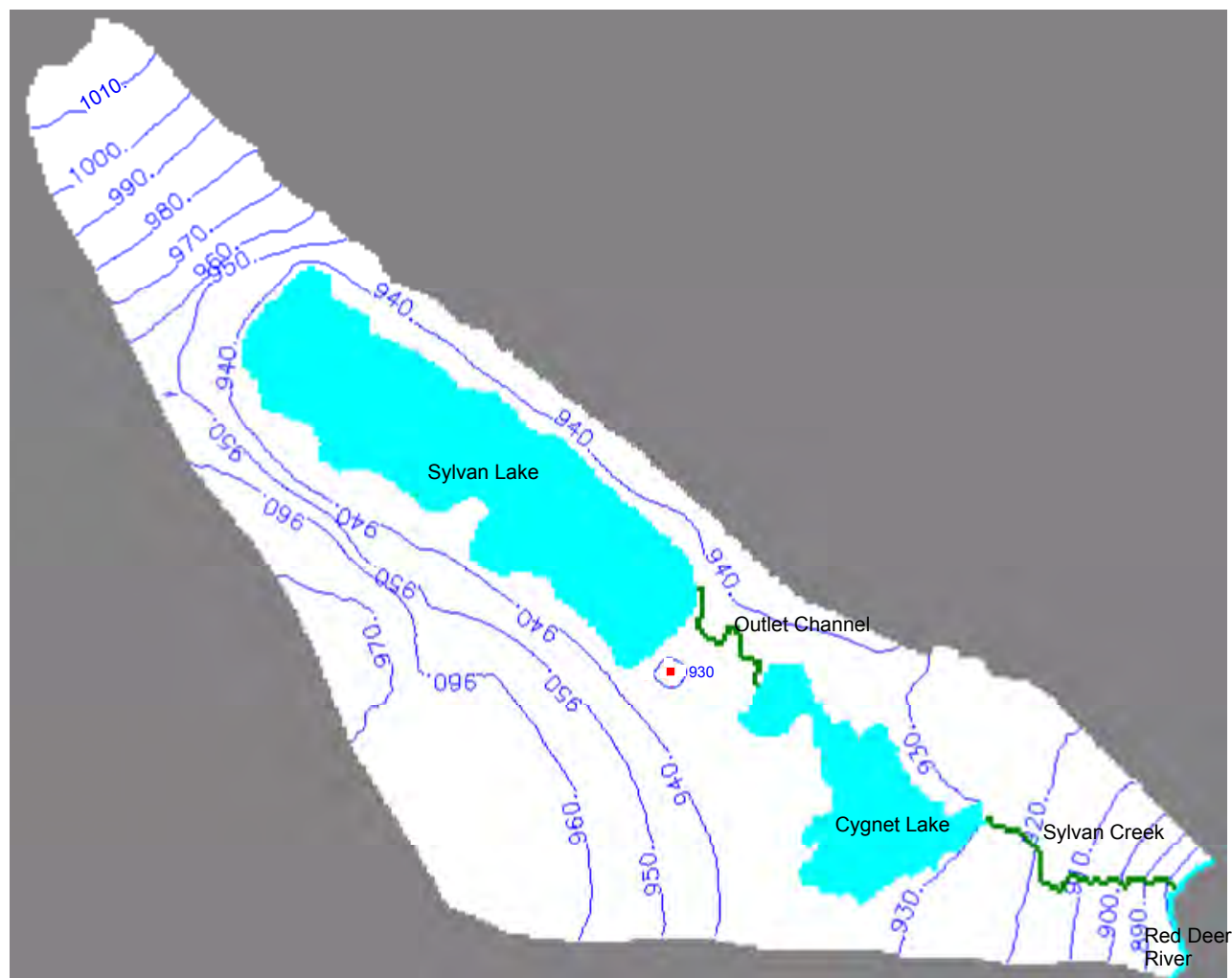


LEGEND

— 960 Hydraulic Head Contour (m asl)

Figure B-15
Simulated Hydraulic Head Distribution Without Town Wells





LEGEND

— 960 Hydraulic Head Contour (m asl)

■ Town Wells

Figure B-16
Simulated Hydraulic Head Distribution With Town Wells
(2003 Pumping)



Attachments B-1

RECEIVED OCT 20 2004

ANALYTICAL REPORT

WESTWATER ENVIRONMENTAL LTD
ATTN: G. MCCLYMONT
808 4TH AVENUE SW
CALGARY AB T2P 3E8

DATE: 10-OCT-04

Lab Work Order #: L212449

Sampled By: SM

Date Received: 01-OCT-04

Project P.O. #:

Project Reference: 04.075

Comments:



DOUG JOHNSON
Director of Operations, Edmonton



RICK ZOLKIEWSKI
Client Service Specialist

THIS REPORT SHALL NOT BE REPRODUCED EXCEPT IN FULL WITHOUT THE WRITTEN AUTHORITY OF THE LABORATORY.
ALL SAMPLES WILL BE DISPOSED OF AFTER 30 DAYS FOLLOWING ANALYSIS. PLEASE CONTACT THE LAB IF YOU
REQUIRE ADDITIONAL SAMPLE STORAGE TIME.

LABORATORY ACCREDITATIONS:

- STANDARDS COUNCIL OF CANADA IN COOPERATION WITH THE CANADIAN ASSOCIATION FOR ENVIRONMENTAL ANALYTICAL LABORATORIES (CAEAL)
FOR SPECIFIC TESTS AS REGISTERED BY THE COUNCIL (EDMONTON, CALGARY, GRANDE PRAIRIE, SASKATOON, WINNIPEG, THUNDER BAY, WATERLOO)
- AMERICAN INDUSTRIAL HYGIENE ASSOCIATION (AIHA) IN THE INDUSTRIAL HYGIENE PROGRAM (EDMONTON, WINNIPEG)
- STANDARDS COUNCIL OF CANADA IN COOPERATION WITH THE CANADIAN FOOD INSPECTION AGENCY (CFIA) FOR FERTILIZER AND FEED TESTING (S

9936 - 67 Avenue, Edmonton, Alberta T6E 0P5, Tel. (780) 413-5227, Fax (780) 437-2311

Canada Wide Tel. 1-800-668-9878 www.envirotest.com

(Edmonton, Calgary, Fort McMurray, Grande Prairie, Saskatoon, Winnipeg, Thunder Bay, Ottawa, Waterloo)

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L212449-1 1.2606 (1-2 SAMPLED) SYLVAN LAKE								
Sample Date: 30-SEP-04								
Matrix: WATER								
Phosphorus, Total Dissolved	0.002		0.001	mg/L		07-OCT-04	TL	R226186
Phosphorus, Total	0.075		0.001	mg/L		07-OCT-04	TL	R226186
Ammonia-N	0.008		0.005	mg/L		05-OCT-04	TL	R225309
Dissolved Organic Carbon	4		1	mg/L		07-OCT-04	RJK	R226370
Nitrate-N	0.868		0.006	mg/L		05-OCT-04	TL	R225685
Nitrite-N	<0.002		0.002	mg/L		05-OCT-04	TL	R225685
Total Dissolved Solids	430		10	mg/L		07-OCT-04	ZOW	R226388
Total Kjeldahl Nitrogen	0.20		0.05	mg/L		08-OCT-04	TL	R226591
Routine Water: Majors,F,Fe,Mn (Dis)&SiO2								
Iron (Fe)-Dissolved	<0.06		0.06	mg/L		07-OCT-04	HAS	R226418
Manganese(Mn)-Dissolved	<0.01		0.01	mg/L		07-OCT-04	HAS	R226418
Chloride (Cl)	2		1	mg/L		07-OCT-04	JTV	R226042
Fluoride (F)	0.13		0.05	mg/L		06-OCT-04	PTT	R226408
Nitrate+Nitrite-N	0.868		0.006	mg/L		05-OCT-04	TL	R225685
Silica (as SiO2)	9.9		0.1	mg/L		06-OCT-04	BMA	R225581
pH, Conductivity and Total Alkalinity								
pH	7.8		0.1	pH		06-OCT-04	PTT	R226408
Conductivity (EC)	671		0.2	uS/cm		06-OCT-04	PTT	R226408
Bicarbonate (HCO3)	461		5	mg/L		06-OCT-04	PTT	R226408
Carbonate (CO3)	<5		5	mg/L		06-OCT-04	PTT	R226408
Hydroxide (OH)	<5		5	mg/L		06-OCT-04	PTT	R226408
Alkalinity, Total (as CaCO3)	378		5	mg/L		06-OCT-04	PTT	R226408
Ion Balance Calculation								
Ion Balance	98.1			%		08-OCT-04		
TDS (Calculated)	404			mg/L		08-OCT-04		
Hardness (as CaCO3)	295			mg/L		08-OCT-04		
ICP metals and SO4 for routine water								
Calcium (Ca)	62.8		0.5	mg/L		06-OCT-04	BMA	R225581
Potassium (K)	2.0		0.1	mg/L		06-OCT-04	BMA	R225581
Magnesium (Mg)	33.6		0.1	mg/L		06-OCT-04	BMA	R225581
Sodium (Na)	48		1	mg/L		06-OCT-04	BMA	R225581
Sulfate (SO4)	25.1		0.5	mg/L		06-OCT-04	BMA	R225581
L212449-2 2.2611 (2-1 SAMPLED) SYLVAN LAKE								
Sample Date: 30-SEP-04								
Matrix: WATER								
Phosphorus, Total Dissolved	0.04		0.02	mg/L		08-OCT-04	JTV	R226639
Phosphorus, Total	0.55		0.02	mg/L		08-OCT-04	JTV	R226639
Ammonia-N	0.042		0.005	mg/L		05-OCT-04	TL	R225309
Dissolved Organic Carbon	9		1	mg/L		07-OCT-04	RJK	R226370
Nitrate-N	3.93		0.006	mg/L		05-OCT-04	TL	R225685
Nitrite-N	0.059		0.002	mg/L		05-OCT-04	TL	R225685
Total Dissolved Solids	770		10	mg/L		07-OCT-04	ZOW	R226388
Total Kjeldahl Nitrogen	1.59		0.05	mg/L		08-OCT-04	TL	R226591
Routine Water: Majors,F,Fe,Mn (Dis)&SiO2								
Iron (Fe)-Dissolved	<0.06		0.06	mg/L		07-OCT-04	HAS	R226418
Manganese(Mn)-Dissolved	0.17		0.01	mg/L		07-OCT-04	HAS	R226418
Chloride (Cl)	14		1	mg/L		07-OCT-04	JTV	R226042

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L212449-2 2.2611 (2-1 SAMPLED) SYLVAN LAKE								
Sample Date: 30-SEP-04								
Matrix: WATER								
Routine Water: Majors,F,Fe,Mn (Dis)&SiO2								
Fluoride (F)	0.20		0.05	mg/L		06-OCT-04	PTT	R226408
Nitrate+Nitrite-N	3.98		0.006	mg/L		05-OCT-04	TL	R225685
Silica (as SiO2)	13.6		0.1	mg/L		06-OCT-04	BMA	R225581
pH, Conductivity and Total Alkalinity								
pH	7.8		0.1	pH		06-OCT-04	PTT	R226408
Conductivity (EC)	993		0.2	uS/cm		06-OCT-04	PTT	R226408
Bicarbonate (HCO3)	712		5	mg/L		06-OCT-04	PTT	R226408
Carbonate (CO3)	<5		5	mg/L		06-OCT-04	PTT	R226408
Hydroxide (OH)	<5		5	mg/L		06-OCT-04	PTT	R226408
Alkalinity, Total (as CaCO3)	584		5	mg/L		06-OCT-04	PTT	R226408
Ion Balance Calculation								
Ion Balance	99.4			%		08-OCT-04		
TDS (Calculated)	702			mg/L		08-OCT-04		
Hardness (as CaCO3)	676			mg/L		08-OCT-04		
ICP metals and SO4 for routine water								
Calcium (Ca)	150		0.5	mg/L		06-OCT-04	BMA	R225581
Potassium (K)	2.8		0.1	mg/L		06-OCT-04	BMA	R225581
Magnesium (Mg)	73.1		0.1	mg/L		06-OCT-04	BMA	R225581
Sodium (Na)	10		1	mg/L		06-OCT-04	BMA	R225581
Sulfate (SO4)	83.8		0.5	mg/L		06-OCT-04	BMA	R225581
L212449-3 3.2613 (3-3 SAMPLED) SYLVAN LAKE								
Sample Date: 30-SEP-04								
Matrix: WATER								
Phosphorus, Total Dissolved	0.004		0.001	mg/L		07-OCT-04	TL	R226186
Phosphorus, Total	0.379		0.001	mg/L		07-OCT-04	TL	R226186
Ammonia-N	<0.005		0.005	mg/L		05-OCT-04	TL	R225309
Dissolved Organic Carbon	13		1	mg/L		07-OCT-04	RJK	R226370
Nitrate-N	1.22		0.006	mg/L		05-OCT-04	TL	R225685
Nitrite-N	<0.002		0.002	mg/L		05-OCT-04	TL	R225685
Total Dissolved Solids	420		10	mg/L		07-OCT-04	ZOW	R226388
Total Kjeldahl Nitrogen	0.40		0.05	mg/L		08-OCT-04	TL	R226591
Routine Water: Majors,F,Fe,Mn (Dis)&SiO2								
Iron (Fe)-Dissolved	<0.06		0.06	mg/L		07-OCT-04	HAS	R226418
Manganese(Mn)-Dissolved	<0.01		0.01	mg/L		07-OCT-04	HAS	R226418
Chloride (Cl)	13		1	mg/L		07-OCT-04	JTV	R226042
Fluoride (F)	0.13		0.05	mg/L		06-OCT-04	PTT	R226408
Nitrate+Nitrite-N	1.22		0.006	mg/L		05-OCT-04	TL	R225685
Silica (as SiO2)	8.5		0.1	mg/L		06-OCT-04	BMA	R225581
pH, Conductivity and Total Alkalinity								
pH	7.9		0.1	pH		06-OCT-04	PTT	R226408
Conductivity (EC)	628		0.2	uS/cm		06-OCT-04	PTT	R226408
Bicarbonate (HCO3)	444		5	mg/L		06-OCT-04	PTT	R226408
Carbonate (CO3)	<5		5	mg/L		06-OCT-04	PTT	R226408
Hydroxide (OH)	<5		5	mg/L		06-OCT-04	PTT	R226408
Alkalinity, Total (as CaCO3)	364		5	mg/L		06-OCT-04	PTT	R226408
Ion Balance Calculation								
Ion Balance	96.4			%		08-OCT-04		
TDS (Calculated)	376			mg/L		08-OCT-04		

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L212449-3 3.2613 (3-3 SAMPLED) SYLVAN LAKE Sample Date: 30-SEP-04 Matrix: WATER Routine Water: Majors,F,Fe,Mn (Dis)&SiO2 Ion Balance Calculation Hardness (as CaCO3)	332			mg/L		08-OCT-04		
ICP metals and SO4 for routine water Calcium (Ca)	53.2		0.5	mg/L		06-OCT-04	BMA	R225581
Potassium (K)	2.6		0.1	mg/L		06-OCT-04	BMA	R225581
Magnesium (Mg)	48.3		0.1	mg/L		06-OCT-04	BMA	R225581
Sodium (Na)	23		1	mg/L		06-OCT-04	BMA	R225581
Sulfate (SO4)	12.1		0.5	mg/L		06-OCT-04	BMA	R225581
L212449-4 4.2618 (4-1 SAMPLED) SYLVAN LAKE Sample Date: 30-SEP-04 Matrix: WATER								
Phosphorus, Total Dissolved	0.079		0.001	mg/L		07-OCT-04	TL	R226186
Phosphorus, Total	10.6		0.02	mg/L		08-OCT-04	JTV	R226639
Ammonia-N	1.84		0.005	mg/L		05-OCT-04	TL	R225309
Dissolved Organic Carbon	18		1	mg/L		07-OCT-04	RJK	R226370
Nitrate-N	<0.006		0.006	mg/L		05-OCT-04	TL	R225685
Nitrite-N	<0.002		0.002	mg/L		05-OCT-04	TL	R225685
Total Dissolved Solids	480		10	mg/L		07-OCT-04	ZOW	R226388
Total Kjeldahl Nitrogen	15.3		0.05	mg/L		07-OCT-04	TL	R226104
Routine Water: Majors,F,Fe,Mn (Dis)&SiO2 Iron (Fe)-Dissolved	<0.06		0.06	mg/L		07-OCT-04	HAS	R226418
Manganese(Mn)-Dissolved	0.29		0.01	mg/L		07-OCT-04	HAS	R226418
Chloride (Cl)	1		1	mg/L		07-OCT-04	JTV	R226042
Fluoride (F)	0.13		0.05	mg/L		06-OCT-04	PTT	R226408
Nitrate+Nitrite-N	<0.006		0.006	mg/L		05-OCT-04	TL	R225685
Silica (as SiO2)	11.5		0.1	mg/L		06-OCT-04	BMA	R225581
pH, Conductivity and Total Alkalinity pH	7.7		0.1	pH		06-OCT-04	PTT	R226408
Conductivity (EC)	724		0.2	uS/cm		06-OCT-04	PTT	R226408
Bicarbonate (HCO3)	543		5	mg/L		06-OCT-04	PTT	R226408
Carbonate (CO3)	<5		5	mg/L		06-OCT-04	PTT	R226408
Hydroxide (OH)	<5		5	mg/L		06-OCT-04	PTT	R226408
Alkalinity, Total (as CaCO3)	445		5	mg/L		06-OCT-04	PTT	R226408
Ion Balance Calculation Ion Balance	95.8			%		08-OCT-04		
TDS (Calculated)	448			mg/L		08-OCT-04		
Hardness (as CaCO3)	409			mg/L		08-OCT-04		
ICP metals and SO4 for routine water Calcium (Ca)	81.7		0.5	mg/L		06-OCT-04	BMA	R225581
Potassium (K)	4.2		0.1	mg/L		06-OCT-04	BMA	R225581
Magnesium (Mg)	49.9		0.1	mg/L		06-OCT-04	BMA	R225581
Sodium (Na)	16		1	mg/L		06-OCT-04	BMA	R225581
Sulfate (SO4)	28.5		0.5	mg/L		06-OCT-04	BMA	R225581
L212449-5 5.2620 (5-2 SAMPLED) SYLVAN LAKE Sample Date: 30-SEP-04 Matrix: WATER								
Phosphorus, Total Dissolved	0.014		0.001	mg/L		07-OCT-04	TL	R226186

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L212449-5 5.2620 (5-2 SAMPLED) SYLVAN LAKE								
Sample Date: 30-SEP-04								
Matrix: WATER								
Phosphorus, Total	0.108		0.001	mg/L		07-OCT-04	TL	R226186
Ammonia-N	0.068		0.005	mg/L		05-OCT-04	TL	R225309
Dissolved Organic Carbon	3		1	mg/L		07-OCT-04	RJK	R226370
Nitrate-N	0.023		0.006	mg/L		05-OCT-04	TL	R225685
Nitrite-N	<0.002		0.002	mg/L		05-OCT-04	TL	R225685
Total Dissolved Solids	540		10	mg/L		07-OCT-04	ZOW	R226388
Total Kjeldahl Nitrogen	0.29		0.05	mg/L		08-OCT-04	TL	R226591
Routine Water: Majors,F,Fe,Mn (Dis)&SiO2								
Iron (Fe)-Dissolved	<0.06		0.06	mg/L		07-OCT-04	HAS	R226418
Manganese(Mn)-Dissolved	<0.01		0.01	mg/L		07-OCT-04	HAS	R226418
Chloride (Cl)	2		1	mg/L		07-OCT-04	JTV	R226042
Fluoride (F)	0.13		0.05	mg/L		06-OCT-04	PTT	R226408
Nitrate+Nitrite-N	0.024		0.006	mg/L		05-OCT-04	TL	R225685
Silica (as SiO2)	17.3		0.1	mg/L		06-OCT-04	BMA	R225581
pH, Conductivity and Total Alkalinity								
pH	8.7		0.1	pH		06-OCT-04	PTT	R226408
Conductivity (EC)	823		0.2	uS/cm		06-OCT-04	PTT	R226408
Bicarbonate (HCO3)	459		5	mg/L		06-OCT-04	PTT	R226408
Carbonate (CO3)	23		5	mg/L		06-OCT-04	PTT	R226408
Hydroxide (OH)	<5		5	mg/L		06-OCT-04	PTT	R226408
Alkalinity, Total (as CaCO3)	415		5	mg/L		06-OCT-04	PTT	R226408
Ion Balance Calculation								
Ion Balance	112	BL:INT		%		08-OCT-04		
TDS (Calculated)	537			mg/L		08-OCT-04		
Hardness (as CaCO3)	30			mg/L		08-OCT-04		
ICP metals and SO4 for routine water								
Calcium (Ca)	6.6		0.5	mg/L		06-OCT-04	BMA	R225581
Potassium (K)	1.5		0.1	mg/L		06-OCT-04	BMA	R225581
Magnesium (Mg)	3.2		0.1	mg/L		06-OCT-04	BMA	R225581
Sodium (Na)	226		1	mg/L		06-OCT-04	BMA	R225581
Sulfate (SO4)	48.4		0.5	mg/L		06-OCT-04	BMA	R225581
L212449-6 6.2694 (6-1 SAMPLED) SYLVAN LAKE								
Sample Date: 30-SEP-04								
Matrix: WATER								
Phosphorus, Total Dissolved	0.103		0.001	mg/L		07-OCT-04	TL	R226186
Phosphorus, Total	0.305		0.001	mg/L		07-OCT-04	TL	R226186
Ammonia-N	0.102		0.005	mg/L		05-OCT-04	TL	R225309
Dissolved Organic Carbon	4		1	mg/L		07-OCT-04	RJK	R226370
Nitrate-N	0.835		0.006	mg/L		05-OCT-04	TL	R225685
Nitrite-N	0.004		0.002	mg/L		05-OCT-04	TL	R225685
Total Dissolved Solids	400		10	mg/L		07-OCT-04	ZOW	R226388
Total Kjeldahl Nitrogen	0.28		0.05	mg/L		08-OCT-04	TL	R226591
Routine Water: Majors,F,Fe,Mn (Dis)&SiO2								
Iron (Fe)-Dissolved	<0.06		0.06	mg/L		07-OCT-04	HAS	R226418
Manganese(Mn)-Dissolved	0.04		0.01	mg/L		07-OCT-04	HAS	R226418
Chloride (Cl)	13		1	mg/L		07-OCT-04	JTV	R226042
Fluoride (F)	0.11		0.05	mg/L		06-OCT-04	PTT	R226408

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L212449-6 6.2694 (6-1 SAMPLED) SYLVAN LAKE Sample Date: 30-SEP-04 Matrix: WATER Routine Water: Majors,F,Fe,Mn (Dis)&SiO2 Nitrate+Nitrite-N 0.839 0.006 mg/L 05-OCT-04 TL R225685 Silica (as SiO2) 7.9 0.1 mg/L 06-OCT-04 BMA R225581 pH, Conductivity and Total Alkalinity pH 7.9 0.1 pH 06-OCT-04 PTT R226408 Conductivity (EC) 596 0.2 uS/cm 06-OCT-04 PTT R226408 Bicarbonate (HCO3) 407 5 mg/L 06-OCT-04 PTT R226408 Carbonate (CO3) <5 5 mg/L 06-OCT-04 PTT R226408 Hydroxide (OH) <5 5 mg/L 06-OCT-04 PTT R226408 Alkalinity, Total (as CaCO3) 333 5 mg/L 06-OCT-04 PTT R226408 Ion Balance Calculation Ion Balance 96.2 % 08-OCT-04 TDS (Calculated) 357 mg/L 08-OCT-04 Hardness (as CaCO3) 295 mg/L 08-OCT-04 ICP metals and SO4 for routine water Calcium (Ca) 59.5 0.5 mg/L 06-OCT-04 BMA R225581 Potassium (K) 2.5 0.1 mg/L 06-OCT-04 BMA R225581 Magnesium (Mg) 35.6 0.1 mg/L 06-OCT-04 BMA R225581 Sodium (Na) 27 1 mg/L 06-OCT-04 BMA R225581 Sulfate (SO4) 16.0 0.5 mg/L 06-OCT-04 BMA R225581								
L212449-7 7.2698 (7-1 SAMPLED) SYLVAN LAKE Sample Date: 30-SEP-04 Matrix: WATER Phosphorus, Total Dissolved 0.007 0.001 mg/L 07-OCT-04 TL R226186 Phosphorus, Total 0.123 0.001 mg/L 07-OCT-04 TL R226186 Ammonia-N 0.315 0.005 mg/L 05-OCT-04 TL R225309 Dissolved Organic Carbon 4 1 mg/L 07-OCT-04 RJK R226370 Nitrate-N <0.006 0.006 mg/L 05-OCT-04 TL R225685 Nitrite-N 0.002 0.002 mg/L 05-OCT-04 TL R225685 Total Dissolved Solids 420 10 mg/L 07-OCT-04 ZOW R226388 Total Kjeldahl Nitrogen 0.44 0.05 mg/L 08-OCT-04 TL R226591 Routine Water: Majors,F,Fe,Mn (Dis)&SiO2 Iron (Fe)-Dissolved <0.06 0.06 mg/L 07-OCT-04 HAS R226418 Manganese(Mn)-Dissolved 0.06 0.01 mg/L 07-OCT-04 HAS R226418 Chloride (Cl) 23 1 mg/L 07-OCT-04 JTV R226042 Fluoride (F) <0.05 0.05 mg/L 06-OCT-04 PTT R226408 Nitrate+Nitrite-N <0.006 0.006 mg/L 05-OCT-04 TL R225685 Silica (as SiO2) 10.4 0.1 mg/L 06-OCT-04 BMA R225581 pH, Conductivity and Total Alkalinity pH 7.9 0.1 pH 06-OCT-04 PTT R226408 Conductivity (EC) 674 0.2 uS/cm 06-OCT-04 PTT R226408 Bicarbonate (HCO3) 437 5 mg/L 06-OCT-04 PTT R226408 Carbonate (CO3) <5 5 mg/L 06-OCT-04 PTT R226408 Hydroxide (OH) <5 5 mg/L 06-OCT-04 PTT R226408 Alkalinity, Total (as CaCO3) 358 5 mg/L 06-OCT-04 PTT R226408 Ion Balance Calculation Ion Balance 93.4 % 08-OCT-04 TDS (Calculated) 400 mg/L 08-OCT-04 Hardness (as CaCO3) 246 mg/L 08-OCT-04 ICP metals and SO4 for routine water								

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L212449-7 7.2698 (7-1 SAMPLED) SYLVAN LAKE Sample Date: 30-SEP-04 Matrix: WATER Routine Water: Majors,F,Fe,Mn (Dis)&SiO2 ICP metals and SO4 for routine water								
Calcium (Ca)	49.8		0.5	mg/L		06-OCT-04	BMA	R225581
Potassium (K)	2.6		0.1	mg/L		06-OCT-04	BMA	R225581
Magnesium (Mg)	29.6		0.1	mg/L		06-OCT-04	BMA	R225581
Sodium (Na)	61		1	mg/L		06-OCT-04	BMA	R225581
Sulfate (SO4)	18.8		0.5	mg/L		06-OCT-04	BMA	R225581
L212449-8 44-1 SYLVAN LAKE Sample Date: 02-OCT-04 Matrix: WATER								
Phosphorus, Total Dissolved	0.025		0.001	mg/L		07-OCT-04	TL	R226186
Phosphorus, Total	1.19		0.001	mg/L		07-OCT-04	TL	R226186
Ammonia-N	0.299		0.005	mg/L		05-OCT-04	TL	R225309
Dissolved Organic Carbon	11		1	mg/L		07-OCT-04	RJK	R226370
Nitrate-N	0.012		0.006	mg/L		05-OCT-04	TL	R225685
Nitrite-N	0.005		0.002	mg/L		05-OCT-04	TL	R225685
Total Dissolved Solids	500		10	mg/L		07-OCT-04	ZOW	R226388
Total Kjeldahl Nitrogen	1.96		0.05	mg/L		08-OCT-04	TL	R226591
Routine Water: Majors,F,Fe,Mn (Dis)&SiO2								
Iron (Fe)-Dissolved	<0.06		0.06	mg/L		07-OCT-04	HAS	R226418
Manganese(Mn)-Dissolved	0.08		0.01	mg/L		07-OCT-04	HAS	R226418
Chloride (Cl)	1		1	mg/L		07-OCT-04	JTV	R226042
Fluoride (F)	0.19		0.05	mg/L		06-OCT-04	PTT	R226408
Nitrate+Nitrite-N	0.017		0.006	mg/L		05-OCT-04	TL	R225685
Silica (as SiO2)	12.1		0.1	mg/L		06-OCT-04	BMA	R225581
pH, Conductivity and Total Alkalinity								
pH	7.7		0.1	pH		06-OCT-04	PTT	R226408
Conductivity (EC)	649		0.2	uS/cm		06-OCT-04	PTT	R226408
Bicarbonate (HCO3)	490		5	mg/L		06-OCT-04	PTT	R226408
Carbonate (CO3)	<5		5	mg/L		06-OCT-04	PTT	R226408
Hydroxide (OH)	<5		5	mg/L		06-OCT-04	PTT	R226408
Alkalinity, Total (as CaCO3)	402		5	mg/L		06-OCT-04	PTT	R226408
Ion Balance Calculation								
Ion Balance	97.5			%		08-OCT-04		
TDS (Calculated)	402			mg/L		08-OCT-04		
Hardness (as CaCO3)	382			mg/L		08-OCT-04		
ICP metals and SO4 for routine water								
Calcium (Ca)	84.7		0.5	mg/L		06-OCT-04	BMA	R225581
Potassium (K)	2.5		0.1	mg/L		06-OCT-04	BMA	R225581
Magnesium (Mg)	41.4		0.1	mg/L		06-OCT-04	BMA	R225581
Sodium (Na)	12		1	mg/L		06-OCT-04	BMA	R225581
Sulfate (SO4)	18.8		0.5	mg/L		06-OCT-04	BMA	R225581
L212449-9 TRAVEL BLANK Sample Date: 02-OCT-04 Matrix: WATER								
Phosphorus, Total Dissolved	<0.001		0.001	mg/L		07-OCT-04	TL	R226186
Phosphorus, Total	0.002		0.001	mg/L		07-OCT-04	TL	R226186
Ammonia-N	<0.005		0.005	mg/L		05-OCT-04	TL	R225309

Reference Information

Sample Parameter Qualifier key listed:

Qualifier	Description
BL:INT	Balance Reviewed: Interference Or Non-Measured Component

Methods Listed (if applicable):

ETL Test Code	Matrix	Test Description	Preparation Method Reference(Based On)	Analytical Method Reference(Based On)
C-DIS-ORG-CL	Water	Dissolved Organic Carbon		APHA 5310 B-Instrumental
CL-ED	Water	Chloride (Cl)		APHA 4500 Cl E-Colorimetry
ETL-ROUTINE-ICP-ED	Water	ICP metals and SO4 for routine water		APHA 3120 B-ICP-OES
F-ED	Water	Fluoride (F)		APHA 4500 F-C-Electrode
FE-DIS-HIGH-ED	Water	Iron (Fe)-Dissolved		EPA 200.7
IONBALANCE-ED	Water	Ion Balance Calculation		APHA 1030E
MN-DIS-HIGH-ED	Water	Manganese(Mn)-Dissolved		EPA 200.7
N-TOTKJ-LOW-ED	Water	Total Kjeldahl Nitrogen	TECHNICON	APHA 4500Norg C-Dig.-Auto-Colorimetry
N2N3-LOW-ED	Water	Nitrate+Nitrite-N		APHA 4500 NO3E-Colorimetry
NH4-LOW-ED	Water	Ammonia-N		APHA 4500 NH3F-Colorimetry
NO2-LOW-ED	Water	Nitrite-N		APHA 4500 NO2B-Colorimetry
NO3-LOW-ED	Water	Nitrate-N		APHA 4500 NO3H-Colorimetry
P-TOTAL-ED	Water	Phosphorus, Total		APHA 4500 P B,E-Auto-Colorimetry
P-TOTAL-LOW-ED	Water	Phosphorus, Total		APHA 4500 P B,E-Auto-Colorimetry
P-TOTALDIS-ED	Water	Phosphorus, Total Dissolved		APHA 4500 P B,E-Auto-Colorimetry
P-TOTALDIS-LOW-ED	Water	Phosphorus, Dissolved		APHA 4500 P B,E-Auto-Colorimetry
PH/EC/ALK-ED	Water	pH, Conductivity and Total Alkalinity		APHA 4500-H, 2510, 2320
SIO2-CALC-ED	Water	Silica (as SIO2)		ICP/CALCULATION-ICP/CALCULATION
SOLIDS-TDS-ED	Water	Total Dissolved Solids		APHA 2540 C

** Laboratory Methods employed follow in-house procedures, which are generally based on nationally or internationally accepted methodologies.

Chain of Custody numbers:

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location	Laboratory Definition Code	Laboratory Location
CL	Enviro-Test Laboratories - Calgary, Alberta, Canada	ED	Enviro-Test Laboratories - Edmonton, Alberta, Canada

Reference Information

GLOSSARY OF REPORT TERMS

Surr - A surrogate is an organic compound that is similar to the target analyte(s) in chemical composition and behavior but not normally detected in environmental samples. Prior to sample processing, samples are fortified with one or more surrogate compounds.

The reported surrogate recovery value provides a measure of method efficiency. The Laboratory warning units are determined under column heading D.L.

mg/kg (units) - unit of concentration based on mass, parts per million

mg/L (units) - unit of concentration based on volume, parts per million

< - Less than

D.L. - Detection Limit

N/A - Result not available. Refer to qualifier code and definition for explanation

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

UNLESS OTHERWISE STATED, SAMPLES ARE NOT CORRECTED FOR CLIENT FIELD BLANKS.

Although test results are generated under strict QA/QC protocols, any unsigned test reports, faxes, or emails are considered preliminary.

Enviro-Test Laboratories has an extensive QA/QC program where all analytical data reported is analyzed using approved referenced procedures followed by checks and reviews by senior managers and quality assurance personnel. However, since the results are obtained from chemical measurements and thus cannot be guaranteed, Enviro-Test Laboratories assumes no liability for the use or interpretation of the results.

Enviro-Test Quality Control Report

Workorder: L212449

Client: WESTWATER ENVIRONMENTAL LTD
808 4TH AVENUE SW
CALGARY AB T2P 3E8

Contact: G. MCCLYMONT

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
C-DIS-ORG-CL		Water						
Batch	R226370							
WG234033-5	DUP	L212449-1						
Dissolved Organic Carbon		4	4	J	mg/L	0	3.1	07-OCT-04
WG234033-7	DUP	L212449-8						
Dissolved Organic Carbon		11	11		mg/L	0.63	10	07-OCT-04
WG234033-2	LCS							
Dissolved Organic Carbon			98		%		90-105	07-OCT-04
WG234033-1	MB							
Dissolved Organic Carbon			1		mg/L		1	07-OCT-04
WG234033-6	MS	L212449-1						
Dissolved Organic Carbon			93		%		86-104	07-OCT-04
CL-ED		Water						
Batch	R226042							
WG233664-14	DUP	L212854-5						
Chloride (Cl)		3	3	J	mg/L	0	3.1	07-OCT-04
WG233664-16	DUP	L212617-1						
Chloride (Cl)		4	4	J	mg/L	0	3.1	07-OCT-04
WG233664-18	DUP	L212618-1						
Chloride (Cl)		4	4	J	mg/L	0	3.1	07-OCT-04
WG233664-20	DUP	L212824-2						
Chloride (Cl)		<1	<1	RPD-NA	mg/L	N/A	5	07-OCT-04
WG233664-22	DUP	L212575-1						
Chloride (Cl)		373	373		mg/L	0.10	5	07-OCT-04
WG233664-2	LCS							
Chloride (Cl)			101		%		93-107	07-OCT-04
WG233664-3	LCS							
Chloride (Cl)			100		%		93-107	07-OCT-04
WG233664-1	MB							
Chloride (Cl)			<1		mg/L		1	07-OCT-04
WG233664-15	MS	L212854-5						
Chloride (Cl)			98		%		91-111	07-OCT-04
WG233664-17	MS	L212617-1						
Chloride (Cl)			104		%		91-111	07-OCT-04
WG233664-19	MS	L212618-1						
Chloride (Cl)			101		%		91-111	07-OCT-04
WG233664-21	MS	L212824-2						
Chloride (Cl)			103		%		91-111	07-OCT-04
WG233664-23	MS	L212575-1						

Enviro-Test Quality Control Report

Workorder: L212449

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
<u>CL-ED</u>		<u>Water</u>						
Batch	R226042							
WG233664-23 MS		L212575-1						
Chloride (Cl)			94		%		91-111	07-OCT-04
<u>ETL-ROUTINE-ICP-ED</u>		<u>Water</u>						
Batch	R225581							
WG233050-3 CRM								
Calcium (Ca)			98		%		97-106	06-OCT-04
Magnesium (Mg)			98		%		95-108	06-OCT-04
Potassium (K)			94		%		91-103	06-OCT-04
Sodium (Na)			91	H	%		92-105	06-OCT-04
Sulfate (SO4)			91		%		91-104	06-OCT-04
WG233050-17 DUP		L212575-11						
Calcium (Ca)		315	315		mg/L	0.0013	15	06-OCT-04
Magnesium (Mg)		189	190		mg/L	0.20	7.8	06-OCT-04
Potassium (K)		13.4	13.0		mg/L	3.3	12	06-OCT-04
Sodium (Na)		2490	2450		mg/L	1.6	7.8	06-OCT-04
Sulfate (SO4)		4500	4410		mg/L	1.9	7.8	06-OCT-04
WG233050-19 DUP		L212843-7						
Calcium (Ca)		N/A	554		mg/L	1.4	15	06-OCT-04
Magnesium (Mg)		N/A	207		mg/L	0.41	7.8	06-OCT-04
Potassium (K)		N/A	10.8		mg/L	7.6	12	06-OCT-04
Sodium (Na)		N/A	70		mg/L	1.7	7.8	06-OCT-04
Sulfate (SO4)		N/A	1640		mg/L	4.1	7.8	06-OCT-04
WG233050-1 MB								
Calcium (Ca)			<0.5		mg/L		2.5	06-OCT-04
Magnesium (Mg)			<0.1		mg/L		0.5	06-OCT-04
Potassium (K)			<0.1		mg/L		0.5	06-OCT-04
Sodium (Na)			<1		mg/L		5	06-OCT-04
Sulfate (SO4)			<0.5		mg/L		2.5	06-OCT-04
WG233050-18 MS		L212575-11						
Calcium (Ca)			100		%		87-112	06-OCT-04
Magnesium (Mg)			98		%		88-111	06-OCT-04
Potassium (K)			96		%		92-111	06-OCT-04
Sodium (Na)			119	E	%		86-111	06-OCT-04
Sulfate (SO4)			117	E	%		85-112	06-OCT-04
WG233050-20 MS		L212843-7						
Calcium (Ca)			104		%		87-112	06-OCT-04
Magnesium (Mg)			97		%		88-111	06-OCT-04
Potassium (K)			91	H	%		92-111	06-OCT-04
Sodium (Na)			99				86-111	

Enviro-Test Quality Control Report

Workorder: L212449

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
<u>ETL-ROUTINE-ICP-ED</u>		<u>Water</u>						
Batch	R225581							
WG233050-20	MS	L212843-7						
Sodium (Na)			99		%		86-111	06-OCT-04
Sulfate (SO4)			103		%		85-112	06-OCT-04
<u>F-ED</u>		<u>Water</u>						
Batch	R226408							
WG233423-5	DUP	L212843-7						
Fluoride (F)		0.21	0.21	J	mg/L	0.00	0.15	07-OCT-04
WG233423-3	LCS							
Fluoride (F)			107	H	%		93-107	06-OCT-04
<u>FE-DIS-HIGH-ED</u>		<u>Water</u>						
Batch	R226418							
WG233743-10	DUP	L213817-6						
Iron (Fe)-Dissolved		<0.06	<0.06	RPD-NA	mg/L	N/A	13	07-OCT-04
WG233743-4	DUP	L212449-6						
Iron (Fe)-Dissolved		<0.06	<0.06	RPD-NA	mg/L	N/A	13	07-OCT-04
WG233743-8	DUP	L213814-2						
Iron (Fe)-Dissolved		<0.06	<0.06	RPD-NA	mg/L	N/A	13	07-OCT-04
WG233743-1	MB							
Iron (Fe)-Dissolved			<0.06		mg/L		0.3	07-OCT-04
WG233743-5	MS	L212449-6						
Iron (Fe)-Dissolved			93		%		92-108	07-OCT-04
<u>MN-DIS-HIGH-ED</u>		<u>Water</u>						
Batch	R226418							
WG233743-10	DUP	L213817-6						
Manganese(Mn)-Dissolved		<0.01	<0.01	RPD-NA	mg/L	N/A	12	07-OCT-04
WG233743-4	DUP	L212449-6						
Manganese(Mn)-Dissolved		0.04	0.04	J	mg/L	0.00	0.031	07-OCT-04
WG233743-8	DUP	L213814-2						
Manganese(Mn)-Dissolved		0.23	0.23		mg/L	1.8	12	07-OCT-04
WG233743-1	MB							
Manganese(Mn)-Dissolved			<0.01		mg/L		0.05	07-OCT-04
WG233743-5	MS	L212449-6						
Manganese(Mn)-Dissolved			92	H	%		94-106	07-OCT-04
<u>N-TOTKJ-LOW-ED</u>		<u>Water</u>						
Batch	R226104							
WG232990-2	LCS							
Total Kjeldahl Nitrogen			88		%		79-107	07-OCT-04
WG232990-1	MB							
Total Kjeldahl Nitrogen			<0.05		mg/L		0.05	07-OCT-04

Enviro-Test Quality Control Report

Workorder: L212449

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
<u>N-TOTKJ-LOW-ED</u>		<u>Water</u>						
Batch	R226591							
WG233978-2	LCS							
Total Kjeldahl Nitrogen			89		%		79-107	08-OCT-04
WG233978-1	MB							
Total Kjeldahl Nitrogen			<0.05		mg/L		0.05	08-OCT-04
<u>N2N3-LOW-ED</u>		<u>Water</u>						
Batch	R225685							
WG232428-4	DUP	L212854-9						
Nitrate+Nitrite-N		0.027	0.026	J	mg/L	0.000	0.018	05-OCT-04
WG232428-6	DUP	L212860-7						
Nitrate+Nitrite-N		<0.006	<0.006	RPD-NA	mg/L	N/A	7.8	05-OCT-04
WG232428-7	DUP	L212449-6						
Nitrate+Nitrite-N		0.839	0.859		mg/L	2.3	7.8	05-OCT-04
WG232428-2	LCS							
Nitrate+Nitrite-N			98		%		92-105	05-OCT-04
WG232428-1	MB							
Nitrate+Nitrite-N			<0.006		mg/L		0.006	05-OCT-04
WG232428-5	MS	L212854-20						
Nitrate+Nitrite-N			90		%		80-121	05-OCT-04
<u>NH4-LOW-ED</u>		<u>Water</u>						
Batch	R225309							
WG232426-5	DUP	L212854-9						
Ammonia-N		<0.005	<0.005	RPD-NA	mg/L	N/A	7.7	05-OCT-04
WG232426-7	DUP	L212860-7						
Ammonia-N		<0.005	<0.005	RPD-NA	mg/L	N/A	7.7	05-OCT-04
WG232426-8	DUP	L212449-9						
Ammonia-N		<0.005	<0.005	RPD-NA	mg/L	N/A	7.7	05-OCT-04
WG232426-2	LCS							
Ammonia-N			95		%		75-125	05-OCT-04
WG232426-1	MB							
Ammonia-N			<0.005		mg/L		0.005	05-OCT-04
WG232426-4	MS	L212219-3						
Ammonia-N			103		%		70-143	05-OCT-04
WG232426-6	MS	L212854-19						
Ammonia-N			106		%		70-143	05-OCT-04
<u>NO2-LOW-ED</u>		<u>Water</u>						
Batch	R225685							
WG232428-4	DUP	L212854-9						
Nitrite-N		<0.002	<0.002	RPD-NA	mg/L	N/A	6.9	05-OCT-04
WG232428-6	DUP	L212860-7						
Nitrite-N		<0.002	<0.002	RPD-NA	mg/L	N/A	6.9	05-OCT-04
WG232428-7	DUP	L212449-6						
Nitrite-N		0.004	0.004	J	mg/L	0.000	0.0061	05-OCT-04

Enviro-Test Quality Control Report

Workorder: L212449

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
<u>P-TOTALDIS-LOW-ED</u> <u>Water</u>								
Batch	R226186							
WG233324-2	LCS							
Phosphorus, Total Dissolved			99		%		91-112	07-OCT-04
WG233324-1	MB							
Phosphorus, Total Dissolved			0.001		mg/L		0.001	07-OCT-04
<u>PH/EC/ALK-ED</u> <u>Water</u>								
Batch	R226408							
WG233423-4	DUP	L212587-18						
Alkalinity, Total (as CaCO3)		345	345		mg/L	0.19	5	06-OCT-04
Bicarbonate (HCO3)		368	365		mg/L	0.83	20	06-OCT-04
Carbonate (CO3)		26	28	J	mg/L	2	15	06-OCT-04
Conductivity (EC)		757	742		uS/cm	2.0	5.5	06-OCT-04
Hydroxide (OH)		<5	<5	RPD-NA	mg/L	N/A	20	06-OCT-04
pH		8.8	8.8	J	pH	0.0	0.1	06-OCT-04
WG233423-1	LCS							
Conductivity (EC)			101		%		96-104	06-OCT-04
WG233423-2	LCS							
pH			7.0		pH		6.9-7.1	06-OCT-04
WG233423-3	LCS							
Alkalinity, Total (as CaCO3)			100		%		93-107	06-OCT-04
<u>SOLIDS-TDS-ED</u> <u>Water</u>								
Batch	R226388							
WG233795-3	DUP	L212569-2						
Total Dissolved Solids		250	250		mg/L	3.2	8.7	07-OCT-04
WG233795-4	DUP	L212662-4						
Total Dissolved Solids		680	670		mg/L	1.5	8.7	07-OCT-04
WG233795-2	LCS							
Total Dissolved Solids			109		%		96-112	07-OCT-04
WG233795-1	MB							
Total Dissolved Solids			10		mg/L		10	07-OCT-04
Product - Batch and Sample Number Relations:								
C-DIS-ORG-CL	1							
R226370		L212449-1	L212449-2	L212449-3	L212449-4	L212449-5		
		L212449-6	L212449-7	L212449-8	L212449-9			
CL-ED	1							
R226042		L212449-1	L212449-2	L212449-3	L212449-4	L212449-5		
		L212449-6	L212449-7	L212449-8	L212449-9			
ETL-ROUTINE-ICP-ED	1							
R225581		L212449-1	L212449-2	L212449-3	L212449-4	L212449-5		
		L212449-6	L212449-7	L212449-8	L212449-9			
F-ED	1							
R226408		L212449-1	L212449-2	L212449-3	L212449-4	L212449-5		
		L212449-6	L212449-7	L212449-8	L212449-9			

Enviro-Test Quality Control Report

Workorder: L212449

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
Product - Batch and Sample Number Relations:								
FE-DIS-HIGH-ED	1							
R226418		L212449-1	L212449-2	L212449-3		L212449-4	L212449-5	
		L212449-6	L212449-7	L212449-8		L212449-9		
MN-DIS-HIGH-ED	1							
R226418		L212449-1	L212449-2	L212449-3		L212449-4	L212449-5	
		L212449-6	L212449-7	L212449-8		L212449-9		
N-TOTKJ-LOW-ED	1							
R226104		L212449-4	L212449-9					
N-TOTKJ-LOW-ED	1							
R226591		L212449-1	L212449-2	L212449-3		L212449-5	L212449-6	
		L212449-7	L212449-8					
N2N3-LOW-ED	1							
R225685		L212449-1	L212449-2	L212449-3		L212449-4	L212449-5	
		L212449-6	L212449-7	L212449-8		L212449-9		
NH4-LOW-ED	1							
R225309		L212449-1	L212449-2	L212449-3		L212449-4	L212449-5	
		L212449-6	L212449-7	L212449-8		L212449-9		
NO2-LOW-ED	1							
R225685		L212449-1	L212449-2	L212449-3		L212449-4	L212449-5	
		L212449-6	L212449-7	L212449-8		L212449-9		
NO3-LOW-ED	1							
R225685		L212449-1	L212449-2	L212449-3		L212449-4	L212449-5	
		L212449-6	L212449-7	L212449-8		L212449-9		
P-TOTAL-ED	1							
R226639		L212449-2	L212449-4					
P-TOTAL-LOW-ED	1							
R226186		L212449-1	L212449-2	L212449-3		L212449-5	L212449-6	
		L212449-7	L212449-8	L212449-9				
P-TOTALDIS-ED	1							
R226639		L212449-2						
P-TOTALDIS-LOW-ED	1							
R226186		L212449-1	L212449-2	L212449-3		L212449-4	L212449-5	
		L212449-6	L212449-7	L212449-8		L212449-9		
PH/EC/ALK-ED	1							
R226408		L212449-1	L212449-2	L212449-3		L212449-4	L212449-5	
		L212449-6	L212449-7	L212449-8		L212449-9		
SIO2-CALC-ED	1							
R225581		L212449-1	L212449-2	L212449-3		L212449-4	L212449-5	
		L212449-6	L212449-7	L212449-8		L212449-9		
SOLIDS-TDS-ED	1							
R226388		L212449-1	L212449-2	L212449-3		L212449-4	L212449-5	
		L212449-6	L212449-7	L212449-8		L212449-9		

ENVIRO-TEST QC REPORT

Page 8 of 8

Workorder # L212449

Legend:

Limit	95% Confidence Interval (Laboratory Warning Limits)
DUP	Duplicate
RPD	Relative Percent Difference
N/A	Not Available
LCS	Laboratory Control Sample
SRM	Standard Reference Materials
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ADE	Average Desorption Efficiency
MB	Method Blank
IRM	Internal Reference Material
CRM	Certified Reference Material
CCV	Continuing Calibration Verification
CVS	Calibration Verification Standard
LCSD	Laboratory Control Sample Duplicate

Qualifier:

RPD-NA	Relative Percent Difference Not Available due to result(s) being less than detection limit.
A	Method blank exceeds acceptance limit. Blank correction not applied, unless the qualifier "RAMB" (result adjusted for method blank) appears in the Analytical Report.
B	Method blank result exceeds acceptance limit, however, it is less than 5% of sample concentration. Blank correction not applied.
E	Matrix spike recovery may fall outside the acceptance limits due to high sample background.
F	Silver recovery low, likely due to elevated chloride levels in sample.
G	Outlier - No assignable cause for nonconformity has been determined.
H	Result falls within the 99% Confidence Interval (Laboratory Control Limits)
J	Duplicate results and limit(s) are expressed in terms of absolute difference.
K	The sample referenced above is of a non-standard matrix type; standard QC acceptance criteria may not be achievable.

ANALYTICAL REPORT

WESTWATER ENVIRONMENTAL LTD
ATTN: G. MCCLYMONT/ S. MORTON
900, 808 4TH AVENUE SW
CALGARY AB T2P 3E8

DATE: 04-NOV-04 03:00 PM

Revision: 1

Lab Work Order #: L219368

Sampled By: SM

Date Received: 25-OCT-04

Project P.O. #: NA

Project Reference: 04.075.10

Comments:



RON MINKS
Director of Operations, Calgary



KELLY JONES
Client Service Specialist

THIS REPORT SHALL NOT BE REPRODUCED EXCEPT IN FULL WITHOUT THE WRITTEN AUTHORITY OF THE LABORATORY.
ANY REMAINING SAMPLES WILL BE DISPOSED OF AFTER 30 DAYS FOLLOWING ANALYSIS. PLEASE CONTACT THE LAB IF YOU
REQUIRE ADDITIONAL SAMPLE STORAGE TIME.

LABORATORY ACCREDITATIONS:

- STANDARDS COUNCIL OF CANADA IN COOPERATION WITH THE CANADIAN ASSOCIATION FOR ENVIRONMENTAL ANALYTICAL LABORATORIES (CAEAL) FOR SPECIFIC TESTS AS REGISTERED BY THE COUNCIL (EDMONTON, CALGARY, GRANDE PRAIRIE, SASKATOON, WINNIPEG, THUNDER BAY, WATERLOO)
- AMERICAN INDUSTRIAL HYGIENE ASSOCIATION (AIHA) IN THE INDUSTRIAL HYGIENE PROGRAM (EDMONTON, WINNIPEG)
- STANDARDS COUNCIL OF CANADA IN COOPERATION WITH THE CANADIAN FOOD INSPECTION AGENCY (CFIA) FOR FERTILIZER AND FEED TESTING (SASKATOON) AND FOR MICROBIOLOGICAL TESTING IN FOOD (WINNIPEG)

LABORATORY RECOGNITIONS:

- STANDARDS COUNCIL OF CANADA - GLP COMPLIANT FACILITY (EDMONTON, OTTAWA)

Bay 7, 1313 - 44 Avenue N.E., Calgary, Alberta T2E 6L5, Tel. (403) 291-9897, Fax (403) 291-0298
Canada Wide Tel. 1-800-668-9878 www.envirotest.com

(Edmonton, Calgary, Grande Prairie, Saskatoon, Winnipeg, Thunder Bay, Ottawa, Waterloo, Montreal)

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L219368-1 4.2684 (4-1 SAMPLED) SYLVAN LAKE Sample Date: 21-OCT-04 Matrix: WATER								
Phosphorus, Total Dissolved	0.043		0.001	mg/L		28-OCT-04	WNG	R232970
Phosphorus, Total	0.405		0.001	mg/L		28-OCT-04	WNG	R232970
Ammonia-N	0.047		0.005	mg/L		27-OCT-04	TL/W	R232453
Dissolved Organic Carbon	8		1	mg/L		28-OCT-04	RJK	R232848
Nitrate-N	<0.1		0.1	mg/L		26-OCT-04	MOR	R232071
Nitrite-N	<0.05		0.05	mg/L		26-OCT-04	MOR	R232071
Total Dissolved Solids	380		10	mg/L		27-OCT-04	ZOW	R232697
Total Kjeldahl Nitrogen	1.21		0.05	mg/L		27-OCT-04	TL	R232448
Routine Water: Majors,F,Fe,Mn (Dis)&SiO2								
Iron (Fe)-Dissolved	0.37		0.06	mg/L		28-OCT-04	HAS	R232949
Manganese(Mn)-Dissolved	0.09		0.01	mg/L		28-OCT-04	HAS	R232949
Chloride (Cl)	1		1	mg/L		26-OCT-04	JTV	R231955
Fluoride (F)	0.24		0.05	mg/L		26-OCT-04	PTT	R232194
Nitrate+Nitrite-N	0.027		0.006	mg/L		26-OCT-04	TL	R231998
Silica (as SiO2)	11.2		0.1	mg/L		27-OCT-04	EOC	R232444
pH, Conductivity and Total Alkalinity								
pH	7.8		0.1	pH		26-OCT-04	PTT	R232194
Conductivity (EC)	740		0.2	uS/cm		26-OCT-04	PTT	R232194
Bicarbonate (HCO3)	488		5	mg/L		26-OCT-04	PTT	R232194
Carbonate (CO3)	<5		5	mg/L		26-OCT-04	PTT	R232194
Hydroxide (OH)	<5		5	mg/L		26-OCT-04	PTT	R232194
Alkalinity, Total (as CaCO3)	400		5	mg/L		26-OCT-04	PTT	R232194
Ion Balance Calculation								
Ion Balance	99.4			%		27-OCT-04		
TDS (Calculated)	413			mg/L		27-OCT-04		
Hardness (as CaCO3)	395			mg/L		27-OCT-04		
ICP metals and SO4 for routine water								
Calcium (Ca)	88.2		0.5	mg/L		27-OCT-04	EOC	R232444
Potassium (K)	2.1		0.1	mg/L		27-OCT-04	EOC	R232444
Magnesium (Mg)	42.5		0.1	mg/L		27-OCT-04	EOC	R232444
Sodium (Na)	13		1	mg/L		27-OCT-04	EOC	R232444
Sulfate (SO4)	26.0		0.5	mg/L		27-OCT-04	EOC	R232444
L219368-2 MW-44 Sample Date: 21-OCT-04 Matrix: WATER								
Phosphorus, Total Dissolved	0.037		0.001	mg/L		28-OCT-04	WNG	R232970
Phosphorus, Total	0.356		0.001	mg/L		28-OCT-04	WNG	R232970
Ammonia-N	0.051		0.005	mg/L		27-OCT-04	TL/W	R232453
Dissolved Organic Carbon	9		1	mg/L		28-OCT-04	RJK	R232848
Nitrate-N	<0.1		0.1	mg/L		26-OCT-04	MOR	R232071
Nitrite-N	<0.05		0.05	mg/L		26-OCT-04	MOR	R232071
Total Dissolved Solids	410		10	mg/L		27-OCT-04	ZOW	R232697
Total Kjeldahl Nitrogen	0.94		0.05	mg/L		27-OCT-04	TL	R232448
Routine Water: Majors,F,Fe,Mn (Dis)&SiO2								
Iron (Fe)-Dissolved	0.41		0.06	mg/L		28-OCT-04	HAS	R232949
Manganese(Mn)-Dissolved	0.07		0.01	mg/L		28-OCT-04	HAS	R232949
Chloride (Cl)	1		1	mg/L		26-OCT-04	JTV	R231955

Reference Information

Methods Listed (if applicable):

ETL Test Code	Matrix	Test Description	Preparation Method Reference(Based On)	Analytical Method Reference(Based On)
C-DIS-ORG-CL	Water	Dissolved Organic Carbon		APHA 5310 B-Instrumental
CL-ED	Water	Chloride (Cl)		APHA 4500 Cl E-Colorimetry
ETL-ROUTINE-ICP-ED	Water	ICP metals and SO4 for routine water		APHA 3120 B-ICP-OES
F-ED	Water	Fluoride (F)		APHA 4500 F-C-Electrode
FE-DIS-HIGH-ED	Water	Iron (Fe)-Dissolved		EPA 200.7
IONBALANCE-ED	Water	Ion Balance Calculation		APHA 1030E
MN-DIS-HIGH-ED	Water	Manganese(Mn)-Dissolved		EPA 200.7
N-TOTKJ-LOW-ED	Water	Total Kjeldahl Nitrogen		APHA 4500Norg C-Dig.-Auto-Colorimetry
N2N3-LOW-ED	Water	Nitrate+Nitrite-N		APHA 4500 NO3E-Colorimetry
NH4-LOW-ED	Water	Ammonia-N		APHA 4500 NH3F-Colorimetry
NO2-ED	Water	Nitrite-N		APHA 4500 NO2B-Colorimetry
NO3-ED	Water	Nitrate-N		APHA 4500 NO3H-Colorimetry
P-TOTAL-LOW-ED	Water	Phosphorus, Total		APHA 4500 P B,E-Auto-Colorimetry
P-TOTALDIS-LOW-ED	Water	Phosphorus, Dissolved		APHA 4500 P B,E-Auto-Colorimetry
PH/EC/ALK-ED	Water	pH, Conductivity and Total Alkalinity		APHA 4500-H, 2510, 2320
SIO2-CALC-ED	Water	Silica (as SIO2)		ICP/CALCULATION- ICP/CALCULATION
SOLIDS-TDS-ED	Water	Total Dissolved Solids		APHA 2540 C

** Laboratory Methods employed follow in-house procedures, which are generally based on nationally or internationally accepted methodologies.

Chain of Custody numbers:

154278

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location	Laboratory Definition Code	Laboratory Location
CL	Enviro-Test Laboratories - Calgary, Alberta, Canada	ED	Enviro-Test Laboratories - Edmonton, Alberta, Canada

GLOSSARY OF REPORT TERMS

Surr - A surrogate is an organic compound that is similar to the target analyte(s) in chemical composition and behavior but not normally detected in environmental samples. Prior to sample processing, samples are fortified with one or more surrogate compounds.

The reported surrogate recovery value provides a measure of method efficiency. The Laboratory warning units are determined under column heading D.L.

mg/kg (units) - unit of concentration based on mass, parts per million

mg/L (units) - unit of concentration based on volume, parts per million

< - Less than

D.L. - Detection Limit

N/A - Result not available. Refer to qualifier code and definition for explanation

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

UNLESS OTHERWISE STATED, SAMPLES ARE NOT CORRECTED FOR CLIENT FIELD BLANKS.

Although test results are generated under strict QA/QC protocols, any unsigned test reports, faxes, or emails are considered preliminary.

Enviro-Test Laboratories has an extensive QA/QC program where all analytical data reported is analyzed using approved referenced procedures followed by checks and reviews by senior managers and quality assurance personnel. However, since the results are obtained from chemical measurements and thus cannot be guaranteed, Enviro-Test Laboratories assumes no liability for the use or interpretation of the results.

Workorder: L219368

Contact: G. MCCLYMONT/ S. MORTON

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed	
<u>C-DIS-ORG-CL</u>		<u>Water</u>							
Batch	R232848								
WG241559-10	DUP	L219931-1							
Dissolved Organic Carbon			7	7	J	mg/L	0	3.1	29-OCT-04
WG241559-3	DUP	L218853-1							
Dissolved Organic Carbon			24	24		mg/L	0.90	10	28-OCT-04
WG241559-6	DUP	L219857-5							
Dissolved Organic Carbon			2	2	J	mg/L	0	3.1	28-OCT-04
WG241559-7	DUP	L217736-10							
Dissolved Organic Carbon			<1	<1	RPD-NA	mg/L	N/A	10	28-OCT-04
WG241559-8	DUP	L217756-1							
Dissolved Organic Carbon			16	17		mg/L	6.4	10	28-OCT-04
WG241559-2	LCS								
Dissolved Organic Carbon				103		%		90-105	28-OCT-04
WG241559-1	MB								
Dissolved Organic Carbon				1		mg/L		1	28-OCT-04
WG241559-4	MS	L218853-1							
Dissolved Organic Carbon				88		%		86-104	28-OCT-04
<u>CL-ED</u>		<u>Water</u>							
Batch	R231955								
WG240476-12	DUP	L218879-3							
Chloride (Cl)			<1	<1	RPD-NA	mg/L	N/A	5	26-OCT-04
WG240476-14	DUP	L219022-1							
Chloride (Cl)			1	1	J	mg/L	0	3.1	26-OCT-04
WG240476-16	DUP	L219123-2							
Chloride (Cl)			16	16		mg/L	0.14	5	26-OCT-04
WG240476-3	LCS								
Chloride (Cl)				101		%		93-107	26-OCT-04
WG240476-4	LCS								
Chloride (Cl)				99		%		93-107	26-OCT-04
WG240476-2	MB								
Chloride (Cl)				<1		mg/L		1	26-OCT-04
WG240476-13	MS	L218879-3							
Chloride (Cl)				106		%		91-111	26-OCT-04
WG240476-15	MS	L219022-1							
Chloride (Cl)				100		%		91-111	26-OCT-04
WG240476-17	MS	L219123-2							
Chloride (Cl)				102		%		91-111	26-OCT-04
<u>ETL-ROUTINE-ICP-ED</u>		<u>Water</u>							

Enviro-Test Quality Control Report

Workorder: L219368

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
<u>ETL-ROUTINE-ICP-ED</u>		<u>Water</u>						
Batch	R232444							
WG240958-3	CRM							
Calcium (Ca)			101		%		97-106	27-OCT-04
Magnesium (Mg)			103		%		95-108	27-OCT-04
Potassium (K)			96		%		91-103	27-OCT-04
Sodium (Na)			96		%		92-105	27-OCT-04
Sulfate (SO4)			95		%		91-104	27-OCT-04
WG240958-13	DUP	L216723-2						
Calcium (Ca)		16.4	16.3		mg/L	0.28	15	27-OCT-04
Magnesium (Mg)		345	345		mg/L	0.022	7.8	27-OCT-04
Potassium (K)		52.9	52.0		mg/L	1.7	12	27-OCT-04
Sodium (Na)		1450	1460		mg/L	1.3	7.8	27-OCT-04
Sulfate (SO4)		887	866		mg/L	2.5	7.8	27-OCT-04
WG240958-1	MB							
Calcium (Ca)			<0.5		mg/L		2.5	27-OCT-04
Magnesium (Mg)			<0.1		mg/L		0.5	27-OCT-04
Potassium (K)			<0.1		mg/L		0.5	27-OCT-04
Sodium (Na)			<1		mg/L		5	27-OCT-04
Sulfate (SO4)			<0.5		mg/L		2.5	27-OCT-04
WG240958-14	MS	L216723-2						
Calcium (Ca)			100		%		87-112	27-OCT-04
Magnesium (Mg)			98		%		88-111	27-OCT-04
Potassium (K)			99		%		92-111	27-OCT-04
Sodium (Na)			100		%		86-111	27-OCT-04
Sulfate (SO4)			96		%		85-112	27-OCT-04
<u>F-ED</u>		<u>Water</u>						
Batch	R232194							
WG240886-4	DUP	L219806-4						
Fluoride (F)		1.53	1.54		mg/L	0.65	6.1	26-OCT-04
WG240886-5	DUP	L219123-2						
Fluoride (F)		0.26	0.26	J	mg/L	0.00	0.15	26-OCT-04
WG240886-3	LCS							
Fluoride (F)			108	H	%		93-107	26-OCT-04
<u>FE-DIS-HIGH-ED</u>		<u>Water</u>						
Batch	R232949							
WG241518-6	DUP	L219637-2						
Iron (Fe)-Dissolved		2.77	2.72		mg/L	1.6	13	28-OCT-04
WG241518-8	DUP	L219863-4						
Iron (Fe)-Dissolved		0.41	0.40	J	mg/L	0.01	0.18	28-OCT-04
WG241518-1	MB							
Iron (Fe)-Dissolved			<0.06		mg/L		0.3	28-OCT-04

Workorder: L219368

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed	
FE-DIS-HIGH-ED		<u>Water</u>							
Batch	R232949								
WG241518-7	MS	L219637-2	102		%		92-108	28-OCT-04	
Iron (Fe)-Dissolved									
WG241518-9	MS	L219863-4	100		%		92-108	28-OCT-04	
Iron (Fe)-Dissolved									
MN-DIS-HIGH-ED		<u>Water</u>							
Batch	R232949								
WG241518-6	DUP	L219637-2	0.45	0.43	mg/L	4.8	12	28-OCT-04	
Manganese(Mn)-Dissolved									
WG241518-8	DUP	L219863-4	0.05	0.05	J	mg/L	0.00	0.031	28-OCT-04
Manganese(Mn)-Dissolved									
WG241518-1	MB			<0.01	mg/L		0.05	28-OCT-04	
Manganese(Mn)-Dissolved									
WG241518-7	MS	L219637-2	99		%		94-106	28-OCT-04	
Manganese(Mn)-Dissolved									
WG241518-9	MS	L219863-4	98		%		94-106	28-OCT-04	
Manganese(Mn)-Dissolved									
N-TOTKJ-LOW-ED		<u>Water</u>							
Batch	R232448								
WG240371-2	LCS		88		%		79-107	27-OCT-04	
Total Kjeldahl Nitrogen									
WG240371-1	MB		<0.05		mg/L		0.05	27-OCT-04	
Total Kjeldahl Nitrogen									
N2N3-LOW-ED		<u>Water</u>							
Batch	R231998								
WG240638-2	LCS		97		%		92-105	26-OCT-04	
Nitrate+Nitrite-N									
WG240638-1	MB		<0.006		mg/L		0.006	26-OCT-04	
Nitrate+Nitrite-N									
NH4-LOW-ED		<u>Water</u>							
Batch	R232453								
WG240915-4	DUP	L219368-2	0.051	0.051	mg/L	0.39	7.7	27-OCT-04	
Ammonia-N									
WG240915-2	LCS		91		%		79-111	27-OCT-04	
Ammonia-N									
WG240915-1	MB		<0.005		mg/L		0.005	27-OCT-04	
Ammonia-N									
WG240915-5	MS	L219937-2	78		%		70-143	27-OCT-04	
Ammonia-N									
NO2-ED		<u>Water</u>							

Enviro-Test Quality Control Report

Workorder: L219368

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
NO2-ED		Water						
Batch	R232071							
WG240504-2	LCS							
Nitrite-N			95		%		93-107	26-OCT-04
WG240504-1	MB							
Nitrite-N			<0.05		mg/L		0.05	26-OCT-04
WG240504-3	MS	L218603-10						
Nitrite-N			94		%		90-106	26-OCT-04
WG240504-5	MS	L219053-1						
Nitrite-N			99		%		90-106	26-OCT-04
WG240504-7	MS	L219383-2						
Nitrite-N			100		%		90-106	26-OCT-04
WG240504-8	MS	L219711-1						
Nitrite-N			100		%		90-106	26-OCT-04
WG240504-4	MSD	WG240504-3						
Nitrite-N		94	93		%	1.4	5	26-OCT-04
WG240504-6	MSD	WG240504-5						
Nitrite-N		99	99		%	0.33	5	26-OCT-04
WG240504-9	MSD	WG240504-8						
Nitrite-N		100	99		%	0.55	5	26-OCT-04
P-TOTAL-LOW-ED		Water						
Batch	R232970							
WG240551-2	LCS							
Phosphorus, Total			89	H	%		91-112	28-OCT-04
WG240551-1	MB							
Phosphorus, Total			<0.001		mg/L		0.001	28-OCT-04
WG240551-4	MS	L219408-1						
Phosphorus, Total			99		%		83-116	28-OCT-04
P-TOTALDIS-LOW-ED		Water						
Batch	R232970							
WG240551-2	LCS							
Phosphorus, Total Dissolved			89	H	%		91-112	28-OCT-04
WG240551-1	MB							
Phosphorus, Total Dissolved			<0.001		mg/L		0.001	28-OCT-04
PH/EC/ALK-ED		Water						
Batch	R232194							
WG240886-4	DUP	L219806-4						
Alkalinity, Total (as CaCO3)		148	150		mg/L	1.1	5	26-OCT-04
Bicarbonate (HCO3)		181	183		mg/L	1.1	20	26-OCT-04
Carbonate (CO3)		<5	<5	RPD-NA	mg/L	N/A	20	26-OCT-04
Conductivity (EC)		708	707		uS/cm	0.14	5.5	26-OCT-04
Hydroxide (OH)		<5	<5	RPD-NA	mg/L	N/A	20	26-OCT-04
pH		8.2	8.2	J	pH	0.0	0.1	26-OCT-04

Enviro-Test Quality Control Report

Workorder: L219368

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
<u>PH/EC/ALK-ED</u>		<u>Water</u>						
Batch	R232194							
WG240886-5	DUP	L219123-2						
Alkalinity, Total (as CaCO3)		388	389		mg/L	0.33	5	26-OCT-04
Bicarbonate (HCO3)		473	475		mg/L	0.33	20	26-OCT-04
Carbonate (CO3)		<5	<5	RPD-NA	mg/L	N/A	20	26-OCT-04
Conductivity (EC)		1700	1700		uS/cm	0.12	5.5	26-OCT-04
Hydroxide (OH)		<5	<5	RPD-NA	mg/L	N/A	20	26-OCT-04
pH		7.9	7.9	J	pH	0.0	0.1	26-OCT-04
WG240886-1	LCS							
Conductivity (EC)			99		%		96-104	26-OCT-04
WG240886-2	LCS							
pH			7.0		pH		6.9-7.1	26-OCT-04
WG240886-3	LCS							
Alkalinity, Total (as CaCO3)			99		%		93-107	26-OCT-04
<u>SIO2-CALC-ED</u>		<u>Water</u>						
Batch	R232444							
WG240958-3	CRM							
Silica (as SiO2)			100		%		93-110	27-OCT-04
WG240958-1	MB							
Silica (as SiO2)			<0.1		mg/L		0.5	27-OCT-04
<u>SOLIDS-TDS-ED</u>		<u>Water</u>						
Batch	R232697							
WG241111-3	DUP	L218961-2						
Total Dissolved Solids		440	440		mg/L	0.0	8.7	27-OCT-04
WG241111-4	DUP	L219368-2						
Total Dissolved Solids		410	400		mg/L	2.5	8.7	27-OCT-04
WG241111-2	LCS							
Total Dissolved Solids			103		%		96-112	27-OCT-04
WG241111-1	MB							
Total Dissolved Solids			<10		mg/L		10	27-OCT-04

Product - Batch and Sample Number Relations:

C-DIS-ORG-CL	1		
R232848		L219368-1	L219368-2
CL-ED	1		
R231955		L219368-1	L219368-2
ETL-ROUTINE-ICP-ED	1		
R232444		L219368-1	L219368-2
F-ED	1		
R232194		L219368-1	L219368-2
FE-DIS-HIGH-ED	1		
R232949		L219368-1	L219368-2

Enviro-Test Quality Control Report

Workorder: L219368

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
Product - Batch and Sample Number Relations:								
MN-DIS-HIGH-ED	1							
R232949		L219368-1	L219368-2					
N-TOTKJ-LOW-ED	1							
R232448		L219368-1	L219368-2					
N2N3-LOW-ED	1							
R231998		L219368-1	L219368-2					
NH4-LOW-ED	1							
R232453		L219368-1	L219368-2					
NO2-ED	1							
R232071		L219368-1	L219368-2					
NO3-ED	1							
R232071		L219368-1	L219368-2					
P-TOTAL-LOW-ED	1							
R232970		L219368-1	L219368-2					
P-TOTALDIS-LOW-ED	1							
R232970		L219368-1	L219368-2					
PH/EC/ALK-ED	1							
R232194		L219368-1	L219368-2					
SIO2-CALC-ED	1							
R232444		L219368-1	L219368-2					
SOLIDS-TDS-ED	1							
R232697		L219368-1	L219368-2					

Workorder # L219368

Legend:

Limit 95% Confidence Interval (Laboratory Warning Limits)
DUP Duplicate
RPD Relative Percent Difference
N/A Not Available
LCS Laboratory Control Sample
SRM Standard Reference Materials
MS Matrix Spike
MSD Matrix Spike Duplicate
ADE Average Desorption Efficiency
MB Method Blank
IRM Internal Reference Material
CRM Certified Reference Material
CCV Continuing Calibration Verification
CVS Calibration Verification Standard
LCSD Laboratory Control Sample Duplicate

Qualifier:

RPD-NA Relative Percent Difference Not Available due to result(s) being less than detection limit.
A Method blank exceeds acceptance limit. Blank correction not applied, unless the qualifier "RAMB" (result adjusted for method blank) appears in the Analytical Report.
B Method blank result exceeds acceptance limit, however, it is less than 5% of sample concentration. Blank correction not applied.
E Matrix spike recovery may fall outside the acceptance limits due to high sample background.
F Silver recovery low, likely due to elevated chloride levels in sample.
G Outlier - No assignable cause for nonconformity has been determined.
H Result falls within the 99% Confidence Interval (Laboratory Control Limits)
J Duplicate results and limit(s) are expressed in terms of absolute difference.
K The sample referenced above is of a non-standard matrix type; standard QC acceptance criteria may not be achievable.

ETL EnviroTest

A DIVISION OF ETL CHEMSPEC ANALYTICAL LIMITED

ANALYTICAL REPORT

WESTWATER ENVIRONMENTAL LTD

DATE: 29-OCT-04

ATTN: S. MORTON

900, 808 4TH AVENUE SW

CALGARY AB T2P 3E8

Lab Work Order #: L215354

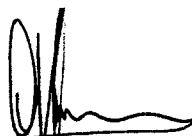
Sampled By: SM

Date Received: 14-OCT-04

Project P.O. #:

Project Reference: 04.075

Comments: Unable to complete TDS analysis on -6 due to Insufficient Sample.



DOUG JOHNSON
Director of Operations, Edmonton



JESSICA MARIE WEBER
Client Service Specialist

THIS REPORT SHALL NOT BE REPRODUCED EXCEPT IN FULL WITHOUT THE WRITTEN AUTHORITY OF THE LABORATORY.
ALL SAMPLES WILL BE DISPOSED OF AFTER 30 DAYS FOLLOWING ANALYSIS. PLEASE CONTACT THE LAB IF YOU
REQUIRE ADDITIONAL SAMPLE STORAGE TIME.

LABORATORY ACCREDITATIONS:

- STANDARDS COUNCIL OF CANADA IN COOPERATION WITH THE CANADIAN ASSOCIATION FOR ENVIRONMENTAL ANALYTICAL LABORATORIES (CAEAL) FOR SPECIFIC TESTS AS REGISTERED BY THE COUNCIL (EDMONTON, CALGARY, GRANDE PRAIRIE, SASKATOON, WINNIPEG, THUNDER BAY, WATERLOO)
- AMERICAN INDUSTRIAL HYGIENE ASSOCIATION (AIHA) IN THE INDUSTRIAL HYGIENE PROGRAM (EDMONTON, WINNIPEG)
- STANDARDS COUNCIL OF CANADA IN COOPERATION WITH THE CANADIAN FOOD INSPECTION AGENCY (CFIA) FOR FERTILIZER AND FEED TESTING (SASKATOON) AND FOR MICROBIOLOGICAL TESTING IN FOOD (WINNIPEG)

9936 - 67 Avenue, Edmonton, Alberta T6E 0P5, Tel. (780) 413-5227, Fax (780) 437-2311

Canada Wide Tel. 1-800-668-9878 www.envirotest.com

(Edmonton, Calgary, Fort McMurray, Grande Prairie, Saskatoon, Winnipeg, Thunder Bay, Ottawa, Waterloo)

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L215354-1 MW-1 SYLVAN LAKE								
Sample Date: 12-OCT-04								
Matrix: WATER								
Phosphorus, Total Dissolved	0.018		0.001	mg/L		19-OCT-04	TL	R229583
Phosphorus, Total	2.78		0.001	mg/L		19-OCT-04	TL	R229583
Ammonia-N	0.065		0.005	mg/L		15-OCT-04	TL/W	R228649
Dissolved Organic Carbon	17		1	mg/L		19-OCT-04	SIW	R229380
MF - E. Coli	2		1	CFU/100mL		18-OCT-04	DEL	R229089
MF - Fecal Coliforms	3		1	CFU/100mL		18-OCT-04	DEL	R229089
Nitrate+Nitrite-N	9.1		0.1	mg/L		16-OCT-04	SHC	R229092
Nitrate-N	9.6		0.1	mg/L		14-OCT-04	SHC	R227965
Nitrite-N	<0.05		0.05	mg/L		14-OCT-04	SHC	R227965
Total Dissolved Solids	950		10	mg/L		18-OCT-04	ZOW	R229420
Total Kjeldahl Nitrogen	2.21		0.05	mg/L		15-OCT-04	TL	R228503
Routine Water: Majors,F,Fe,Mn (Dis)&SiO2								
Iron (Fe)-Dissolved	<0.06		0.06	mg/L		14-OCT-04	HAS	R228160
Manganese(Mn)-Dissolved	0.20		0.01	mg/L		14-OCT-04	HAS	R228160
Chloride (Cl)	75		1	mg/L		14-OCT-04	SHC	R227965
Fluoride (F)	0.21		0.05	mg/L		13-OCT-04	PTT	R228412
Silica (as SiO2)	14.3		0.1	mg/L		13-OCT-04	EOC	R227541
pH, Conductivity and Total Alkalinity								
pH	7.5		0.1	pH		13-OCT-04	PTT	R228412
Conductivity (EC)	1560		0.2	uS/cm		13-OCT-04	PTT	R228412
Bicarbonate (HCO3)	799		5	mg/L		13-OCT-04	PTT	R228412
Carbonate (CO3)	<5		5	mg/L		13-OCT-04	PTT	R228412
Hydroxide (OH)	<5		5	mg/L		13-OCT-04	PTT	R228412
Alkalinity, Total (as CaCO3)	655		5	mg/L		13-OCT-04	PTT	R228412
Ion Balance Calculation								
Ion Balance	102			%		18-OCT-04		
TDS (Calculated)	943			mg/L		18-OCT-04		
Hardness (as CaCO3)	771			mg/L		18-OCT-04		
ICP metals and SO4 for routine water								
Calcium (Ca)	186		0.5	mg/L		13-OCT-04	EOC	R227541
Potassium (K)	4.2		0.1	mg/L		13-OCT-04	EOC	R227541
Magnesium (Mg)	74.5		0.1	mg/L		13-OCT-04	EOC	R227541
Sodium (Na)	67		1	mg/L		13-OCT-04	EOC	R227541
Sulfate (SO4)	101		0.5	mg/L		13-OCT-04	EOC	R227541
L215354-2 MW-5 SYLVAN LAKE								
Sample Date: 12-OCT-04								
Matrix: WATER								
Phosphorus, Total Dissolved	0.020		0.001	mg/L		19-OCT-04	TL	R229583
Phosphorus, Total	12.7		0.001	mg/L		19-OCT-04	TL	R229583
Ammonia-N	0.498		0.005	mg/L		15-OCT-04	TL/W	R228649
Dissolved Organic Carbon	11		1	mg/L		19-OCT-04	SIW	R229380
MF - E. Coli	<1		1	CFU/100mL		18-OCT-04	DEL	R229089
MF - Fecal Coliforms	<1		1	CFU/100mL		18-OCT-04	DEL	R229089
Nitrate+Nitrite-N	0.3		0.1	mg/L		16-OCT-04	SHC	R229092
Nitrate-N	0.2		0.1	mg/L		14-OCT-04	SHC	R227965
Nitrite-N	0.12		0.05	mg/L		14-OCT-04	SHC	R227965
Total Dissolved Solids	1800		10	mg/L		18-OCT-04	ZOW	R229420
Total Kjeldahl Nitrogen	11.1		0.05	mg/L		15-OCT-04	TL	R228503

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L215354-2 MW-5 SYLVAN LAKE Sample Date: 12-OCT-04 Matrix: WATER								
Routine Water: Majors,F,Fe,Mn (Dis)&SiO2								
Iron (Fe)-Dissolved	<0.06		0.06	mg/L		14-OCT-04	HAS	R228160
Manganese(Mn)-Dissolved	0.08		0.01	mg/L		14-OCT-04	HAS	R228160
Chloride (Cl)	6		1	mg/L		14-OCT-04	SHC	R227965
Fluoride (F)	0.25		0.05	mg/L		13-OCT-04	PTT	R228412
Silica (as SiO2)	10.8		0.1	mg/L		13-OCT-04	EOC	R227541
pH, Conductivity and Total Alkalinity								
pH	8.1		0.1	pH		13-OCT-04	PTT	R228412
Conductivity (EC)	1540		0.2	uS/cm		13-OCT-04	PTT	R228412
Bicarbonate (HCO3)	812		5	mg/L		13-OCT-04	PTT	R228412
Carbonate (CO3)	<5		5	mg/L		13-OCT-04	PTT	R228412
Hydroxide (OH)	<5		5	mg/L		13-OCT-04	PTT	R228412
Alkalinity, Total (as CaCO3)	666		5	mg/L		13-OCT-04	PTT	R228412
Ion Balance Calculation								
Ion Balance	102			%		18-OCT-04		
TDS (Calculated)	948			mg/L		18-OCT-04		
Hardness (as CaCO3)	140			mg/L		18-OCT-04		
ICP metals and SO4 for routine water								
Calcium (Ca)	35.8		0.5	mg/L		13-OCT-04	EOC	R227541
Potassium (K)	3.8		0.1	mg/L		13-OCT-04	EOC	R227541
Magnesium (Mg)	12.2		0.1	mg/L		13-OCT-04	EOC	R227541
Sodium (Na)	328		1	mg/L		13-OCT-04	EOC	R227541
Sulfate (SO4)	161		0.5	mg/L		13-OCT-04	EOC	R227541
L215354-3 MW-7 SYLVAN LAKE Sample Date: 12-OCT-04 Matrix: WATER								
Phosphorus, Total Dissolved	0.035		0.001	mg/L		19-OCT-04	TL	R229583
Phosphorus, Total	3.51		0.001	mg/L		19-OCT-04	TL	R229583
Ammonia-N	0.087		0.005	mg/L		15-OCT-04	TL/W	R228649
Dissolved Organic Carbon	15		1	mg/L		19-OCT-04	SIW	R229380
MF - E. Coli	<1		1	CFU/100mL		18-OCT-04	DEL	R229089
MF - Fecal Coliforms	<1		1	CFU/100mL		18-OCT-04	DEL	R229089
Nitrate+Nitrite-N	4.8		0.1	mg/L		16-OCT-04	SHC	R229092
Nitrate-N	4.9		0.1	mg/L		14-OCT-04	SHC	R227965
Nitrite-N	0.28		0.05	mg/L		14-OCT-04	SHC	R227965
Total Dissolved Solids	1000		10	mg/L		18-OCT-04	ZOW	R229420
Total Kjeldahl Nitrogen	5.33		0.05	mg/L		15-OCT-04	TL	R228503
Routine Water: Majors,F,Fe,Mn (Dis)&SiO2								
Iron (Fe)-Dissolved	<0.06		0.06	mg/L		14-OCT-04	HAS	R228160
Manganese(Mn)-Dissolved	0.51		0.01	mg/L		14-OCT-04	HAS	R228160
Chloride (Cl)	33		1	mg/L		14-OCT-04	SHC	R227965
Fluoride (F)	0.16		0.05	mg/L		13-OCT-04	PTT	R228412
Silica (as SiO2)	13.5		0.1	mg/L		13-OCT-04	EOC	R227541
pH, Conductivity and Total Alkalinity								
pH	7.5		0.1	pH		13-OCT-04	PTT	R228412
Conductivity (EC)	1470		0.2	uS/cm		13-OCT-04	PTT	R228412
Bicarbonate (HCO3)	881		5	mg/L		13-OCT-04	PTT	R228412
Carbonate (CO3)	<5		5	mg/L		13-OCT-04	PTT	R228412
Hydroxide (OH)	<5		5	mg/L		13-OCT-04	PTT	R228412

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L215354-3 MW-7 SYLVAN LAKE Sample Date: 12-OCT-04 Matrix: WATER Routine Water: Majors,F,Fe,Mn (Dis)&SiO2 pH, Conductivity and Total Alkalinity Alkalinity, Total (as CaCO3) Ion Balance Calculation Ion Balance TDS (Calculated) Hardness (as CaCO3) ICP metals and SO4 for routine water Calcium (Ca) Potassium (K) Magnesium (Mg) Sodium (Na) Sulfate (SO4)	722 104 864 744 161 5.3 83.0 62 63.5		5	mg/L % mg/L mg/L mg/L mg/L mg/L mg/L mg/L		13-OCT-04 18-OCT-04 18-OCT-04 18-OCT-04 13-OCT-04 13-OCT-04 13-OCT-04 13-OCT-04 13-OCT-04	PTT EOC EOC EOC EOC EOC EOC EOC EOC	R228412 R227541 R227541 R227541 R227541 R227541 R227541 R227541 R227541
L215354-4 TRIP BLANK SYLVAN LAKE Sample Date: 13-OCT-04 Matrix: WATER Phosphorus, Total Dissolved Phosphorus, Total Ammonia-N Dissolved Organic Carbon MF - Fecal Coliforms Nitrate+Nitrite-N Nitrate-N Nitrite-N Total Dissolved Solids Total Kjeldahl Nitrogen Routine Water: Majors,F,Fe,Mn (Dis)&SiO2 Iron (Fe)-Dissolved Manganese(Mn)-Dissolved Chloride (Cl) Fluoride (F) Silica (as SiO2) pH, Conductivity and Total Alkalinity pH Conductivity (EC) Bicarbonate (HCO3) Carbonate (CO3) Hydroxide (OH) Alkalinity, Total (as CaCO3) Ion Balance Calculation Ion Balance TDS (Calculated) Hardness (as CaCO3) ICP metals and SO4 for routine water Calcium (Ca) Potassium (K) Magnesium (Mg) Sodium (Na) Sulfate (SO4)	0.002 0.003 <0.005 1 <1 <0.1 <0.1 <0.05 <10 <0.05 <0.06 <0.01 <1 <0.05 <0.1 7.1 2.6 <5 <5 <5 <5 Low TDS <1 <1 <0.5 <0.1 <0.1 <1 <0.5			0.001 0.001 0.005 1 1 0.1 0.1 0.05 10 0.05 0.06 0.01 1 0.05 0.1 0.1 0.2 5 5 5 5 5 0.5 0.1 0.1 0.1 1 0.5	mg/L mg/L mg/L mg/L CFU/100mL mg/L mg/L mg/L mg/L mg/L mg/L mg/L mg/L mg/L pH uS/cm mg/L mg/L mg/L mg/L mg/L mg/L mg/L mg/L mg/L mg/L mg/L	19-OCT-04 19-OCT-04 15-OCT-04 22-OCT-04 18-OCT-04 16-OCT-04 16-OCT-04 17-OCT-04 19-OCT-04 18-OCT-04 18-OCT-04 18-OCT-04 19-OCT-04 14-OCT-04 15-OCT-04 14-OCT-04 14-OCT-04 14-OCT-04 14-OCT-04 14-OCT-04 14-OCT-04 14-OCT-04 15-OCT-04 15-OCT-04 15-OCT-04 15-OCT-04 15-OCT-04	TL TL TL/W HSC DEL SHC SHC SHC ZOW TL HAS HAS JTV PTT BMA PTT PTT PTT PTT PTT PTT PTT BMA BMA BMA BMA BMA	R229583 R229583 R228649 R230927 R229089 R229092 R229092 R229075 R229835 R229138 R229296 R229296 R229601 R228478 R228354 R228478 R228478 R228478 R228478 R228478 R228478 R228478 R228354 R228354 R228354 R228354 R228354

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L215354-5	MW-2 SYLVAN LAKE							
Sample Date: 13-OCT-04								
Matrix: WATER								
Phosphorus, Total Dissolved	0.027		0.001	mg/L		19-OCT-04	TL	R229583
Phosphorus, Total	1.99		0.001	mg/L		19-OCT-04	TL	R229583
Ammonia-N	0.161		0.005	mg/L		15-OCT-04	TL/W	R228649
Dissolved Organic Carbon	21		1	mg/L		22-OCT-04	HSC	R230927
MF - E. Coli	<1		1	CFU/100mL		18-OCT-04	DEL	R229089
MF - Fecal Coliforms	<1		1	CFU/100mL		18-OCT-04	DEL	R229089
Nitrate+Nitrite-N	1.1		0.1	mg/L		16-OCT-04	SHC	R229092
Nitrate-N	0.8		0.1	mg/L		16-OCT-04	SHC	R229092
Nitrite-N	0.28		0.05	mg/L		17-OCT-04	SHC	R229075
Total Dissolved Solids	1230		10	mg/L		19-OCT-04	ZOW	R229835
Total Kjeldahl Nitrogen	2.93		0.05	mg/L		18-OCT-04	TL	R229138
Routine Water: Majors,F,Fe,Mn (Dis)&SiO2								
Iron (Fe)-Dissolved	<0.06		0.06	mg/L		18-OCT-04	HAS	R229296
Manganese(Mn)-Dissolved	0.08		0.01	mg/L		18-OCT-04	HAS	R229296
Chloride (Cl)	26		1	mg/L		19-OCT-04	JTV	R229601
Fluoride (F)	0.15		0.05	mg/L		14-OCT-04	PTT	R228478
Silica (as SiO2)	10.2		0.1	mg/L		15-OCT-04	BMA	R228354
pH, Conductivity and Total Alkalinity								
pH	7.8		0.1	pH		14-OCT-04	PTT	R228478
Conductivity (EC)	1810		0.2	uS/cm		14-OCT-04	PTT	R228478
Bicarbonate (HCO3)	644		5	mg/L		14-OCT-04	PTT	R228478
Carbonate (CO3)	<5		5	mg/L		14-OCT-04	PTT	R228478
Hydroxide (OH)	<5		5	mg/L		14-OCT-04	PTT	R228478
Alkalinity, Total (as CaCO3)	527		5	mg/L		14-OCT-04	PTT	R228478
Ion Balance Calculation								
Ion Balance	104			%		20-OCT-04		
TDS (Calculated)	1160			mg/L		20-OCT-04		
Hardness (as CaCO3)	557			mg/L		20-OCT-04		
ICP metals and SO4 for routine water								
Calcium (Ca)	136		0.5	mg/L		15-OCT-04	BMA	R228354
Potassium (K)	5.8		0.1	mg/L		15-OCT-04	BMA	R228354
Magnesium (Mg)	52.7		0.1	mg/L		15-OCT-04	BMA	R228354
Sodium (Na)	214		1	mg/L		15-OCT-04	BMA	R228354
Sulfate (SO4)	407		0.5	mg/L		15-OCT-04	BMA	R228354
L215354-6	MW-3 SYLVAN LAKE							
Sample Date: 13-OCT-04								
Matrix: WATER								
Phosphorus, Total Dissolved	0.026		0.001	mg/L		19-OCT-04	TL	R229583
Phosphorus, Total	2.11		0.001	mg/L		19-OCT-04	TL	R229583
Ammonia-N	0.098		0.005	mg/L		15-OCT-04	TL/W	R228649
Dissolved Organic Carbon	15		1	mg/L		22-OCT-04	HSC	R230927
MF - E. Coli	<1		1	CFU/100mL		18-OCT-04	DEL	R229089
MF - Fecal Coliforms	<1		1	CFU/100mL		18-OCT-04	DEL	R229089
Nitrate+Nitrite-N	0.9		0.1	mg/L		16-OCT-04	SHC	R229092
Nitrate-N	0.7		0.1	mg/L		16-OCT-04	SHC	R229092
Nitrite-N	0.22		0.05	mg/L		17-OCT-04	SHC	R229075
Total Kjeldahl Nitrogen	1.66		0.05	mg/L		18-OCT-04	TL	R229138
Routine Water: Majors,F,Fe,Mn (Dis)&SiO2								

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L215354-6 MW-3 SYLVAN LAKE								
Sample Date: 13-OCT-04								
Matrix: WATER								
Routine Water: Majors,F,Fe,Mn (Dis)&SiO2								
Iron (Fe)-Dissolved	<0.06		0.06	mg/L		18-OCT-04	HAS	R229296
Manganese(Mn)-Dissolved	<0.01		0.01	mg/L		18-OCT-04	HAS	R229296
Chloride (Cl)	28		1	mg/L		19-OCT-04	JTV	R229601
Fluoride (F)	0.14		0.05	mg/L		14-OCT-04	PTT	R228478
Silica (as SiO2)	12.2		0.1	mg/L		15-OCT-04	BMA	R228354
pH, Conductivity and Total Alkalinity								
pH	8.0		0.1	pH		14-OCT-04	PTT	R228478
Conductivity (EC)	1560		0.2	uS/cm		14-OCT-04	PTT	R228478
Bicarbonate (HCO3)	712		5	mg/L		14-OCT-04	PTT	R228478
Carbonate (CO3)	<5		5	mg/L		14-OCT-04	PTT	R228478
Hydroxide (OH)	<5		5	mg/L		14-OCT-04	PTT	R228478
Alkalinity, Total (as CaCO3)	584		5	mg/L		14-OCT-04	PTT	R228478
Ion Balance Calculation								
Ion Balance	103			%		20-OCT-04		
TDS (Calculated)	1030			mg/L		20-OCT-04		
Hardness (as CaCO3)	641			mg/L		20-OCT-04		
ICP metals and SO4 for routine water								
Calcium (Ca)	156		0.5	mg/L		15-OCT-04	BMA	R228354
Potassium (K)	5.9		0.1	mg/L		15-OCT-04	BMA	R228354
Magnesium (Mg)	61.0		0.1	mg/L		15-OCT-04	BMA	R228354
Sodium (Na)	139		1	mg/L		15-OCT-04	BMA	R228354
Sulfate (SO4)	287		0.5	mg/L		15-OCT-04	BMA	R228354
L215354-7 MW-4 SYLVAN LAKE								
Sample Date: 13-OCT-04								
Matrix: WATER								
Phosphorus, Total Dissolved	0.018		0.001	mg/L		19-OCT-04	TL	R229583
Phosphorus, Total	1.61		0.001	mg/L		19-OCT-04	TL	R229583
Ammonia-N	0.068		0.005	mg/L		15-OCT-04	TL/W	R228649
Dissolved Organic Carbon	21		1	mg/L		22-OCT-04	HSC	R230927
MF - E. Coli	<1		1	CFU/100mL		18-OCT-04	DEL	R229089
MF - Fecal Coliforms	>200		1	CFU/100mL		18-OCT-04	DEL	R229089
Nitrate+Nitrite-N	7.8		0.1	mg/L		16-OCT-04	SHC	R229092
Nitrate-N	7.8		0.1	mg/L		16-OCT-04	SHC	R229092
Nitrite-N	<0.05		0.05	mg/L		17-OCT-04	SHC	R229075
Total Dissolved Solids	660		10	mg/L		19-OCT-04	ZOW	R229835
Total Kjeldahl Nitrogen	6.29		0.05	mg/L		18-OCT-04	TL	R229138
Routine Water: Majors,F,Fe,Mn (Dis)&SiO2								
Iron (Fe)-Dissolved	<0.06		0.06	mg/L		18-OCT-04	HAS	R229296
Manganese(Mn)-Dissolved	<0.01		0.01	mg/L		18-OCT-04	HAS	R229296
Chloride (Cl)	52		1	mg/L		19-OCT-04	JTV	R229601
Fluoride (F)	0.18		0.05	mg/L		14-OCT-04	PTT	R228478
Silica (as SiO2)	10.8		0.1	mg/L		15-OCT-04	BMA	R228354
pH, Conductivity and Total Alkalinity								
pH	7.6		0.1	pH		14-OCT-04	PTT	R228478
Conductivity (EC)	1040		0.2	uS/cm		14-OCT-04	PTT	R228478
Bicarbonate (HCO3)	543		5	mg/L		14-OCT-04	PTT	R228478
Carbonate (CO3)	<5		5	mg/L		14-OCT-04	PTT	R228478
Hydroxide (OH)	<5		5	mg/L		14-OCT-04	PTT	R228478
Alkalinity, Total (as CaCO3)	445		5	mg/L		14-OCT-04	PTT	R228478

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L215354-7 MW-4 SYLVAN LAKE Sample Date: 13-OCT-04 Matrix: WATER Routine Water: Majors,F,Fe,Mn (Dis)&SiO2 Ion Balance Calculation Ion Balance 101 % 20-OCT-04 TDS (Calculated) 622 mg/L 20-OCT-04 Hardness (as CaCO3) 518 mg/L 20-OCT-04 ICP metals and SO4 for routine water Calcium (Ca) 142 0.5 mg/L 15-OCT-04 BMA R228354 Potassium (K) 5.0 0.1 mg/L 15-OCT-04 BMA R228354 Magnesium (Mg) 39.8 0.1 mg/L 15-OCT-04 BMA R228354 Sodium (Na) 34 1 mg/L 15-OCT-04 BMA R228354 Sulfate (SO4) 47.5 0.5 mg/L 15-OCT-04 BMA R228354								
L215354-8 MW-6 SYLVAN LAKE Sample Date: 13-OCT-04 Matrix: WATER Phosphorus, Total Dissolved 0.019 0.001 mg/L 19-OCT-04 TL R229583 Phosphorus, Total 0.784 0.001 mg/L 19-OCT-04 TL R229583 Ammonia-N 0.053 0.005 mg/L 15-OCT-04 TL/W R228649 Dissolved Organic Carbon 22 1 mg/L 22-OCT-04 HSC R230927 MF - E. Coli <1 1 CFU/100mL 18-OCT-04 DEL R229089 MF - Fecal Coliforms <1 1 CFU/100mL 18-OCT-04 DEL R229089 Nitrate+Nitrite-N <0.1 0.1 mg/L 16-OCT-04 SHC R229092 Nitrate-N <0.1 0.1 mg/L 16-OCT-04 SHC R229092 Nitrite-N <0.05 0.05 mg/L 17-OCT-04 SHC R229075 Total Dissolved Solids 510 10 mg/L 19-OCT-04 ZOW R229835 Total Kjeldahl Nitrogen 0.95 0.05 mg/L 18-OCT-04 TL R229138 Routine Water: Majors,F,Fe,Mn (Dis)&SiO2 Iron (Fe)-Dissolved <0.06 0.06 mg/L 18-OCT-04 HAS R229296 Manganese(Mn)-Dissolved 0.08 0.01 mg/L 18-OCT-04 HAS R229296 Chloride (Cl) 4 1 mg/L 19-OCT-04 JTV R229601 Fluoride (F) 0.15 0.05 mg/L 14-OCT-04 PTT R228478 Silica (as SiO2) 9.4 0.1 mg/L 15-OCT-04 BMA R228354 pH, Conductivity and Total Alkalinity pH 7.7 0.1 pH 14-OCT-04 PTT R228478 Conductivity (EC) 831 0.2 uS/cm 14-OCT-04 PTT R228478 Bicarbonate (HCO3) 516 5 mg/L 14-OCT-04 PTT R228478 Carbonate (CO3) <5 5 mg/L 14-OCT-04 PTT R228478 Hydroxide (OH) <5 5 mg/L 14-OCT-04 PTT R228478 Alkalinity, Total (as CaCO3) 423 5 mg/L 14-OCT-04 PTT R228478 Ion Balance Calculation Ion Balance 102 % 20-OCT-04 TDS (Calculated) 482 mg/L 20-OCT-04 Hardness (as CaCO3) 355 mg/L 20-OCT-04 ICP metals and SO4 for routine water Calcium (Ca) 69.7 0.5 mg/L 15-OCT-04 BMA R228354 Potassium (K) 3.7 0.1 mg/L 15-OCT-04 BMA R228354 Magnesium (Mg) 44.0 0.1 mg/L 15-OCT-04 BMA R228354 Sodium (Na) 58 1 mg/L 15-OCT-04 BMA R228354 Sulfate (SO4) 48.3 0.5 mg/L 15-OCT-04 BMA R228354								

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L215354-9 MW-8 SYLVAN LAKE								
Sample Date: 13-OCT-04								
Matrix: WATER								
Phosphorus, Total Dissolved	0.027		0.001	mg/L		19-OCT-04	TL	R229583
Phosphorus, Total	1.65		0.001	mg/L		19-OCT-04	TL	R229583
Ammonia-N	0.300		0.005	mg/L		15-OCT-04	TL/W	R228649
Dissolved Organic Carbon	29		1	mg/L		22-OCT-04	HSC	R230927
MF - E. Coli	<1		1	CFU/100mL		18-OCT-04	DEL	R229089
MF - Fecal Coliforms	<1		1	CFU/100mL		18-OCT-04	DEL	R229089
Nitrate+Nitrite-N	<0.1		0.1	mg/L		16-OCT-04	SHC	R229092
Nitrate-N	<0.1		0.1	mg/L		16-OCT-04	SHC	R229092
Nitrite-N	<0.05		0.05	mg/L		17-OCT-04	SHC	R229075
Total Dissolved Solids	740		10	mg/L		19-OCT-04	ZOW	R229835
Total Kjeldahl Nitrogen	5.50		0.05	mg/L		18-OCT-04	TL	R229138
Routine Water: Majors,F,Fe,Mn (Dis)&SiO2								
Iron (Fe)-Dissolved	<0.06		0.06	mg/L		18-OCT-04	HAS	R229296
Manganese(Mn)-Dissolved	0.77		0.01	mg/L		18-OCT-04	HAS	R229296
Chloride (Cl)	8		1	mg/L		19-OCT-04	JTV	R229601
Fluoride (F)	0.21		0.05	mg/L		14-OCT-04	PTT	R228478
Silica (as SiO2)	12.5		0.1	mg/L		15-OCT-04	BMA	R228354
pH, Conductivity and Total Alkalinity								
pH	7.3		0.1	pH		14-OCT-04	PTT	R228478
Conductivity (EC)	1140		0.2	uS/cm		14-OCT-04	PTT	R228478
Bicarbonate (HCO3)	752		5	mg/L		14-OCT-04	PTT	R228478
Carbonate (CO3)	<5		5	mg/L		14-OCT-04	PTT	R228478
Hydroxide (OH)	<5		5	mg/L		14-OCT-04	PTT	R228478
Alkalinity, Total (as CaCO3)	616		5	mg/L		14-OCT-04	PTT	R228478
Ion Balance Calculation								
Ion Balance	101			%		20-OCT-04		
TDS (Calculated)	706			mg/L		20-OCT-04		
Hardness (as CaCO3)	517			mg/L		20-OCT-04		
ICP metals and SO4 for routine water								
Calcium (Ca)	127		0.5	mg/L		15-OCT-04	BMA	R228354
Potassium (K)	8.5		0.1	mg/L		15-OCT-04	BMA	R228354
Magnesium (Mg)	48.6		0.1	mg/L		15-OCT-04	BMA	R228354
Sodium (Na)	80		1	mg/L		15-OCT-04	BMA	R228354
Sulfate (SO4)	64.1		0.5	mg/L		15-OCT-04	BMA	R228354
L215354-10 MW-88 SYLVAN LAKE								
Sample Date: 13-OCT-04								
Matrix: WATER								
Phosphorus, Total Dissolved	0.021		0.001	mg/L		19-OCT-04	TL	R229583
Phosphorus, Total	3.09		0.001	mg/L		19-OCT-04	TL	R229583
Ammonia-N	0.097		0.005	mg/L		15-OCT-04	TL/W	R228649
Dissolved Organic Carbon	9		1	mg/L		22-OCT-04	HSC	R230927
MF - E. Coli	<1		1	CFU/100mL		18-OCT-04	DEL	R229089
MF - Fecal Coliforms	>200		1	CFU/100mL		18-OCT-04	DEL	R229089
Nitrate+Nitrite-N	7.8		0.1	mg/L		16-OCT-04	SHC	R229092
Nitrate-N	7.8		0.1	mg/L		16-OCT-04	SHC	R229092
Nitrite-N	<0.05		0.05	mg/L		17-OCT-04	SHC	R229075
Total Dissolved Solids	640		10	mg/L		19-OCT-04	ZOW	R229835
Total Kjeldahl Nitrogen	9.69		0.05	mg/L		18-OCT-04	TL	R229138

Reference Information

Sample Parameter Qualifier key listed:

Qualifier	Description
NDIS	No Data: Insufficient Sample

Methods Listed (if applicable):

ETL Test Code	Matrix	Test Description	Preparation Method Reference(Based On)	Analytical Method Reference(Based On)
C-DIS-ORG-CL	Water	Dissolved Organic Carbon		APHA 5310 B-Instrumental
CL-ED	Water	Chloride (Cl)		APHA 4500 Cl E-Colorimetry
ECC-MF-RAW-ED	Water	Escherchia coli Count (E.coli)-MF		APHA 9221F MF
ETL-ROUTINE-ICP-ED	Water	ICP metals and SO4 for routine water		APHA 3120 B-ICP-OES
F-ED	Water	Fluoride (F)		APHA 4500 F-C-Electrode
FCC-MF-RAW-ED	Water	Fecal Coliform Count-MF		APHA 9222D MF
FE-DIS-HIGH-ED	Water	Iron (Fe)-Dissolved		EPA 200.7
IONBALANCE-ED	Water	Ion Balance Calculation		APHA 1030E
MN-DIS-HIGH-ED	Water	Manganese(Mn)-Dissolved		EPA 200.7
N-TOTKJ-LOW-ED	Water	Total Kjeldahl Nitrogen	TECHNICON	APHA 4500Norg C-Dig.-Auto-Colorimetry
N2N3-ED	Water	Nitrate+Nitrite-N		APHA 4500 NO3H-Colorimetry
NH4-LOW-ED	Water	Ammonia-N		APHA 4500 NH3F-Colorimetry
NO2-ED	Water	Nitrite-N		APHA 4500 NO2B-Colorimetry
NO3-ED	Water	Nitrate-N		APHA 4500 NO3H-Colorimetry
P-TOTAL-LOW-ED	Water	Phosphorus, Total		APHA 4500 P B,E-Auto-Colorimetry
P-TOTALDIS-LOW-ED	Water	Phosphorus, Dissolved		APHA 4500 P B,E-Auto-Colorimetry
PH/EC/ALK-ED	Water	pH, Conductivity and Total Alkalinity		APHA 4500-H, 2510, 2320
SIO2-CALC-ED	Water	Silica (as SIO2)		ICP/CALCULATION-ICP/CALCULATION
SOLIDS-TDS-ED	Water	Total Dissolved Solids		APHA 2540 C

** Laboratory Methods employed follow in-house procedures, which are generally based on nationally or internationally accepted methodologies.

Chain of Custody numbers:

154277

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location	Laboratory Definition Code	Laboratory Location
CL	Enviro-Test Laboratories - Calgary, Alberta, Canada	ED	Enviro-Test Laboratories - Edmonton, Alberta, Canada

Reference Information

GLOSSARY OF REPORT TERMS

Surr - A surrogate is an organic compound that is similar to the target analyte(s) in chemical composition and behavior but not normally detected in environmental samples. Prior to sample processing, samples are fortified with one or more surrogate compounds.

The reported surrogate recovery value provides a measure of method efficiency. The Laboratory warning units are determined under column heading D.L.

mg/kg (units) - unit of concentration based on mass, parts per million

mg/L (units) - unit of concentration based on volume, parts per million

< - Less than

D.L. - Detection Limit

N/A - Result not available. Refer to qualifier code and definition for explanation

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

UNLESS OTHERWISE STATED, SAMPLES ARE NOT CORRECTED FOR CLIENT FIELD BLANKS.

Although test results are generated under strict QA/QC protocols, any unsigned test reports, faxes, or emails are considered preliminary.

Enviro-Test Laboratories has an extensive QA/QC program where all analytical data reported is analyzed using approved referenced procedures followed by checks and reviews by senior managers and quality assurance personnel. However, since the results are obtained from chemical measurements and thus cannot be guaranteed, Enviro-Test Laboratories assumes no liability for the use or interpretation of the results.

Enviro-Test Quality Control Report

Workorder: L215354

Client: WESTWATER ENVIRONMENTAL LTD
900, 808 4TH AVENUE SW
CALGARY AB T2P 3E8

Contact: S. MORTON

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
C-DIS-ORG-CL		Water						
Batch	R229380							
WG237642-3	DUP	L214788-4						
Dissolved Organic Carbon		7	8	J	mg/L	1	3.1	19-OCT-04
WG237642-4	DUP	L215343-5						
Dissolved Organic Carbon		9	8	J	mg/L	1	3.1	19-OCT-04
WG237642-2	LCS							
Dissolved Organic Carbon			97		%		90-105	19-OCT-04
WG237642-1	MB							
Dissolved Organic Carbon			<1		mg/L		1	19-OCT-04
Batch	R230927							
WG239551-3	DUP	L213865-1						
Dissolved Organic Carbon		2	2	J	mg/L	0	3.1	22-OCT-04
WG239551-5	DUP	L215354-10						
Dissolved Organic Carbon		9	8	J	mg/L	1	3.1	22-OCT-04
WG239551-9	DUP	L215933-1						
Dissolved Organic Carbon		1	1	J	mg/L	0	3.1	22-OCT-04
WG239551-2	LCS							
Dissolved Organic Carbon			92		%		90-105	22-OCT-04
WG239551-1	MB							
Dissolved Organic Carbon			<1		mg/L		1	22-OCT-04
WG239551-4	MS	L213865-1						
Dissolved Organic Carbon			90		%		86-104	22-OCT-04
CL-ED		Water						
Batch	R227965							
WG235852-12	DUP	L215883-2						
Chloride (Cl)		26	26		mg/L	0.27	5	14-OCT-04
WG235852-17	DUP	L215187-15						
Chloride (Cl)		1	1	J	mg/L	0	3.1	14-OCT-04
WG235852-20	DUP	L215469-2						
Chloride (Cl)		8	8	J	mg/L	0	3.1	14-OCT-04
WG235852-10	LCS							
Chloride (Cl)			98		%		93-107	14-OCT-04
WG235852-11	LCS							
Chloride (Cl)			100		%		93-107	14-OCT-04
WG235852-9	MB							
Chloride (Cl)			<1		mg/L		1	14-OCT-04
WG235852-18	MS	L215187-1						
Chloride (Cl)			98		%		91-111	14-OCT-04

Workorder: L215354

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
CL-ED								
Water								
Batch	R227965							
WG235852-19	MS	L215263-2	105		%		91-111	14-OCT-04
Chloride (Cl)								
Batch	R229601							
WG237753-19	DUP	L216331-4	8	J	mg/L	0	3.1	19-OCT-04
Chloride (Cl)		8						
WG237753-21	DUP	L216363-1	17		mg/L	0.18	5	19-OCT-04
Chloride (Cl)		17						
WG237753-23	DUP	L216387-1	3	J	mg/L	0	3.1	19-OCT-04
Chloride (Cl)		3						
WG237753-25	DUP	L216389-1	2	J	mg/L	0	3.1	19-OCT-04
Chloride (Cl)		2						
WG237753-27	DUP	L216453-1	85		mg/L	0.033	5	19-OCT-04
Chloride (Cl)		85						
WG237753-29	DUP	L216553-19	<1	RPD-NA	mg/L	N/A	5	19-OCT-04
Chloride (Cl)		<1						
WG237753-31	DUP	L216740-1	6	J	mg/L	0	3.1	19-OCT-04
Chloride (Cl)		6						
WG237753-5	DUP	L215715-1	3	J	mg/L	0	3.1	19-OCT-04
Chloride (Cl)		3						
WG237753-2	LCS		103		%		93-107	19-OCT-04
Chloride (Cl)								
WG237753-3	LCS		100		%		93-107	19-OCT-04
Chloride (Cl)								
WG237753-1	MB		<1		mg/L		1	19-OCT-04
Chloride (Cl)								
WG237753-20	MS	L216331-4	102		%		91-111	19-OCT-04
Chloride (Cl)								
WG237753-22	MS	L216363-1	103		%		91-111	19-OCT-04
Chloride (Cl)								
WG237753-24	MS	L216387-1	104		%		91-111	19-OCT-04
Chloride (Cl)								
WG237753-26	MS	L216389-1	109		%		91-111	19-OCT-04
Chloride (Cl)								
WG237753-28	MS	L216453-1	101		%		91-111	19-OCT-04
Chloride (Cl)								
WG237753-30	MS	L216553-19	101		%		91-111	19-OCT-04
Chloride (Cl)								
WG237753-32	MS	L216740-1	107		%		91-111	19-OCT-04
Chloride (Cl)								
WG237753-6	MS	L215715-1	91	H	%		91-111	19-OCT-04
Chloride (Cl)								
ECC-MF-RAW-ED								
Water								

Enviro-Test Quality Control Report

Workorder: L215354

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
ECC-MF-RAW-ED		<u>Water</u>						
Batch	R229089							
WG237190-4	DUP	L215354-8						
MF - E. Coli		<1	<1	RPD-NA	CFU/100mL	N/A	30	18-OCT-04
ETL-ROUTINE-ICP-ED		<u>Water</u>						
Batch	R227541							
WG235449-3	CRM							
Calcium (Ca)			100		%		97-106	13-OCT-04
Magnesium (Mg)			101		%		95-108	13-OCT-04
Potassium (K)			95		%		91-103	13-OCT-04
Sodium (Na)			95		%		92-105	13-OCT-04
Sulfate (SO4)			98		%		91-104	13-OCT-04
WG235449-15	DUP	L214832-13						
Calcium (Ca)		322	319		mg/L	0.72	15	13-OCT-04
Magnesium (Mg)		169	168		mg/L	0.47	7.8	13-OCT-04
Potassium (K)		3.4	3.5		mg/L	2.4	12	13-OCT-04
Sodium (Na)		279	278		mg/L	0.14	7.8	13-OCT-04
Sulfate (SO4)		20.7	21.1		mg/L	1.6	7.8	13-OCT-04
WG235449-17	DUP	L214896-26						
Calcium (Ca)		47.1	46.6		mg/L	1.1	15	13-OCT-04
Magnesium (Mg)		15.4	15.5		mg/L	0.061	7.8	13-OCT-04
Potassium (K)		5.1	5.1		mg/L	0.13	12	13-OCT-04
Sodium (Na)		237	238		mg/L	0.27	7.8	13-OCT-04
Sulfate (SO4)		82.6	84.5		mg/L	2.3	7.8	13-OCT-04
WG235449-21	DUP	L215187-15						
Calcium (Ca)		54.0	54.1		mg/L	0.087	15	13-OCT-04
Magnesium (Mg)		22.7	22.6		mg/L	0.71	7.8	13-OCT-04
Potassium (K)		2.6	2.6		mg/L	3.5	12	13-OCT-04
Sodium (Na)		7	7	J	mg/L	0	3.1	13-OCT-04
Sulfate (SO4)		24.6	24.4		mg/L	0.75	7.8	13-OCT-04
WG235449-1	MB							
Calcium (Ca)			<0.5		mg/L		2.5	13-OCT-04
Magnesium (Mg)			<0.1		mg/L		0.5	13-OCT-04
Potassium (K)			<0.1		mg/L		0.5	13-OCT-04
Sodium (Na)			<1		mg/L		5	13-OCT-04
Sulfate (SO4)			<0.5		mg/L		2.5	13-OCT-04
WG235449-16	MS	L214832-13						
Calcium (Ca)			104		%		87-112	13-OCT-04
Magnesium (Mg)			105		%		88-111	13-OCT-04
Potassium (K)			101		%		92-111	13-OCT-04
Sodium (Na)			100				86-111	

Enviro-Test Quality Control Report

Workorder: L215354

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
ETL-ROUTINE-ICP-ED		Water						
Batch	R227541							
WG235449-16	MS	L214832-13						
Sodium (Na)			100		%		86-111	13-OCT-04
Sulfate (SO4)			99		%		85-112	13-OCT-04
WG235449-18	MS	L214896-26						
Calcium (Ca)			100		%		87-112	13-OCT-04
Magnesium (Mg)			98		%		88-111	13-OCT-04
Potassium (K)			104		%		92-111	13-OCT-04
Sodium (Na)			106		%		86-111	13-OCT-04
Sulfate (SO4)			94		%		85-112	13-OCT-04
WG235449-22	MS	L215187-15						
Calcium (Ca)			97		%		87-112	13-OCT-04
Magnesium (Mg)			99		%		88-111	13-OCT-04
Potassium (K)			98		%		92-111	13-OCT-04
Sodium (Na)			97		%		86-111	13-OCT-04
Sulfate (SO4)			97		%		85-112	13-OCT-04
Batch	R228354							
WG236345-3	CRM							
Calcium (Ca)			101		%		97-106	15-OCT-04
Magnesium (Mg)			102		%		95-108	15-OCT-04
Potassium (K)			101		%		91-103	15-OCT-04
Sodium (Na)			100		%		92-105	15-OCT-04
Sulfate (SO4)			95		%		91-104	15-OCT-04
WG236345-15	DUP	L215354-10						
Calcium (Ca)		140	139		mg/L	1.1	15	15-OCT-04
Magnesium (Mg)		40.4	39.9		mg/L	1.3	7.8	15-OCT-04
Potassium (K)		4.6	4.6		mg/L	0.17	12	15-OCT-04
Sodium (Na)		33	33		mg/L	0.66	7.8	15-OCT-04
Sulfate (SO4)		44.3	43.3		mg/L	2.4	7.8	15-OCT-04
WG236345-1	MB							
Calcium (Ca)			<0.5		mg/L		2.5	15-OCT-04
Magnesium (Mg)			<0.1		mg/L		0.5	15-OCT-04
Potassium (K)			<0.1		mg/L		0.5	15-OCT-04
Sodium (Na)			<1		mg/L		5	15-OCT-04
Sulfate (SO4)			<0.5		mg/L		2.5	15-OCT-04
WG236345-16	MS	L215354-10						
Calcium (Ca)			94		%		87-112	15-OCT-04
Magnesium (Mg)			93		%		88-111	15-OCT-04
Potassium (K)			97		%		92-111	15-OCT-04
Sodium (Na)			98		%		86-111	15-OCT-04

Workorder: L215354

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed	
ETL-ROUTINE-ICP-ED		Water							
Batch	R228354								
WG236345-16	MS	L215354-10	95		%		85-112	15-OCT-04	
Sulfate (SO4)									
F-ED		Water							
Batch	R228412								
WG235771-5	DUP	L215619-16	0.13	0.13	J	mg/L	0.00	0.15	14-OCT-04
Fluoride (F)									
WG235771-3	LCS		106		%		93-107	13-OCT-04	
Fluoride (F)									
Batch	R228478								
WG236391-3	LCS		104		%		93-107	15-OCT-04	
Fluoride (F)									
FCC-MF-RAW-ED		Water							
Batch	R229089								
WG237190-12	DUP	L216766-2							
WG237190-5	DUP	L215354-9	<1	<1	RPD-NA	CFU/100mL	N/A	30	18-OCT-04
MF - Fecal Coliforms									
WG237190-9	DUP	L216515-1	<1	<1	RPD-NA	CFU/100mL	N/A	30	18-OCT-04
MF - Fecal Coliforms									
WG237190-1	MB		<1			CFU/100mL		1	18-OCT-04
MF - Fecal Coliforms									
WG237190-10	MB		<1			CFU/100mL		1	18-OCT-04
MF - Fecal Coliforms									
WG237190-13	MB		<1			CFU/100mL		1	18-OCT-04
MF - Fecal Coliforms									
WG237190-7	MB		<1			CFU/100mL		1	18-OCT-04
MF - Fecal Coliforms									
FE-DIS-HIGH-ED		Water							
Batch	R228160								
WG235833-1	MB		<0.06		mg/L		0.3	14-OCT-04	
Iron (Fe)-Dissolved									
Batch	R229296								
WG237134-1	MB		<0.06		mg/L		0.3	18-OCT-04	
Iron (Fe)-Dissolved									
WG237134-11	MS	L216639-12	98		%		92-108	18-OCT-04	
Iron (Fe)-Dissolved									
WG237134-9	MS	L216639-2	96		%		92-108	18-OCT-04	
Iron (Fe)-Dissolved									
MN-DIS-HIGH-ED		Water							

Enviro-Test Quality Control Report

Workorder: L215354

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
<u>MN-DIS-HIGH-ED</u>		<u>Water</u>						
Batch	R228160							
WG235833-1	MB							
Manganese(Mn)-Dissolved			<0.01		mg/L		0.05	14-OCT-04
Batch	R229296							
WG237134-1	MB							
Manganese(Mn)-Dissolved			<0.01		mg/L		0.05	18-OCT-04
WG237134-11	MS	L216639-12	96		%		94-106	18-OCT-04
Manganese(Mn)-Dissolved								
WG237134-9	MS	L216639-2	94		%		94-106	18-OCT-04
Manganese(Mn)-Dissolved								
<u>N-TOTKJ-LOW-ED</u>		<u>Water</u>						
Batch	R228503							
WG236009-2	LCS							
Total Kjeldahl Nitrogen			91		%		79-107	15-OCT-04
WG236009-1	MB							
Total Kjeldahl Nitrogen			<0.05		mg/L		0.05	15-OCT-04
Batch	R229138							
WG236602-2	LCS							
Total Kjeldahl Nitrogen			104		%		79-107	18-OCT-04
WG236602-1	MB							
Total Kjeldahl Nitrogen			<0.05		mg/L		0.05	18-OCT-04
WG236602-4	MS	L215918-1	104		%		64-119	18-OCT-04
Total Kjeldahl Nitrogen								
<u>N2N3-ED</u>		<u>Water</u>						
Batch	R229092							
WG236919-2	LCS							
Nitrate+Nitrite-N			97		%		88-105	16-OCT-04
WG236919-1	MB							
Nitrate+Nitrite-N			<0.1		mg/L		0.1	16-OCT-04
WG236919-11	MS	L216104-3	104		%		90-108	16-OCT-04
Nitrate+Nitrite-N								
WG236919-13	MS	L216358-1	97		%		90-108	16-OCT-04
Nitrate+Nitrite-N								
WG236919-15	MS	L216746-11	97		%		90-108	16-OCT-04
Nitrate+Nitrite-N								
WG236919-3	MS	L215354-4	101		%		90-108	16-OCT-04
Nitrate+Nitrite-N								
WG236919-5	MS	L215619-1	94		%		90-108	16-OCT-04
Nitrate+Nitrite-N								
WG236919-7	MS	L215619-9	97		%		90-108	16-OCT-04
Nitrate+Nitrite-N								
WG236919-9	MS	L215828-8						

Enviro-Test Quality Control Report

Workorder: L215354

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
N2N3-ED		Water						
Batch	R229092							
WG236919-9	MS	L215828-8	99		%		90-108	16-OCT-04
Nitrate+Nitrite-N								
WG236919-10	MSD	WG236919-9	102		%	2.5	5	16-OCT-04
Nitrate+Nitrite-N		99						
WG236919-12	MSD	WG236919-11	104		%	0.11	5	16-OCT-04
Nitrate+Nitrite-N		104						
WG236919-14	MSD	WG236919-13	96		%	1.8	5	16-OCT-04
Nitrate+Nitrite-N		97						
WG236919-16	MSD	WG236919-15	97		%	0.45	5	16-OCT-04
Nitrate+Nitrite-N		97						
WG236919-4	MSD	WG236919-3	95	H	%	5.5	5	16-OCT-04
Nitrate+Nitrite-N		101						
WG236919-6	MSD	WG236919-5	93		%	1.3	5	16-OCT-04
Nitrate+Nitrite-N		94						
WG236919-8	MSD	WG236919-7	94		%	3.9	5	16-OCT-04
Nitrate+Nitrite-N		97						
NH4-LOW-ED		Water						
Batch	R228649							
WG236312-4	DUP	L215354-6	0.099		mg/L	1.6	7.7	15-OCT-04
Ammonia-N		0.098						
WG236312-6	DUP	L216457-6	<0.005	RPD-NA	mg/L	N/A	7.7	15-OCT-04
Ammonia-N		<0.005						
WG236312-2	LCS		102		%		79-111	15-OCT-04
Ammonia-N								
WG236312-1	MB		<0.005		mg/L		0.005	15-OCT-04
Ammonia-N								
WG236312-5	MS	L215918-6	127		%		70-143	15-OCT-04
Ammonia-N								
NO2-ED		Water						
Batch	R227965							
WG235852-12	DUP	L215883-2	<0.05	RPD-NA	mg/L	N/A	5	14-OCT-04
Nitrite-N		<0.05						
WG235852-17	DUP	L215187-15	<0.05	RPD-NA	mg/L	N/A	5	14-OCT-04
Nitrite-N		<0.05						
WG235852-20	DUP	L215469-2	<0.05	RPD-NA	mg/L	N/A	5	14-OCT-04
Nitrite-N		<0.05						
WG235852-10	LCS		95		%		92-105	14-OCT-04
Nitrite-N								
WG235852-9	MB		<0.05		mg/L		0.05	14-OCT-04
Nitrite-N								
WG235852-18	MS	L215187-1	105		%		90-106	14-OCT-04
Nitrite-N								

Workorder: L215354

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
NO2-ED		Water						
Batch	R227965							
WG235852-19	MS	L215263-2						
Nitrite-N			101		%		90-106	14-OCT-04
Batch		R229075						
WG236921-17	DUP	L215597-19						
Nitrite-N		<0.05	<0.05	RPD-NA	mg/L	N/A	5	17-OCT-04
WG236921-18	DUP	L216104-3						
Nitrite-N		<0.05	<0.05	RPD-NA	mg/L	N/A	5	17-OCT-04
WG236921-19	DUP	L216746-8						
Nitrite-N		<0.05	<0.05	RPD-NA	mg/L	N/A	5	17-OCT-04
WG236921-20	DUP	L215943-6						
Nitrite-N		<0.05	<0.05	RPD-NA	mg/L	N/A	5	17-OCT-04
WG236921-2	LCS							
Nitrite-N			97		%		93-107	17-OCT-04
WG236921-1	MB							
Nitrite-N			<0.05		mg/L		0.05	17-OCT-04
WG236921-21	MS	L215943-6						
Nitrite-N			106	H	%		90-106	17-OCT-04
WG236921-22	MS	L215597-19						
Nitrite-N			105		%		90-106	17-OCT-04
WG236921-23	MS	L216104-3						
Nitrite-N			105		%		90-106	17-OCT-04
WG236921-24	MS	L216746-8						
Nitrite-N			106	H	%		90-106	17-OCT-04
P-TOTAL-LOW-ED		Water						
Batch	R229583							
WG237551-5	DUP	L215354-8						
Phosphorus, Total		0.784	0.767		mg/L	2.2	7.5	19-OCT-04
WG237551-2	LCS							
Phosphorus, Total			98		%		91-112	19-OCT-04
WG237551-1	MB							
Phosphorus, Total			0.001		mg/L		0.001	19-OCT-04
WG237551-4	MS	L215354-4						
Phosphorus, Total			93		%		83-116	19-OCT-04
P-TOTALDIS-LOW-ED		Water						
Batch	R229583							
WG237551-2	LCS							
Phosphorus, Total Dissolved			98		%		91-112	19-OCT-04
WG237551-1	MB							
Phosphorus, Total Dissolved			0.001		mg/L		0.001	19-OCT-04
PH/EC/ALK-ED		Water						

Workorder: L215354

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
PH/EC/ALK-ED		Water						
Batch R228412								
WG235771-4	DUP	L215263-6						
Alkalinity, Total (as CaCO3)		39	38	J	mg/L	0	15	13-OCT-04
Bicarbonate (HCO3)		47	47	J	mg/L	1	15	13-OCT-04
Carbonate (CO3)		<5	<5	RPD-NA	mg/L	N/A	20	13-OCT-04
Conductivity (EC)		2230	2200		uS/cm	1.4	5.5	13-OCT-04
Hydroxide (OH)		<5	<5	RPD-NA	mg/L	N/A	20	13-OCT-04
pH		6.8	6.8	J	pH	0.0	0.1	13-OCT-04
WG235771-5	DUP	L215619-16						
Alkalinity, Total (as CaCO3)		130	128		mg/L	1.0	5	14-OCT-04
Bicarbonate (HCO3)		156	154		mg/L	1.1	20	14-OCT-04
Carbonate (CO3)		<5	<5	RPD-NA	mg/L	N/A	20	14-OCT-04
Conductivity (EC)		319	325		uS/cm	1.9	5.5	14-OCT-04
Hydroxide (OH)		<5	<5	RPD-NA	mg/L	N/A	20	14-OCT-04
pH		8.3	8.3	J	pH	0.0	0.1	14-OCT-04
WG235771-1	LCS							
Conductivity (EC)			100		%		96-104	13-OCT-04
WG235771-2	LCS							
pH			7.0		pH		6.9-7.1	13-OCT-04
WG235771-3	LCS							
Alkalinity, Total (as CaCO3)			99		%		93-107	13-OCT-04
Batch R228478								
WG236391-4	DUP	L215597-19						
Alkalinity, Total (as CaCO3)		452	449		mg/L	0.62	5	15-OCT-04
Bicarbonate (HCO3)		552	548		mg/L	0.62	20	15-OCT-04
Carbonate (CO3)		<5	<5	RPD-NA	mg/L	N/A	20	15-OCT-04
Conductivity (EC)		935	941		uS/cm	0.64	5.5	15-OCT-04
Hydroxide (OH)		<5	<5	RPD-NA	mg/L	N/A	20	15-OCT-04
pH		7.9	7.9	J	pH	0.0	0.1	15-OCT-04
WG236391-5	DUP	L215828-15						
Alkalinity, Total (as CaCO3)		<5	<5	RPD-NA	mg/L	N/A	5	15-OCT-04
Bicarbonate (HCO3)		<5	<5	RPD-NA	mg/L	N/A	20	15-OCT-04
Carbonate (CO3)		<5	<5	RPD-NA	mg/L	N/A	20	15-OCT-04
Conductivity (EC)		1.4	1.3	J	uS/cm	0.0	7.7	15-OCT-04
Hydroxide (OH)		<5	<5	RPD-NA	mg/L	N/A	20	15-OCT-04
pH		5.8	5.7	J	pH	0.1	0.1	15-OCT-04
WG236391-1	LCS							
Conductivity (EC)			103		%		96-104	15-OCT-04
WG236391-2	LCS							
pH			7.0		pH		6.9-7.1	15-OCT-04
WG236391-3	LCS							

Enviro-Test Quality Control Report

Workorder: L215354

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
PH/EC/ALK-ED		Water						
Batch	R228478							
WG236391-3	LCS							
Alkalinity, Total (as CaCO3)			99		%		93-107	15-OCT-04
SIO2-CALC-ED		Water						
Batch	R227541							
WG235449-3	CRM							
Silica (as SiO2)			103		%		93-110	13-OCT-04
WG235449-1	MB							
Silica (as SiO2)			<0.1		mg/L		0.5	13-OCT-04
Batch	R228354							
WG236345-3	CRM							
Silica (as SiO2)			106		%		93-110	15-OCT-04
WG236345-15	DUP	L215354-10						
Silica (as SiO2)		11.5	10.9		mg/L	2.9	13	15-OCT-04
WG236345-1	MB							
Silica (as SiO2)			<0.1		mg/L		0.5	15-OCT-04
Batch	R229208							
WG237197-3	CRM							
Silica (as SiO2)			102		%		93-110	18-OCT-04
WG237197-1	MB							
Silica (as SiO2)			<0.1		mg/L		0.5	18-OCT-04
WG237197-16	MS	L215354-10						
Silica (as SiO2)			95		%		93-109	18-OCT-04
SOLIDS-TDS-ED		Water						
Batch	R229420							
WG237366-3	DUP	L215717-2						
Total Dissolved Solids		230	230		mg/L	0.0	8.7	18-OCT-04
WG237366-2	LCS							
Total Dissolved Solids			105		%		96-112	18-OCT-04
WG237366-1	MB							
Total Dissolved Solids			<10		mg/L		10	18-OCT-04
Batch	R229835							
WG237895-3	DUP	L215354-10						
Total Dissolved Solids		640	650		mg/L	1.2	8.7	19-OCT-04
WG237895-4	DUP	L216240-1						
Total Dissolved Solids		210	220		mg/L	4.7	8.7	19-OCT-04
WG237895-2	LCS							
Total Dissolved Solids			99		%		96-112	19-OCT-04
WG237895-1	MB							
Total Dissolved Solids			<10		mg/L		10	19-OCT-04

Enviro-Test Quality Control Report

Workorder: L215354

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
Product - Batch and Sample Number Relations:								
C-DIS-ORG-CL	1							
R229380		L215354-1	L215354-2	L215354-3				
C-DIS-ORG-CL	1							
R230927		L215354-4	L215354-5	L215354-6	L215354-7	L215354-8		
		L215354-9	L215354-10					
CL-ED	1							
R227965		L215354-1	L215354-2	L215354-3				
CL-ED	1							
R229601		L215354-4	L215354-5	L215354-6	L215354-7	L215354-8		
		L215354-9	L215354-10					
ECC-MF-RAW-ED	1							
R229089		L215354-1	L215354-2	L215354-3	L215354-5	L215354-6		
		L215354-7	L215354-8	L215354-9	L215354-10			
ETL-ROUTINE-ICP-ED	1							
R227541		L215354-1	L215354-2	L215354-3				
ETL-ROUTINE-ICP-ED	1							
R228354		L215354-4	L215354-5	L215354-6	L215354-7	L215354-8		
		L215354-9	L215354-10					
F-ED	1							
R228412		L215354-1	L215354-2	L215354-3				
F-ED	1							
R228478		L215354-4	L215354-5	L215354-6	L215354-7	L215354-8		
		L215354-9	L215354-10					
FCC-MF-RAW-ED	1							
R229089		L215354-1	L215354-2	L215354-3	L215354-4	L215354-5		
		L215354-6	L215354-7	L215354-8	L215354-9	L215354-10		
FE-DIS-HIGH-ED	1							
R228160		L215354-1	L215354-2	L215354-3				
FE-DIS-HIGH-ED	1							
R229296		L215354-4	L215354-5	L215354-6	L215354-7	L215354-8		
		L215354-9	L215354-10					
MN-DIS-HIGH-ED	1							
R228160		L215354-1	L215354-2	L215354-3				
MN-DIS-HIGH-ED	1							
R229296		L215354-4	L215354-5	L215354-6	L215354-7	L215354-8		
		L215354-9	L215354-10					
N-TOTKJ-LOW-ED	1							
R228503		L215354-1	L215354-2	L215354-3				
N-TOTKJ-LOW-ED	1							
R229138		L215354-4	L215354-5	L215354-6	L215354-7	L215354-8		
		L215354-9	L215354-10					
N2N3-ED	1							
R229092		L215354-1	L215354-2	L215354-3	L215354-4	L215354-5		
		L215354-6	L215354-7	L215354-8	L215354-9	L215354-10		

Enviro-Test Quality Control Report

Workorder: L215354

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
Product - Batch and Sample Number Relations:								
NH4-LOW-ED	1							
R228649		L215354-1	L215354-2	L215354-3		L215354-4	L215354-5	
		L215354-6	L215354-7	L215354-8		L215354-9	L215354-10	
NO2-ED	1							
R227965		L215354-1	L215354-2	L215354-3				
NO2-ED	1							
R229075		L215354-4	L215354-5	L215354-6		L215354-7	L215354-8	
		L215354-9	L215354-10					
NO3-ED	1							
R227965		L215354-1	L215354-2	L215354-3				
NO3-ED	1							
R229092		L215354-4	L215354-5	L215354-6		L215354-7	L215354-8	
		L215354-9	L215354-10					
P-TOTAL-LOW-ED	1							
R229583		L215354-1	L215354-2	L215354-3		L215354-4	L215354-5	
		L215354-6	L215354-7	L215354-8		L215354-9	L215354-10	
P-TOTALDIS-LOW-ED	1							
R229583		L215354-1	L215354-2	L215354-3		L215354-4	L215354-5	
		L215354-6	L215354-7	L215354-8		L215354-9	L215354-10	
PH/EC/ALK-ED	1							
R228412		L215354-1	L215354-2	L215354-3				
PH/EC/ALK-ED	1							
R228478		L215354-4	L215354-5	L215354-6		L215354-7	L215354-8	
		L215354-9	L215354-10					
SIO2-CALC-ED	1							
R227541		L215354-1	L215354-2	L215354-3				
SIO2-CALC-ED	1							
R228354		L215354-4	L215354-5	L215354-6		L215354-7	L215354-8	
		L215354-9						
SIO2-CALC-ED	1							
R229208		L215354-10						
SOLIDS-TDS-ED	1							
R229420		L215354-1	L215354-2	L215354-3				
SOLIDS-TDS-ED	1							
R229835		L215354-4	L215354-5	L215354-7		L215354-8	L215354-9	
		L215354-10						

Workorder # L215354

Legend:

Limit 95% Confidence Interval (Laboratory Warning Limits)
DUP Duplicate
RPD Relative Percent Difference
N/A Not Available
LCS Laboratory Control Sample
SRM Standard Reference Materials
MS Matrix Spike
MSD Matrix Spike Duplicate
ADE Average Desorption Efficiency
MB Method Blank
IRM Internal Reference Material
CRM Certified Reference Material
CCV Continuing Calibration Verification
CVS Calibration Verification Standard
LCSD Laboratory Control Sample Duplicate

Qualifier:

RPD-NA Relative Percent Difference Not Available due to result(s) being less than detection limit.
A Method blank exceeds acceptance limit. Blank correction not applied, unless the qualifier "RAMB" (result adjusted for method blank) appears in the Analytical Report.
B Method blank result exceeds acceptance limit, however, it is less than 5% of sample concentration. Blank correction not applied.
E Matrix spike recovery may fall outside the acceptance limits due to high sample background.
F Silver recovery low, likely due to elevated chloride levels in sample.
G Outlier - No assignable cause for nonconformity has been determined.
H Result falls within the 99% Confidence Interval (Laboratory Control Limits)
J Duplicate results and limit(s) are expressed in terms of absolute difference.
K The sample referenced above is of a non-standard matrix type; standard QC acceptance criteria may not be achievable.

Attachments B-2

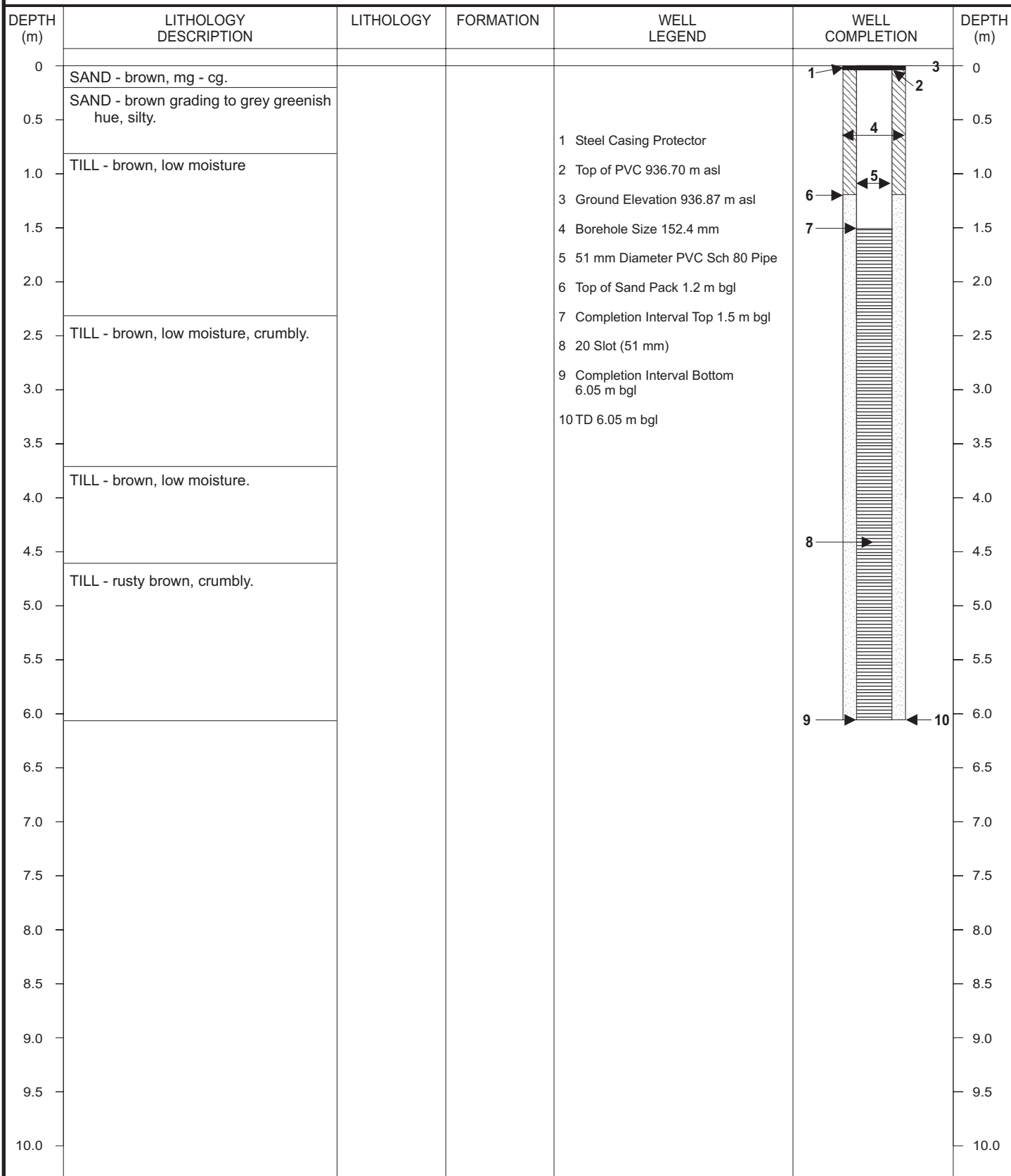
Well Completion Diagram

PROJECT NUMBER 04.075

WELL NUMBER S1

PROJECT: Sylvan Lake
 DRILLING CONTRACTOR: Mobile Augers & Research Ltd.
 DRILLING METHOD: Auger
 NORTHING: 5807604 EASTING: 691305

LOCATION: 12-26-39-2 W5M
 GROUND ELEVATION: 936.87 m asl
 TOC ELEVATION: 936.70 m asl
 WATER LEVEL: 936.28 m asl
 WELL COMPLETION DATE: October 7, 2004
 October 21, 2004





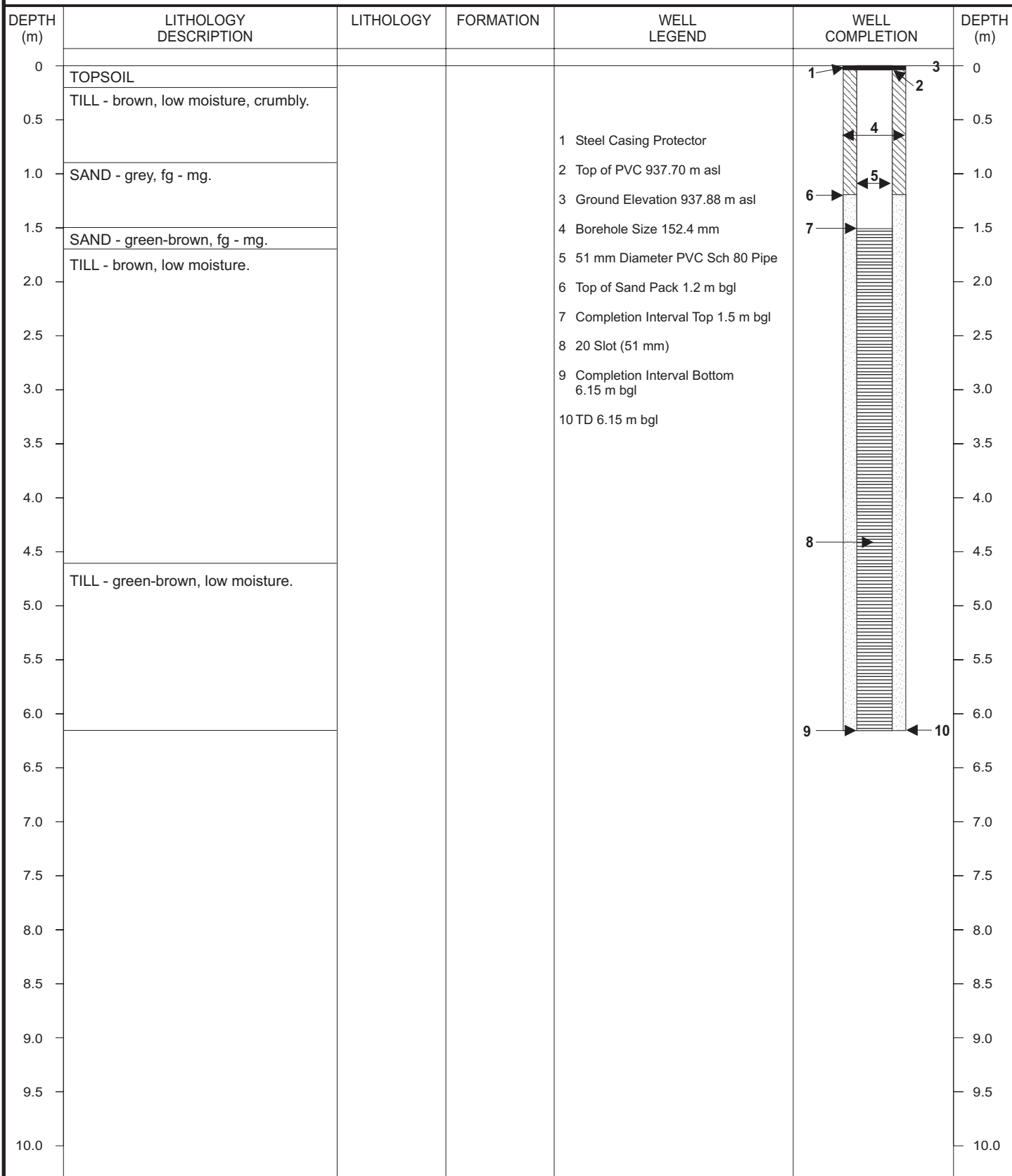
Well Completion Diagram

PROJECT NUMBER 04.075

WELL NUMBER S2

PROJECT: Sylvan Lake
 DRILLING CONTRACTOR: Mobile Augers & Research Ltd.
 DRILLING METHOD: Auger
 NORTHING: 5807659 EASTING: 691153

LOCATION: 12-26-39-2 W5M
 GROUND ELEVATION: 937.88 m asl
 TOC ELEVATION: 937.70 m asl
 WATER LEVEL: 936.37 m asl
 October 21, 2004
 WELL COMPLETION DATE: October 7, 2004





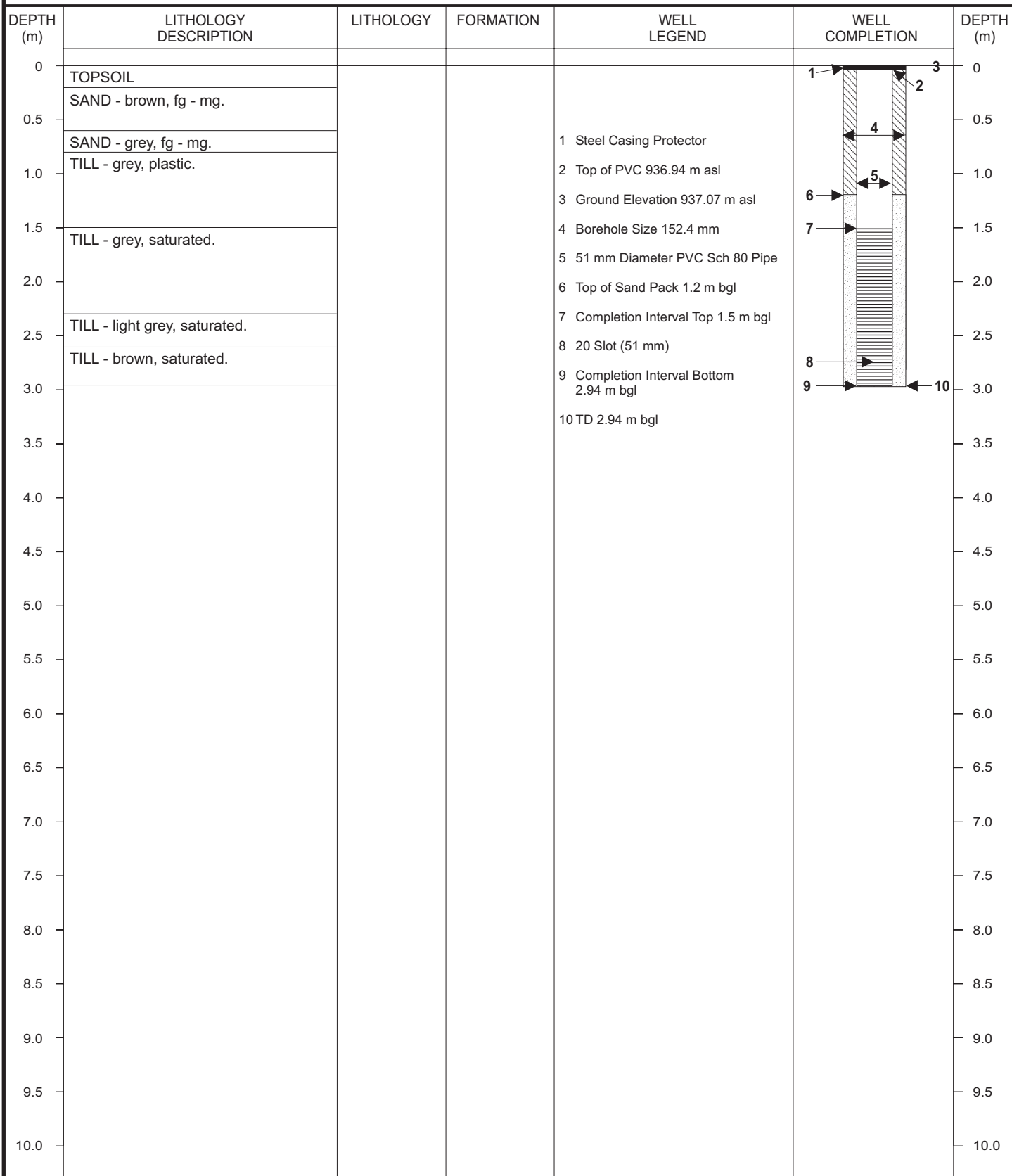
Well Completion Diagram

PROJECT NUMBER 04.075

WELL NUMBER S3

PROJECT: Sylvan Lake
 DRILLING CONTRACTOR: Mobile Augers & Research Ltd.
 DRILLING METHOD: Auger
 NORTHING: 5807761 EASTING: 690836

LOCATION: 9-27-39-2 W5M
 GROUND ELEVATION: 937.07 m asl
 TOC ELEVATION: 936.94 m asl
 WATER LEVEL: 936.24 m asl
 October 21, 2004
 WELL COMPLETION DATE: October 6, 2004





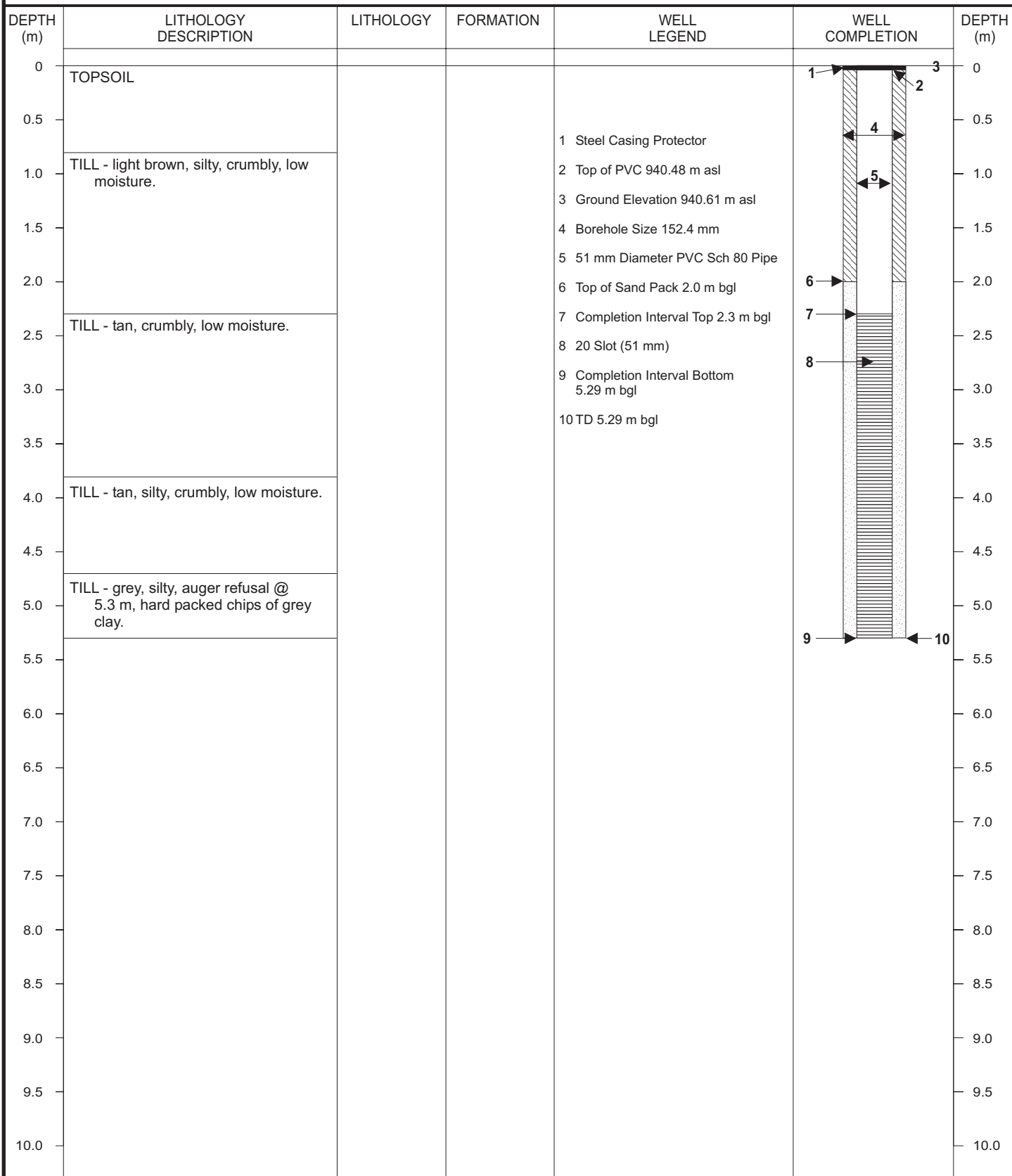
Well Completion Diagram

PROJECT NUMBER 04.075

WELL NUMBER N1

PROJECT: Sylvan Lake
 DRILLING CONTRACTOR: Mobile Augers & Research Ltd.
 DRILLING METHOD: Auger
 NORTHING: 5800415 EASTING: 696790

LOCATION: 3-5-39-1 W5M
 GROUND ELEVATION: 940.61 m asl
 TOC ELEVATION: 940.48 m asl
 WATER LEVEL: 936.29 m asl
 October 21, 2004
 WELL COMPLETION DATE: October 6, 2004





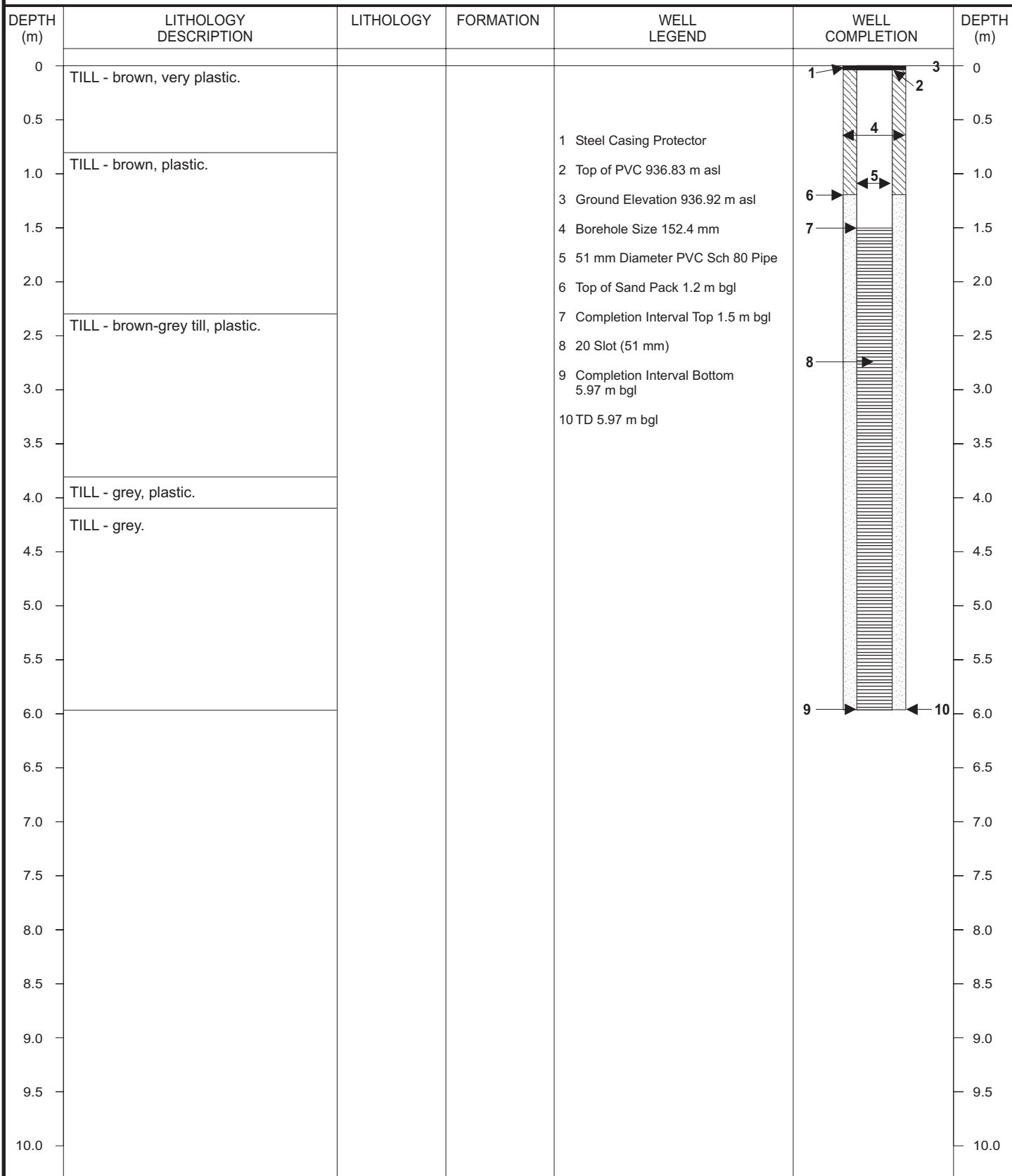
Well Completion Diagram

PROJECT NUMBER 04.075

WELL NUMBER N2

PROJECT: Sylvan Lake
 DRILLING CONTRACTOR: Mobile Augers & Research Ltd.
 DRILLING METHOD: Auger
 NORTHING: 5801643 EASTING: 694519

LOCATION: 16-1-39-2 W5M
 GROUND ELEVATION: 936.92 m asl
 TOC ELEVATION: 936.83 m asl
 WATER LEVEL: 936.68 m asl
 October 21, 2004
 WELL COMPLETION DATE: October 6, 2004





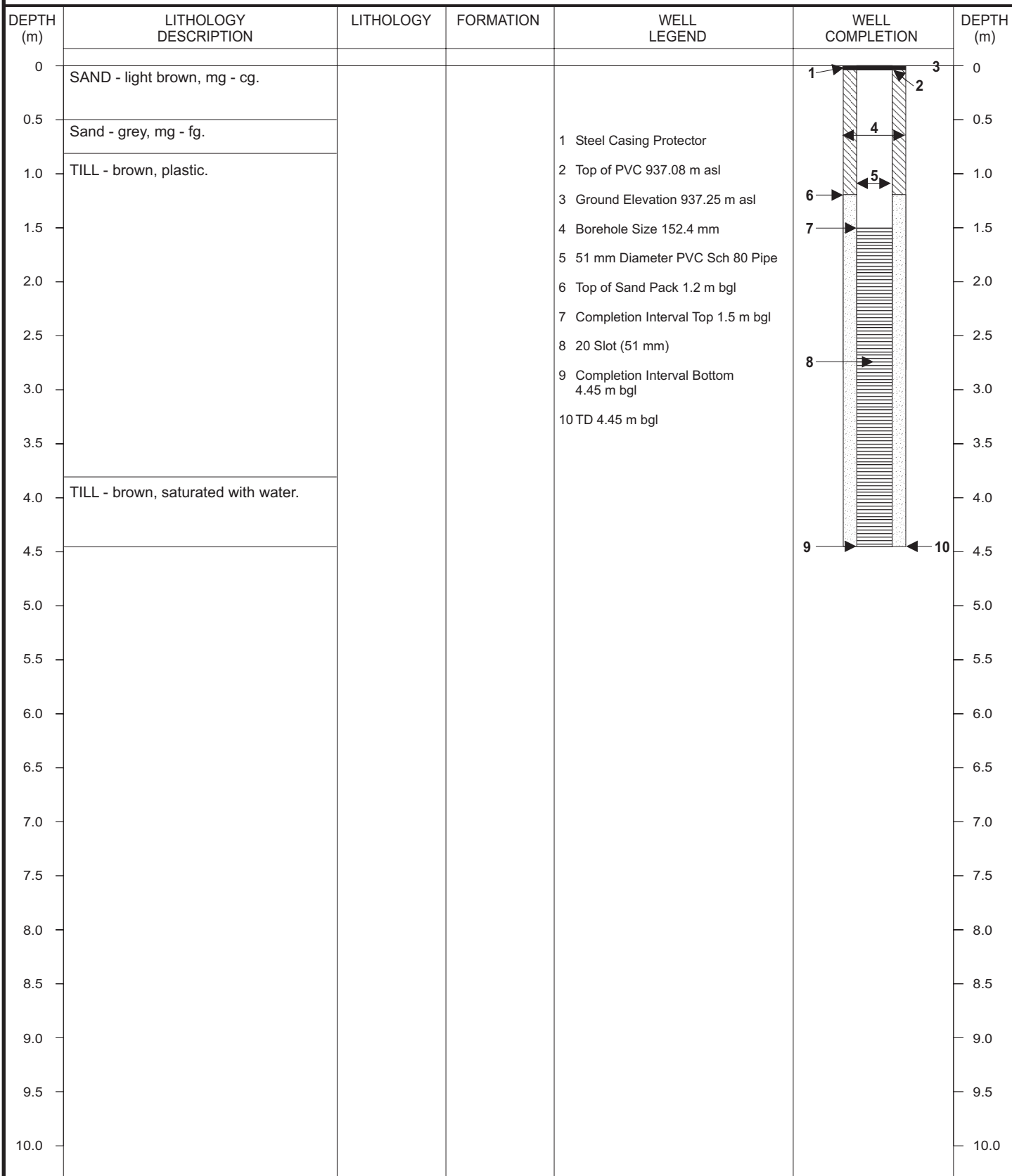
Well Completion Diagram

PROJECT NUMBER 04.075

WELL NUMBER H1

PROJECT: Sylvan Lake
 DRILLING CONTRACTOR: Mobile Augers & Research Ltd.
 DRILLING METHOD: Auger
 NORTHING: 5803160 EASTING: 692819

LOCATION: 16-11-39-2 W5M
 GROUND ELEVATION: 937.25 m asl
 TOC ELEVATION: 937.08 m asl
 WATER LEVEL: 936.40 m asl
 WELL COMPLETION DATE: October 6, 2004
 October 21, 2004





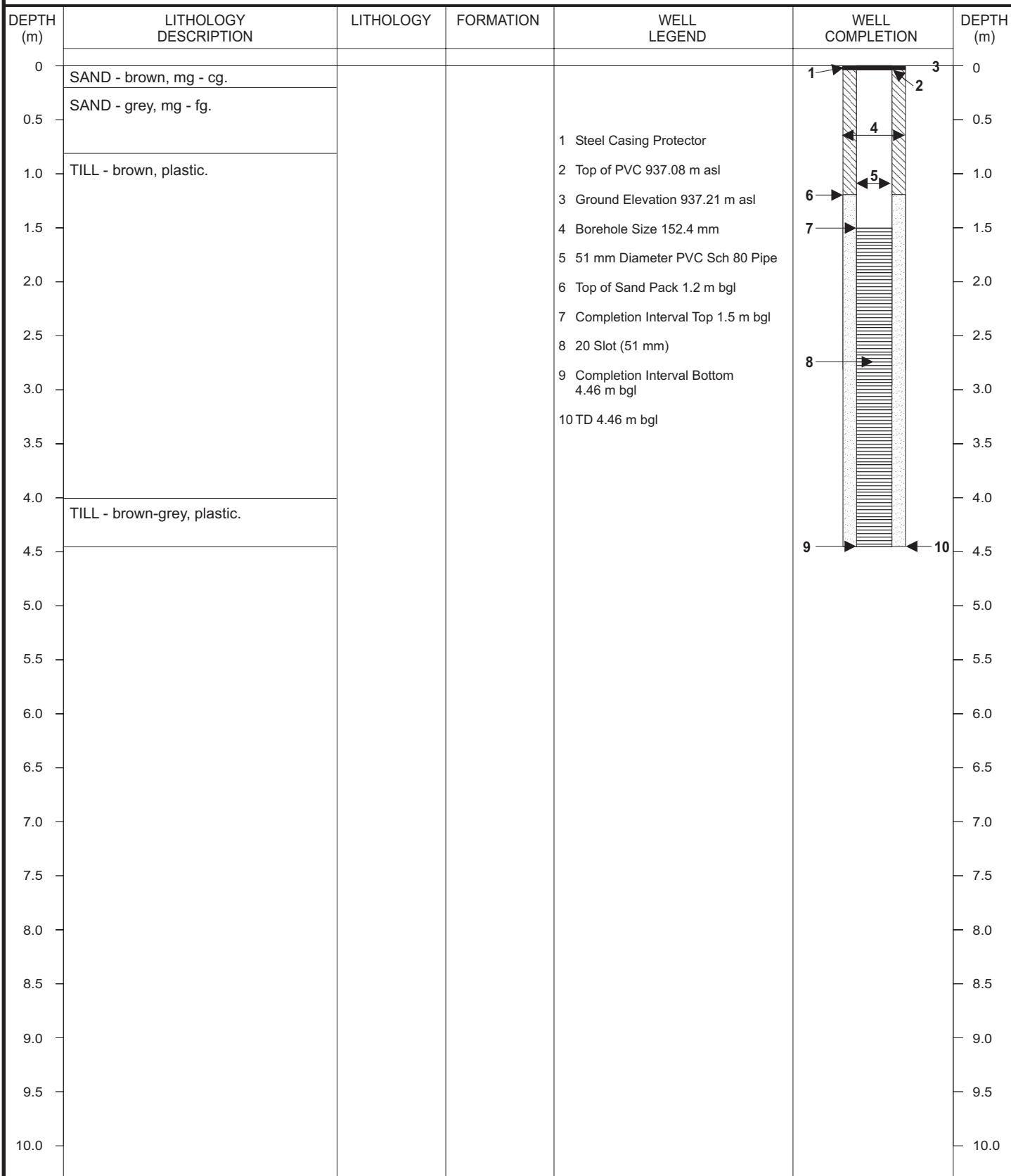
Well Completion Diagram

PROJECT NUMBER 04.075

WELL NUMBER H2

PROJECT: Sylvan Lake
 DRILLING CONTRACTOR: Mobile Augers & Research Ltd.
 DRILLING METHOD: Auger
 NORTHING: 5803191 EASTING: 692538

LOCATION: 16-11-39-2 W5M
 GROUND ELEVATION: 937.21 m asl
 TOC ELEVATION: 937.08 m asl
 WATER LEVEL: 933.56 m asl
 October 21, 2004
 WELL COMPLETION DATE: October 6, 2004





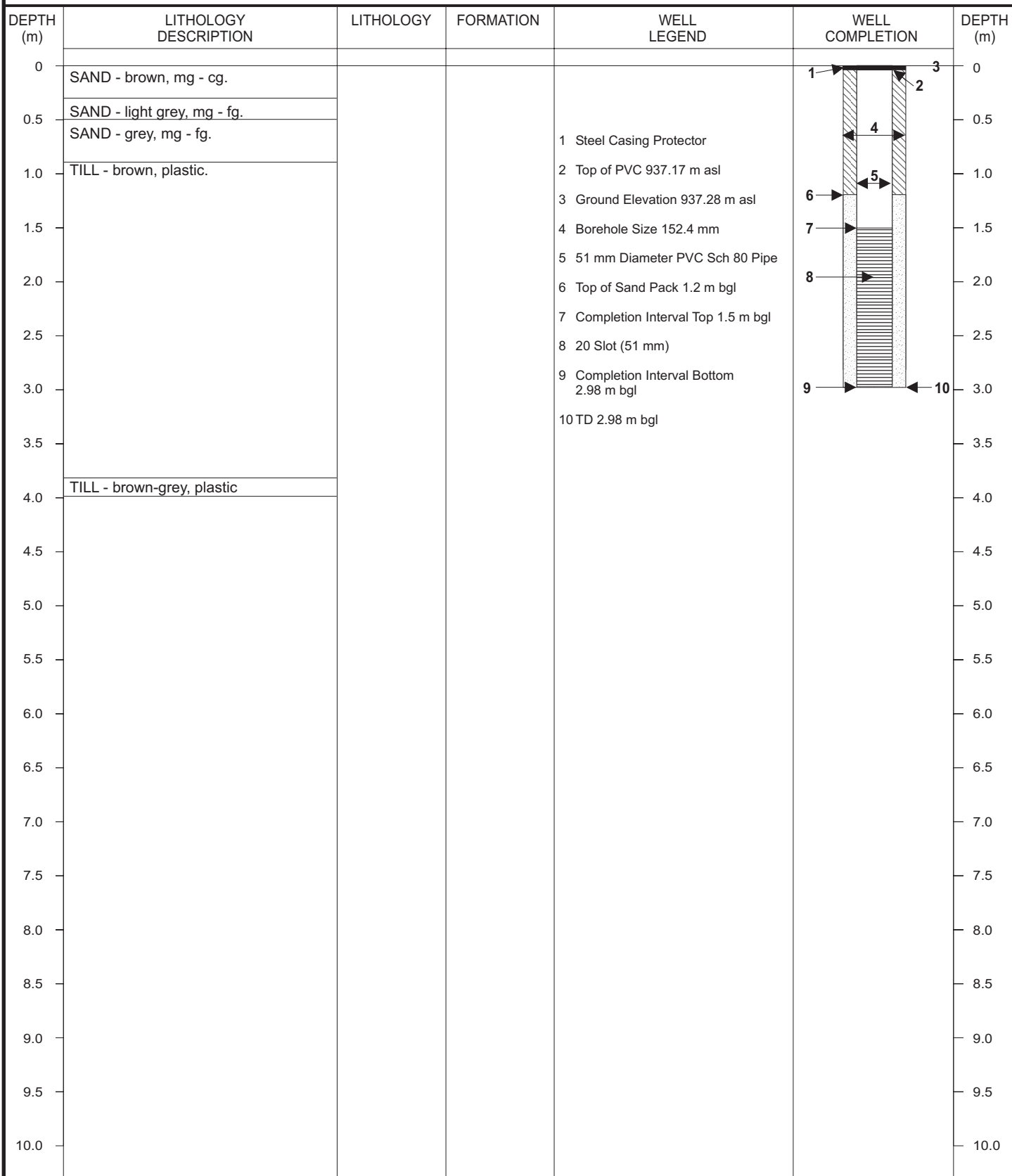
Well Completion Diagram

PROJECT NUMBER 04.075

WELL NUMBER H3

PROJECT: Sylvan Lake
 DRILLING CONTRACTOR: Mobile Augers & Research Ltd.
 DRILLING METHOD: Auger
 NORTHING: 5803226 EASTING: 692480

LOCATION: 16-11-39-2 W5M
 GROUND ELEVATION: 937.28 m asl
 TOC ELEVATION: 937.17 m asl
 WATER LEVEL: 934.65 m asl
 WELL COMPLETION DATE: October 6, 2004
 October 21, 2004



**Appendix C. Bathymetry, water quality, sediment chemistry, and phytoplankton in
Sylvan Lake: September, 2004.**

Sylvan Lake 2004 Sampling Methods:

Bathymetry

A detailed bathymetric survey of Sylvan Lake was conducted on September 04 and September 23 to 24, 2004. The bathymetric survey was performed using differential global positioning system (DGPS) technology, involving the continual collection of positional and depth data. The survey made use of the following boat mounted equipment:

- a Trimble TSC1 data logger with Asset Surveyor™ Version 5.20 software;
- a Trimble GPS Pathfinder® Pro XR Integrated GPS/Beacon/Satellite Differential Receiver; and
- a Meridata MD100 digital depth sounder.

Based on previous bathymetry data (Mitchell and Prepas 1990), most of Sylvan Lake's basin complexity is near shore; therefore, more survey effort was focused on this area. Depth data were acquired continuously in a zigzag pattern in the nearshore areas, encompassing the transitions from shallow to deep depths (<2 to >5 m). Sylvan Lake also had extensive nearshore areas that were less than 1 m deep, which limits the depth sounder interpretation ability. Therefore, to validate contouring software interpretation of these areas, manual depth measurements were entered into the data logger along transects from a depth of 1 m to the shoreline. This was completed at 13 locations around the lake. Offshore depth data were acquired along 21 transects across the lake spaced less than 900 m apart.

Trimble's Pro XR series GPS receiver provides a horizontal accuracy of 0.5 m after post-processing. This is dependent on the reference station location, which degrades accuracy by 0.1 m for every 100 km distance it is away from the roving unit. The reference station used in post-processing was situated in Calgary, approximately 150 km away, which resulted in all positions having a horizontal precision of less than 1 m. The precision of all depth measurements was 0.1 m.

Post-processing of the GPS data was completed with Pathfinder Office Version 3.00 software and exported with the depth data to Microsoft®Excel. The depth data were then plotted against the distance between sounder measurements to determine the validity of each depth measurement. Detected false echo depths were removed from the database.

Sylvan Lake's surface elevation was interpreted from a staff gauge installed in the marina and maintained by AENV. Readings were noted at the time of the survey and used to standardize water depth measurements to lake surface elevation in meters above sea level (m ASL). The elevation adjustment from the staff gauge reference of 936.380 m ASL was +0.110 m.

A new shoreline was digitized from the Orthophoto mosaic and CAD datasets provided by Red Deer County and Lacombe County (via AXYS Consultants). The shoreline from the CAD file was edited to more closely match the interpreted shoreline of the 2002 Orthophoto. Historical Sylvan Lake surface elevation data were used to assign a mean annual lake elevation to the newly created shoreline. The mean annual lake elevation for 2002 was 936.550 m ASL. The new shoreline was used as a breakline in the creation of bathymetric surface.

A digital bathymetric surface model was created using Surfer® (Version 8), a contouring and 3D surface mapping program. To generate the bathymetric contours, an elliptical kriging interpolation model was used. The final production of the bathymetric map was completed in CorelDRAW® Version 12.

Sylvan Lake Bathymetric Model

Two bathymetric models were derived from the sonar data collected by North/South Consultants Inc. (North/South). The primary bathymetric model used sonar data collected by North/South in addition to a vector shoreline provided by the client. The primary model should be considered to be a more accurate depiction of Sylvan Lake bathymetry. A second bathymetric model was interpolated using the sonar data collected by North/South and the elevation data surrounding Sylvan Lake. The second of the two models was required to generate volumes and areas for historical water balance equations.

The shoreline for the primary model was taken from an existing CAD dataset provided to North/South. It was edited to more closely match the high resolution 2002 orthophoto provided. A mean lake level of 936.5 m ASL for 2002 was derived from historical lake level data and assigned to the shoreline. The vector shoreline has an area of 42.41 km² and a distance of 36.36 km. The vector shoreline area tends to be more true to the actual area of the lake. The modelled area of the lake at 936.5 m ASL is 42.36 km².

Volumes and surface areas were required for lake elevations outside the model's threshold of 936.5 m ASL (2002 mean lake level). It was decided that another model would be built that would encompass surrounding Shuttle Radar Telemetry Mission or SRTM 90 meter resolution digital elevation model data. A global data set of 90 m medium resolution digital elevation exists and is available from NASA online. The data was deemed to be the most complete and readily available data. A new shoreline at 937.0 m ASL was derived and used to build a second bathymetric model. This new shoreline is only as accurate as the lower resolution DEM data. The model allowed estimations of surface areas and lake volumes outside of the original model's threshold. This model will generate slightly differing surface areas and volumes than the primary bathymetric model. For example, the surface area of the lake at 936.5 m ASL for this model is 41.75 km².

Water and Sediment Quality

Water Quality Sites

A water and sediment quality sampling program was conducted in September 2004 to provide further information on the current conditions with respect to nutrients in Sylvan Lake. The main objective of this program was to examine the nutrient status of the lake and to evaluate potential effects of shoreline developments and sources of nutrients on water quality.

The water quality sampling program consisted of collection of samples of surface water from offshore areas and seven nearshore areas. Four offshore sites were evaluated to characterize the deeper water zone, as indicated in Figure A-1. Data were collected along depth profiles at three of the sites and from a composite sample collected from the euphotic zone. One site (SLA) was located at the deepest area of the lake (approximately 18 m), where historical depth profiles have been measured. Two additional sites were evaluated across depth: (1) one at a depth of 16 m (SLB); and the second at a depth of approximately 14 m (SLC). The fourth site was a composite of 10 sub-samples collected throughout the offshore zone from the euphotic zone (SLD). The latter site was consistent with the methodologies used by AENV in their monitoring program of Sylvan Lake.

Water quality was also evaluated at seven nearshore areas adjacent to the following shoreline areas:

- Town of Sylvan Lake (TSL);
- Halfmoon Bay (HB);
- Sylvan Lake natural area (SLNA);
- Birchcliff (BC);
- Jarvis Bay (JB);
- Sunbreaker Cove (SBC); and
- Norglenwold (NORG).

Two tributary streams were discharging at the time of the water quality sampling program. Samples of surface water were collected from Golf Course Creek and North West Creek for analysis, and discharge was measured to facilitate computation of loads.

Water quality variables examined in the study included nutrients (phosphorus and nitrogen), dissolved oxygen (DO), pH, conductivity, temperature, major ions and bacteria. The composite sample collected from the deepwater area of Sylvan Lake was also analysed for phytoplankton species composition and biomass.

Sediment Quality Sites

Surficial sediments (top 5 cm) were also collected from two of the deepwater water quality sites (SLB and SLC) and at four of the nearshore areas (SLNA, TSL, HB and BC). A sediment core was collected from a site at approximately 8 m depth and was sectioned in five depth strata for chemical analysis. Attempts to collect an intact core from deeper areas of the lake were not successful. Variables measured in sediments included total phosphorus and nitrogen, inorganic and organic carbon, phosphorus sorption capacity and supporting variables (particle size and moisture content).

Methods

Water Quality

Nearshore sites

In situ variables were measured at the surface, mid-depth and near the bottom for sites in excess of 1 m. *In situ* measurements consisted of water temperature, DO, pH, oxygen reduction potential, specific conductance, and salinity measured with a YSI 556 Multimeter. This meter was field calibrated daily for all parameters. Turbidity readings were measured with a portable Analite NEP-160 turbidity meter. All sample site locations were recorded with a Garmin hand held GPS unit. At each water quality site, a hand dipped grab sample was taken at an approximate depth of 30 cm. The sample bottles (provided by the analytical laboratory) were each rinsed three times on-site with lake water and capped. The sample bottle was then uncapped, filled and recapped by hand underwater. During the entire sampling procedure, field personnel wore unpowdered polyethylene shoulder length gloves to prevent contamination from handling. Samples were preserved according to laboratory specifications, packed on ice in a cooler, and shipped to the laboratory via Greyhound Courier within 24 hours of collection.

Offshore Sites

In situ measurements were measured at 1 m depth intervals at the offshore sites. A Secchi depth measurement was taken at each site and locations were recorded with a Garmin hand held GPS unit. Discrete-depth water samples were collected at 2 m depth intervals using a 4.2 L Beta™ bottle sampler. Water sample bottles provided by the analytical laboratory were rinsed three times and filled directly from the Beta bottle. During the entire sampling procedure field personnel wore unpowdered polyethylene gloves to prevent contamination due to handling. Samples were preserved according to laboratory specifications, packed on ice in a cooler, and shipped to the laboratory via Greyhound Courier within 24 hours of collection.

Deep-water Composite Site

A composite sample of the photic zone (defined as twice the Secchi disk depth) was collected using a sampling tube (provided by AENV and conducted according to their protocol) from 10 sites ranging in depth from 13 to 17 m. *In situ* measurements were taken at the surface of each site and locations were recorded with a Garmin hand held GPS unit.

Sediments

Sediment sampling sites are indicated in Figure A-2. The following is a description of sampling methodologies.

Surficial Sediments

A composite sample of five grabs of sediment was collected with an Ekman dredge (6" x 6" or 0.023 m² opening) for each sediment sampling site in the nearshore areas and two offshore sites (SLB and SLC). A sub-sample of the top 5 cm was removed from each grab sample, placed in a clean polyethylene bucket, homogenized, and containers provided by the analytical laboratory were filled. In addition, a sub-sample of each composite sample was archived for potential future analysis and submitted to AENV. Each site was located with a Garmin hand held GPS unit to be consistent with water quality sample locations. Samples were packed on ice in a cooler and shipped to the laboratory via Greyhound Courier within 24 hours of collection.

Sediment Core

A Wildco 2" diameter corer fitted with a cellulose acetate butyrate (CAB) liner was used to obtain sediment cores. To obtain adequate amounts of sediment for laboratory analysis, coring was repeated four times. Each core was photographed, measured (total length and lengths of any distinct strata), and each core was sectioned into five intervals for chemical analysis. Intervals were 0-5 cm, 5-10 cm, 10-15 cm, 15-20 cm, and 20-30 cm. Samples corresponding to the discrete intervals were homogenized in a large Ziploc bag, packed on ice in a cooler, and shipped to the laboratory via Greyhound Courier within 24 hours of collection.

Phytoplankton

One sample of surface water was collected from the offshore composite water sample (SLD) for identification and enumeration of phytoplankton taxa. A sample bottle provided by the analytical laboratory was filled, the sample was preserved with Lugol's solution, packed on ice in a cooler, and shipped to the laboratory via Greyhound Courier within 24 hours of collection.

Analytical Methodologies

All laboratory analyses were conducted by Enviro-Test Laboratories, with the exception of chlorophyll *a* which was analysed by AENV.

Quality Assurance/Quality Control

Water Quality

Water quality analysis was performed by Enviro-Test Laboratories (ETL) in Edmonton under their quality assurance/quality control (QA/QC) protocols. Other QA/QC procedures for water quality sampling included a field blank and equipment blank to check that sampling and transport procedures did not introduce contamination. The field blank was prepared by filling a full suite of sampling containers with de-ionized water (supplied by ETL) following the same sampling protocol followed for collection of Sylvan Lake water samples (i.e., containers were rinsed three times with de-ionized water). For the equipment blank, the Beta bottle sampler was rinsed three times with de-ionized water, filled with more de-ionized water, and emptied into a suite of water sample containers. The field, trip, and equipment blanks were sent to the laboratory in the same manner as lake samples for analysis. Four triplicate water quality samples were also taken (at TSL-1, NA-1, BC-1, and HB-4) to ensure within site QA/QC. During sampling the field crew also wore powder-free latex gloves.

Sediments

Sediment quality analysis was performed ETL in Edmonton under their QA/QC protocols. To minimize potential contamination during sample collection, the dredge, bucket, and mixing utensil were cleaned with phosphate-free soap prior to the field trip and rinsed five times with lake water at each sampling site. Between sampling sites, any residual sediment was scrubbed off and the rinsing routine was repeated. During sampling the field crew also wore powder-free latex gloves.

RESULTS

Detailed results of the water and sediment quality monitoring and phytoplankton community composition are provided in Tables A-1 to A-8. *In situ* water quality monitoring results for the nearshore, deep water sampling sites, and tributary streams are provided in Tables A-1 to A-3, respectively. Results of laboratory water quality analyses for the nearshore, deep water sites, and tributary streams are presented in Tables A-4 and A-6, respectively. Results of the sediment quality monitoring for the nearshore and deep water sites are presented in Table A-7. Results of the phytoplankton species composition and biomass analysis are presented in Table A-8.

References

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Tables

and

Figures

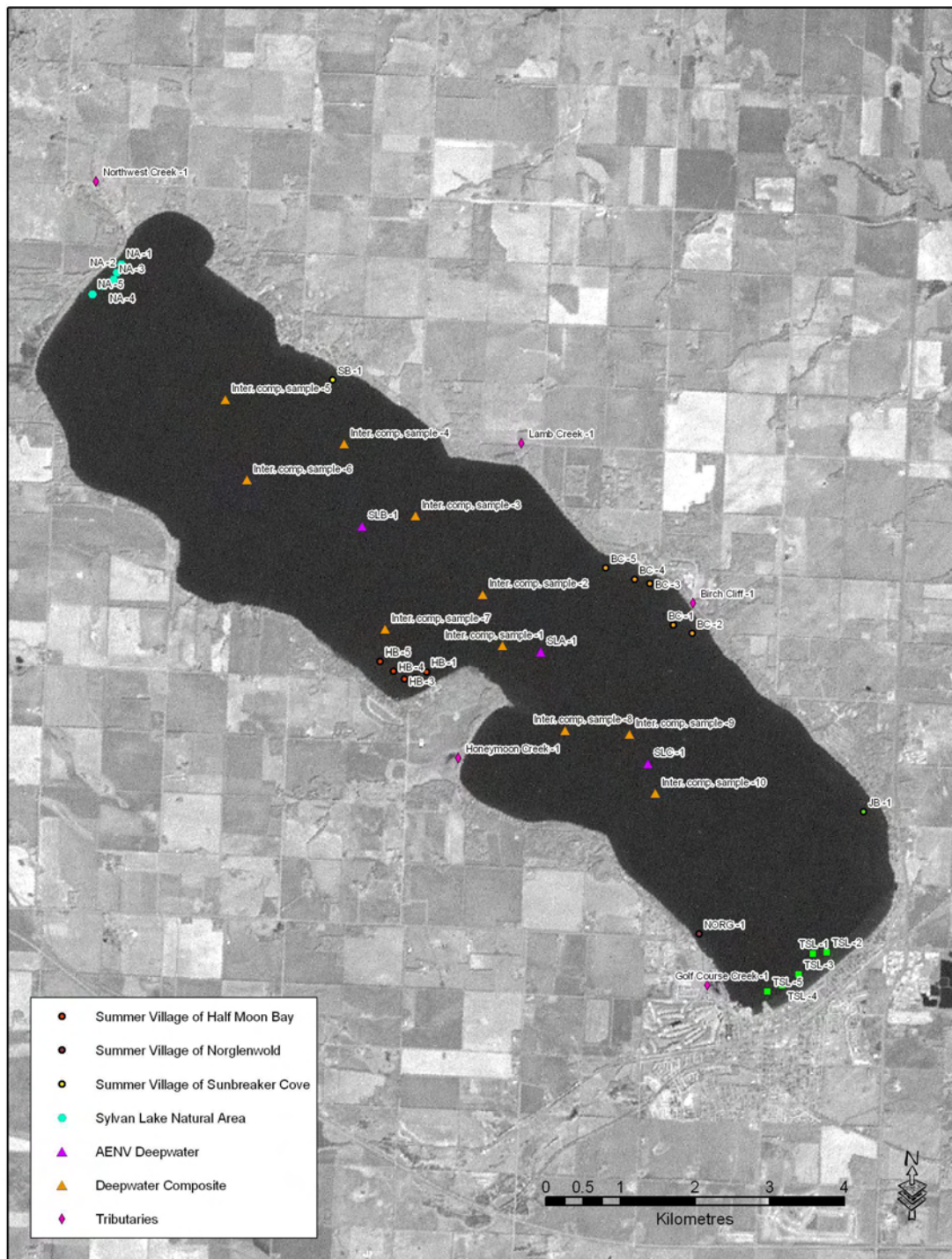


Figure C-1. Locations of water quality sampling sites, September 2004.



Figure C-2. Locations of sediment quality sampling sites, September 2004.

Table C-1 In Situ Water Quality Data Collected from Nearshore Areas of Sylvan Lake in September 2004

Site Area	Site ID	Site #	Location UTM 11U	Date	Time	Total Depth (m)	Secchi Disk Depth (m)	Z ₁ ¹ (m ⁻¹)	K _e ¹ (m ⁻¹)	Total Depth (m)	Temperature (°C)	Conductivity (mS/cm)	Total Dissolved Solids (g/L)	Salinity (PPT)	Dissolved oxygen		pH	Oxidation Reduction Potential (mV)
															(mg/L)	(% Saturation)		
Town of Sylvan Lake	TSL	1	698466 5800393	9/5/2004	11:15	2.9	1.55	5.1	0.84	Surface	15.38	0.598	0.389	0.29	10.51	105.1	9.93	78.7
	TSL	1								1.5	15.39	0.598	0.389	0.29	10.48	104.5	9.96	73.0
	TSL	1								2.75	15.38	0.598	0.389	0.29	10.48	105.0	9.93	82.3
	TSL	2	698650 5800430	9/5/2004	12:30	1.1	1.1	3.6	1.18	Surface	15.05	0.597	0.388	0.29	10.86	108.2	9.88	106.2
	TSL	2								0.75	15.06	0.597	0.388	0.29	10.80	107.4	9.89	101.5
	TSL	3	698299 5800102	9/5/2004	12:50	2.1	1.5	5.0	0.87	Surface	15.29	0.598	0.389	0.29	10.77	107.8	9.99	79.0
	TSL	3								1	15.28	0.598	0.389	0.29	10.83	108.2	10.04	70.8
	TSL	3								1.9	15.28	0.598	0.389	0.29	10.81	107.8	10.07	66.5
	TSL	4	698089 5799932	9/5/2004	13:05	2.6	2.5	8.3	0.52	Surface	15.68	0.599	0.389	0.29	10.55	106.5	10.00	75.1
	TSL	4								1.3	15.68	0.599	0.389	0.29	10.42	105.3	10.05	72.1
	TSL	4								2.4	15.68	0.599	0.389	0.29	10.41	104.9	10.07	68.4
	TSL	5	697898 5799840	9/5/2004	13:25	2.3	2.3	7.6	0.57	Surface	15.83	0.600	0.390	0.29	10.49	106.1	10.04	92.5
	TSL	5								1.1	15.83	0.600	0.390	0.29	10.47	106.0	10.04	88.5
	TSL	5								2.1	15.83	0.600	0.390	0.29	10.45	106.0	10.03	95.3
Summer Village of Norglenwold	NORG	1	696923 5800530	9/5/2004	14:18	1.4	1.4	4.6	0.93	Surface	16.20	0.601	0.391	0.29	10.63	108.3	10.06	76.7
	NORG	1								0.7	16.19	0.601	0.391	0.29	10.59	108.2	10.08	73.2
	NORG	1								1.2	16.20	0.601	0.391	0.29	10.57	107.6	10.07	72.6
Summer Village of Half Moon Bay	HB	1	692988 5803726	9/5/2004	14:50	2.1	2.1	6.9	0.62	Surface	16.28	0.598	0.388	0.29	10.59	108.4	10.07	71.7
	HB	1								1	16.39	0.597	0.388	0.29	10.65	109.1	10.13	70.4
	HB	1								2	16.39	0.598	0.388	0.29	10.57	108.1	10.14	69.3
	HB	2	692849 5803635	9/5/2004	15:09	2.45	2.45	8.1	0.53	Surface	16.32	0.602	0.391	0.29	10.92	111.7	10.11	75.1
	HB	2								1.2	16.36	0.602	0.391	0.29	10.84	111.0	10.15	67.9
	HB	2								2.25	16.35	0.601	0.391	0.29	10.91	111.5	10.16	65.6
	HB	3	692701 5803605	9/5/2004	15:42	1.4	1.4	4.6	0.93	Surface	16.25	0.602	0.391	0.29	10.85	110.6	10.10	83.1
	HB	3									16.29	0.601	0.391	0.29	10.88	111.0	10.14	79.0
	HB	4	692548 5803701	9/5/2004	15:55	1.5	1.5	5.0	0.87	Surface	16.47	0.600	0.390	0.29	10.97	112.8	10.17	77.5
	HB	4								1.3	16.46	0.600	0.390	0.29	10.93	112.1	10.19	75.0
	HB	5	692360 5803812	9/5/2004	16:25	1.6	1.6	5.3	0.81	Surface	16.48	0.602	0.391	0.29	10.94	112.0	10.12	98.5
	HB	5								1	16.48	0.601	0.391	0.29	10.83	111.0	10.18	94.5
	HB	5								1.4	16.48	0.601	0.391	0.29	10.86	111.5	10.18	96.4
Sylvan Lake Natural Area	NA	1	688456 5808827	9/5/2004	17:00	1.8	1.8	5.9	0.72	Surface	16.70	0.600	0.390	0.29	10.52	108.4	10.20	94.2
	NA	1								1	16.70	0.600	0.390	0.29	10.72	110.4	10.22	88.1
	NA	1								1.6	16.70	0.600	0.390	0.29	10.52	107.9	10.24	85.2
	NA	2	688406 5808708	9/5/2004	17:30	2.5	2.25	7.4	0.58	Surface	16.57	0.599	0.389	0.29	10.83	111.2	10.20	75.3
	NA	2								1.25	16.59	0.599	0.389	0.29	10.41	107.2	10.21	79.3
	NA	2								2.3	16.59	0.599	0.389	0.29	10.92	112.5	10.22	78.3
	NA	3	688370 5808614	9/5/2004	17:45	2.99	2.15	7.1	0.60	Surface	16.41	0.596	0.388	0.29	11.64	119.1	10.24	81.5
	NA	3								1.5	16.23	0.596	0.387	0.29	11.84	121.8	10.27	78.9
	NA	3								2.75	16.23	0.596	0.387	0.29	12.19	124.5	10.27	78.8
	NA	4	688250 5808518	9/5/2004	18:00	2.75	2.5	8.3	0.52	Surface	16.48	0.600	0.390	0.29	10.92	112.1	10.23	77.9

Table C-1 In Situ Water Quality Data Collected from Nearshore Areas of Sylvan Lake in September 2004 (cont'd)

Site Area	Site ID	Site #	Location UTM 11U	Date	Time	Total Depth (m)	Secchi Disk Depth (m)	Z ₁ ¹ (m ⁻¹)	K _e ¹ (m ⁻¹)	Total Depth (m)	Temperature (°C)	Conductivity (mS/cm)	Total Dissolved Solids (g/L)	Salinity (PPT)	Dissolved oxygen		pH	Oxidation Reduction Potential (mV)
															(mg/L)	(% Saturation)		
	NA	4								1.3	16.50	0.600	0.390	0.29	10.66	109.8	10.23	79.5
	NA	4								2.5	16.38	0.598	0.389	0.29	10.90	112.0	10.25	77.9
	NA	5	688107 5808392	9/5/2004	18:15	2.25	2.25	7.4	0.58	Surface	16.39	0.599	0.389	0.29	11.06	113.2	10.01	75.6
	NA	5								1.1	16.46	0.600	0.390	0.29	10.01	108.6	10.22	82.6
	NA	5								2.1	16.45	0.599	0.389	0.29	11.02	112.7	10.22	83.6
Summer Village of Sunbreaker Cove	SBC	1	691412 5807514	9/5/2004	16:35	2.75	2.35	7.8	0.55	Surface	16.51	0.601	0.391	0.29	10.51	107.6	10.21	95.8
	SBC	1								1.3	16.53	0.601	0.391	0.29	10.48	107.5	10.21	91.0
	SBC	1								2.6	16.51	0.601	0.391	0.29	10.46	107.1	10.23	86.1
Summer Village of Jarvis Bay	JB	1	698987 5802343	9/6/2004	9:00	1.8	1.8	5.9	0.72	Surface	14.94	0.598	0.389	0.29	8.76	86.6	9.02	204.8
	JB	1								0.9	13.89	0.601	0.391	0.29	8.82	86.3	9.03	207.3
	JB	1								1.6	13.28	0.598	0.389	0.29	8.96	85.7	9.03	207.6
Summer Village of Birchcliff	BC	1	696238 5804620	9/6/2004	9:55	2.8	2.8	9.2	0.46	Surface	15.65	0.599	0.389	0.29	8.69	87.4	8.99	208.6
	BC	1								1.4	15.66	0.598	0.389	0.29	8.66	87.2	8.99	211.6
	BC	1								2.6	15.52	0.598	0.389	0.29	8.76	88.0	8.99	212.8
	BC	2	696497 5804529	9/6/2004	10:30	2.9	2.9	9.6	0.45	Surface	15.86	0.599	0.389	0.29	8.73	88.2	8.99	208.3
	BC	2								1.4	15.75	0.599	0.390	0.29	8.47	85.6	8.96	209.7
	BC	2								2.7	14.02	0.598	0.389	0.29	9.22	91.4	9.01	210.2
	BC	3	695880 5805147	9/6/2004	10:50	2	2	6.6	0.65	Surface	15.92	0.599	0.389	0.29	8.61	87.1	8.99	207.4
	BC	3								1	15.85	0.599	0.389	0.29	8.67	87.9	8.99	210.9
	BC	3								1.8	15.71	0.598	0.389	0.29	9.07	92.0	9.00	213.6
	BC	4	695669 5805185	9/6/2004	11:07	1.9	1.9	6.3	0.68	Surface	16.01	0.597	0.388	0.29	8.66	87.9	9.98	219.5
	BC	4								0.9	15.96	0.597	0.388	0.29	8.69	87.7	8.97	220.5
	BC	4								1.8	15.86	0.598	0.389	0.29	8.78	88.7	8.84	220.6
	BC	5	695271 5805306	9/6/2004	11:21	1.6	1.6	5.3	0.81	Surface	16.06	0.599	0.389	0.29	8.77	89.3	8.98	222.4
	BC	5								1.4	15.88	0.598	0.389	0.29	8.90	90.1	8.99	222.1

Notes: 1 Z1 and Ke calculated using Kalff (2002) equation for turbid (>5 NTU) systems.
 Ke = 1.3/secchi depth
 z₁ = secchi depth x 3.3

Table C-2 In Situ Water Quality Data Collected from Deep Water Sites in Sylvan Lake in September 2004

Site Area	Site ID	Location UTM 11U	Date	Time	Total Depth (m)	Secchi Disk Depth (m)	Z ₁ ¹ (m ⁻¹)	K _e ¹ (m ⁻¹)	Sampling depth (m)	Temperature (°C)	Conductivity (mS/cm)	Total Dissolved Solids (g/L)	Salinity (PPT)	Dissolved oxygen		pH	Oxidation Reduction Potential (mV)
														(mg/L)	(% Saturation)		
AENV Monitoring Site	SLA	694493 5804113	9/6/2004	11:46	18.7	3.9	12.9	0.33	Surface	16.18	0.599	0.390	0.29	8.64	87.9	8.98	219.7
	SLA								1	16.23	0.599	0.390	0.29	8.55	87.1	8.97	219.3
	SLA								2	16.11	0.599	0.390	0.29	8.64	88.0	8.97	219.0
	SLA								3	16.04	0.599	0.390	0.29	8.65	88.0	8.97	218.5
	SLA								4	16.01	0.599	0.389	0.29	8.67	88.0	8.97	219.0
	SLA								5	15.97	0.599	0.389	0.29	8.72	88.4	8.97	219.0
	SLA								6	15.94	0.599	0.389	0.29	8.58	86.9	8.96	219.2
	SLA								7	15.93	0.599	0.389	0.29	8.44	85.5	8.96	218.6
	SLA								8	15.91	0.599	0.389	0.29	8.47	85.7	8.96	218.2
	SLA								9	15.91	0.599	0.389	0.29	8.48	86.0	8.95	218.0
	SLA								10	15.89	0.599	0.389	0.29	8.49	86.0	8.95	216.9
	SLA								11	15.88	0.599	0.389	0.29	8.32	84.3	8.94	216.2
	SLA								12	15.87	0.599	0.389	0.29	8.32	84.4	8.94	215.3
	SLA								13	15.86	0.599	0.389	0.29	8.30	84.4	8.94	213.3
	SLA								14	15.84	0.599	0.389	0.29	8.22	83.2	8.93	212.0
	SLA								15	15.82	0.600	0.390	0.29	8.20	82.7	8.92	210.8
	SLA								16	15.78	0.599	0.390	0.29	8.10	81.7	8.91	206.8
	SLA								17	15.73	0.600	0.390	0.29	8.04	81.5	8.91	203.3
	SLA								18	15.72	0.600	0.390	0.29	8.09	81.7	8.90	198.5
Sylvan Lake 16 m contour	SLB	691967 5805594	9/6/2004	13:10	16	3.45	11.4	0.38	Surface	16.83	0.597	0.388	0.29	8.57	88.7	8.94	202.9
	SLB								1	16.69	0.597	0.388	0.29	8.60	88.4	8.94	202.6
	SLB								2	16.40	0.597	0.388	0.29	8.60	88.0	8.94	202.5
	SLB								3	16.25	0.597	0.388	0.29	8.77	89.3	8.94	202.4
	SLB								4	16.20	0.597	0.388	0.29	8.74	88.9	8.94	202.1
	SLB								5	16.14	0.597	0.388	0.29	8.73	88.8	8.94	201.7
	SLB								6	16.10	0.597	0.388	0.29	8.94	88.1	8.94	201.2
	SLB								7	16.08	0.598	0.389	0.29	8.50	86.3	8.93	200.4
	SLB								8	16.06	0.598	0.389	0.29	8.50	86.3	8.93	200.6
	SLB								9	16.05	0.598	0.389	0.29	8.45	86.1	8.93	200.7
	SLB								10	16.03	0.598	0.389	0.29	8.48	86.3	8.94	199.9
	SLB								11	15.98	0.598	0.389	0.29	8.53	86.4	8.92	198.4
	SLB								12	15.97	0.598	0.389	0.29	8.58	87.2	8.91	198.4
	SLB								13	15.97	0.598	0.389	0.29	8.59	87.1	8.93	198.2
	SLB								14	15.94	0.599	0.389	0.29	8.54	86.4	8.92	198.1
	SLB								15	15.94	0.599	0.389	0.29	8.50	86.0	8.91	198.3
	SLB								15.4	15.94	0.599	0.389	0.29	8.41	85.2	8.91	197.7
Sylvan Lake 14 m countour	SLC	696053 5802748	9/6/2004	15:45	14.3	2.45	8.1	0.53	Surface	16.18	0.599	0.389	0.29	8.89	90.8	8.95	220.1
	SLC								1	16.16	0.599	0.389	0.29	8.79	89.5	8.95	219.3
	SLC								2	16.04	0.599	0.389	0.29	8.82	89.5	8.95	219.0
	SLC								3	15.88	0.598	0.389	0.29	8.90	90.1	8.96	218.0
	SLC								4	15.84	0.598	0.389	0.29	8.60	87.0	8.95	217.2
	SLC								5	15.83	0.598	0.389	0.29	8.61	86.9	8.95	218.2
	SLC								6	15.82	0.598	0.389	0.29	8.64	87.3	8.95	217.8

Table C-2 In Situ Water Quality Data Collected from Deep Water Sites in Sylvan Lake in September 2004 (cont’d)

Site Area	Site ID	Location UTM 11U	Date	Time	Total Depth (m)	Secchi Disk Depth (m)	Z ₁ ¹ (m ⁻¹)	K _e ¹ (m ⁻¹)	Sampling depth (m)	Temperature (°C)	Conductivity (mS/cm)	Total Dissolved Solids (g/L)	Salinity (PPT)	Dissolved oxygen		pH	Oxidation Reduction Potential (mV)
														(mg/L)	(% Saturation)		
	SLC								7	15.81	0.598	0.389	0.29	8.69	87.7	8.95	217.7
	SLC								8	15.80	0.599	0.389	0.29	8.59	86.7	8.95	217.1
	SLC								9	15.79	0.599	0.389	0.29	8.59	87.0	8.94	217.3
	SLC								10	15.78	0.599	0.389	0.29	8.71	88.1	8.95	217.1
	SLC								11	15.77	0.599	0.389	0.29	8.70	87.9	8.95	217.0
	SLC								12	15.71	0.599	0.389	0.29	8.68	87.6	8.93	217.2
	SLC								13	15.70	0.599	0.389	0.29	8.63	87.0	8.93	217.3
Deepwater Composite Sample	SLD	693978 5804150	9/6/2004	14:08	15.9	2.75	9.1	0.47	1	16.61	0.600	0.390	0.29	8.47	87.0	8.94	189.1
	SLD	693657 5804815		14:17	16.1	3	9.9	0.43	1	16.83	0.599	0.390	0.29	8.50	87.7	8.93	202.4
	SLD	692668 5805789		14:25	16.6	3.4	11.2	0.38	1	16.50	0.600	0.390	0.29	8.68	89.6	8.94	
	SLD	691635 5806671		14:31	14.7	3.4	11.2	0.38	1	16.54	0.599	0.389	0.29	8.63	88.5	8.94	219.8
	SLD	689999 5807132		14:38	13.6	3.4	11.2	0.38	1	16.60	0.600	0.390	0.29	8.60	88.4	8.93	220.9
	SLD	690380 5806802		14:44	14.7	3.25	10.7	0.40	1	16.73	0.600	0.390	0.29	8.70	89.5	8.94	217.2
	SLD	692389 5804243		14:51	15.4	3.25	10.7	0.40	1	16.71	0.600	0.390	0.29	8.56	88.0	8.93	209.3
	SLD	694909 5803098		15:15	14.2	3.4	11.2	0.38	1	16.41	0.599	0.390	0.29	8.78	89.9	8.94	208.3
	SLD	695770 5803120		15:21	14.8	3.15	10.4	0.41	1	16.27	0.599	0.390	0.29	8.86	90.2	8.93	222.5
	SLD	696185 5802359		15:26	14.3	2.75	9.1	0.47	1	16.17	0.599	0.389	0.29	8.88	90.4	8.94	219.8

Notes: 1 Z₁ and Ke calculated using Kalff (2002) equation for turbid (>5 NTU) systems.
 Ke = 1.3/secchi depth
 z₁ = secchi depth x 3.3

Table C-3 In Situ Water Quality And Hydrology Data Collected from Tributary Streams to Sylvan Lake in September 2004

Stream	Location UTM	Location sample taken	Date	Time	Wetted Width (m)	Mean Depth (m)	Total Cross Sectional Srea (calculated) (m ²)	Discharge (m ³ /s)	Mean Velocity (m/s)	Temperature (°C)	Conductivity (mS/cm)	Total Dissolved Solids (g/L)	Salinity (PPT)	Dissolved oxygen		pH	Oxidation Reduction Potential (mV)
														(mg/L)	(% Saturation)		
Golf Course Creek	11U 697093 5799860	WQ Samples D/S double culverts but flow is U/S of single culvert (main road in/out of town)	9/3/2004	8:00	3.60	0.44	1.58	0.009	0.006	12.85	0.0293	0.19	0.14	7.96	75.2	8.15	135.7
Northwest Creek	11U 688026 5809906	U/S of culvert	9/3/2004	9:30	0.53	0.04	0.02	0.002	0.13	10.3	0.636	0.415	0.31	10.19	91.2	7.76	228.7
Honeymoon Creek	11U 0693513 5802618	On Bridge	9/3/2004	-	-	-	-	no discharge	-	-	-	-	-	-	-	-	-
Lamb Creek	11U 694002 5806882	D/S of road south side of road	9/3/2004	-	-	-	-	no discharge	-	-	-	-	-	-	-	-	-
Birch Cliff	11U 696479 5804936	-	9/3/2004	-	-	-	-	no discharge	-	-	-	-	-	-	-	-	-
Town of Sylvan Lake Stormwater Outlet	11U 699584 5801580	-	9/3/2004	-	-	-	-	no discharge	-	-	-	-	-	-	-	-	-

Table C-4 Results of Laboratory Water Quality Analyses for Samples Collected from Nearshore Areas of Sylvan Lake in September 2004¹

Site Area	Location			Date	Time	Total Depth	Sample Depth	Nitrogen					Phosphorus		Molar Ratio ⁵		DOC	TSS	Major Ions										Ion Balance	TDS (Calc)	Cond	Hardness (as CaCO ₃)	pH	Alkalinity					Bacteriological Parameters		
	Site ID	Site #	Lat/Long or UTM 11U					Nitrate/Nitrite-N	Ammonia-N	TKN	DIN ²	Org. N ³	TN ⁴	DP	TP	DIN:DP			DIN:TP	Cl	F	Diss. Fe	Diss. Mn	Silica (as SiO ₂)	Ca	K	Mg	Na						SO ₄	Total (as CaCO ₃)	HCO ₃	CO ₃	OH	E. Coli (CFU/100 mL)	Fecal Coliforms (CFU/100 mL)	Chlorophyll a (µg/L)
						(m)	(m)	(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)	(µS/cm)	(mg/L)		(mg/L)	(mg/L)	(mg/L)	(mg/L)						
QC SAMPLES																																									
	SLF	Field blank	-	9/6/2004	-	-	-	<0.006	<0.005	0.07	-	-	-	<0.001	<0.001	-	-	<1	<1	<1	<0.05	<0.06	<0.01	<0.1	<0.5	<0.1	<0.1	<1	<0.5	Low TDS	<1	1.0	<1	5.7	<5	<5	<5	<5	<1	<1	-
		equip blank	-	9/6/2004	-	-	-	<0.006	<0.005	0.09	-	-	-	<0.001	<0.001	-	-	-	<1	1	<0.05	<0.06	<0.01	<0.1	<0.5	<0.1	<0.1	<1	<0.5	Low EC	1	1.2	<1	6.1	<5	<5	<5	<5	-	-	-
NEARSHORE SITES																																									
Summer Village of Jarvis Bay	JB	JB-1	698987 5802343	9/6/2004	9:00	1.8	-	<0.006	0.007	0.73	0.010	0.72	0.733	0.004	0.015	5.5	1.5	-	-	4	0.16	<0.06	<0.01	5.5	17.0	7.6	37.4	67	13.3	102	343	627	196	8.9	327	327	35	<5	<1	1	6.7
Summer Village of Birchcliff	BC	BC-1 rep. A	698987 5802343	9/6/2004	9:55	2.8	-	<0.006	0.008	0.7	0.011	0.69	0.703	0.004	0.016	6.1	1.5	6	3	4	0.16	<0.06	<0.01	5.6	17.1	7.7	37.6	68	13.2	102	344	628	198	8.9	327	327	36	<5	1	1	6.5
		BC-1 rep. B					-	<0.006	0.018	0.51	0.021	0.49	0.513	0.004	0.015	11.6	3.1	-	2	3	0.17	<0.06	<0.01	5.4	17.0	7.7	37.3	67	13.1	102	341	626	196	8.9	327	326	36	<5	<1	<1	7.0
		BC-1 rep. C					-	<0.006	0.007	0.61	0.010	0.60	0.613	0.007	0.016	3.2	1.4	-	2	3	0.16	<0.06	<0.01	5.5	17.0	7.8	37.5	68	13.1	103	343	626	197	8.9	327	327	35	<5	2	3	6.8
		BC-2	696497 5804529	9/6/2004	10:30	2.9	-	<0.006	0.006	0.71	0.009	0.70	0.713	0.004	0.015	5.0	1.3	-	-	3	0.17	<0.06	<0.01	5.5	17.1	7.7	37.6	68	13.5	103	343	627	198	8.9	327	327	35	<5	<1	<1	-
		BC-3	695880 5805147	9/6/2004	10:50	2	-	<0.006	0.005	0.66	0.008	0.66	0.663	0.004	0.016	4.4	1.1	-	-	4	0.17	<0.06	<0.01	5.7	17.6	8.1	38.8	70	13.9	105	349	628	204	8.9	327	329	35	<5	<1	2	-
		BC-4	695669 5805185	9/6/2004	11:07	1.9	-	<0.006	0.008	0.62	0.011	0.61	0.623	0.004	0.015	6.1	1.6	-	-	4	0.17	<0.06	<0.01	5.5	16.9	8.0	37.0	69	13.4	103	345	626	195	8.9	327	325	36	<5	-	-	6.1
		BC-5	695271 5805306	9/6/2004	11:21	1.6	-	<0.006	0.006	0.69	0.009	0.68	0.693	0.005	0.016	4.0	1.2	-	-	4	0.17	<0.06	<0.01	5.6	17.0	7.7	37.4	67	13.3	102	342	626	196	8.9	326	324	36	<5	-	-	7.0
Town of Sylvan Lake	TSL	TSL-1 rep. A	698466 5800393	9/5/2004	11:15	2.9	-	<0.006	0.011	0.56	0.014	0.55	0.563	0.003	0.013	10.3	2.4	6	2	4	0.13	<0.06	<0.01	5.4	17.0	7.9	38.8	69	14.2	100	355	612	202	8.9	340	344	35	<5	1	4	4.6
		TSL-1 rep. B					-	<0.006	0.008	0.59	0.011	0.58	0.593	<0.001	0.014	48.6	1.7	-	4	4	0.13	<0.06	<0.01	5.3	16.9	7.6	38.2	70	14.2	101	354	611	200	8.9	338	343	34	<5	-	-	5.1
		TSL-1 rep. C					-	<0.006	0.008	0.63	0.011	0.62	0.633	0.005	0.014	4.9	1.7	-	5	4	0.13	<0.06	<0.01	5.2	16.5	7.2	37.2	66	13.6	96.6	348	612	194	8.9	339	341	36	<5	-	-	5.1
		TSL-2	698650 5800430	9/5/2004	12:30	1.1	-	<0.006	0.007	0.66	0.010	0.65	0.663	0.004	0.013	5.5	1.7	-	-	4	0.13	<0.06	<0.01	5.3	16.7	7.4	37.8	68	14	99.1	351	611	197	8.9	338	341	35	<5	1	6	4.7
		TSL-3	698299 5800102	9/5/2004	12:50	2.1	-	<0.006	0.008	0.62	0.011	0.61	0.623	0.004	0.016	6.1	1.5	-	-	4	0.13	<0.06	<0.01	5.1	16.6	7.3	37.3	66	13.5	97.8	347	612	195	8.9	337	341	34	<5	1	4	4.8
		TSL-4	698089 5799932	9/5/2004	13:05	2.6	-	<0.006	0.011	0.67	0.014	0.66	0.673	0.005	0.015	6.2	2.1	-	-	4	0.13	<0.06	<0.01	5.3	17.0	7.4	37.8	67	13.5	99.7	347	612	198	8.9	334	339	34	<5	-	-	5.5
		TSL-5	697898 5799840	9/5/2004	13:25	2.3	-	<0.006	0.009	0.64	0.012	0.63	0.643	0.005	0.016	5.3	1.7	-	-	4	0.13	<0.06	<0.01	5.1	16.5	7.1	36.4	64	13.2	95	344	612	191	8.9	338	343	34	<5	-	-	5.7
Summer Village of Norgenwold	NORG	NORG-1	696923 5800530	9/5/2004	14:18	1.4	-	<0.006	0.01	0.83	0.013	0.82	0.833	0.003	0.014	9.6	2.1	-	-	4	0.13	<0.06	<0.01	5.4	17.2	7.5	38.2	68	13.7	100	351	614	200	8.9	337	340	35	<5	2	7	6.3
Summer Village of Half Moon Bay	HB	HB-1	692988 5803726	9/5/2004	14:50	2.1	-	<0.006	0.011	0.62	0.014	0.61	0.623	0.004	0.013	7.7	2.4	6	3	4	0.13	<0.06	<0.01	5.5	17.2	7.6	37.9	67	13.9	98.8	350	613	199	8.9	338	340	36	<5	1	2	6.0
		HB-2	692849 5803635	9/5/2004	15:09	2.45	-	<0.006	0.011	0.65	0.014	0.64	0.653	0.003	0.016	10.3	1.9	-	-	4	0.13	<0.06	<0.01	5.3	17.0	7.4	37.4	66	13.5	97.3	349	613	196	8.9	340	341	36	<5	<1	<1	6.4
		HB-3	692701 5803605	9/5/2004	15:42	1.4	-	<0.006	0.01	0.63	0.013	0.62	0.633	0.004	0.015	7.2	1.9	-	-	4	0.13	<0.06	<0.01	5.5	17.2	7.5	37.8	67	14	97.5	353	615	199	8.9	343	345	36	<5	<1	<1	6.8
		HB-4 rep. A	692701 5803605	9/5/2004	15:55	1.5	-	<0.006	0.008	0.59	0.011	0.58	0.593																												

Table C-4 Results of Laboratory Water Quality Analyses for Samples Collected from Nearshore Areas of Sylvan Lake in September 2004¹ (cont'd)

Site Area	Location			Date	Time	Total Depth	Sample Depth	Nitrogen					Phosphorus		Molar Ratio ⁵		DOC	TSS	Major Ions										Ion Balance	TDS (Calc)	Cond	Hardness (as CaCO ₃)	pH	Alkalinity				Bacteriological Parameters			
	Site ID	Site #	Lat/Long or UTM 11U					Nitrate/ Nitrite- N	Ammonia- N	TKN	DIN ²	Org. N ³	TN ⁴	DP	TP	DIN:DP			DIN:TP	Cl	F	Diss. Fe	Diss. Mn	Silica (as SiO ₂)	Ca	K	Mg	Na						SO ₄	Total (as CaCO ₃)	HCO ₃	CO ₃	OH	E. Coli	Fecal Coliforms	Chlorophyll a
		SLNA-3	688370 5808614	9/5/2004	17:45	2.99	-	<0.006	0.011	0.61	0.014	0.60	0.613	0.003	0.013	10.3	2.4	-	-	3	0.13	<0.06	<0.01	5.4	16.2	6.9	36.0	63	13.4	93.5	342	611	189	8.9	339	339	37	<5	<1	1	6.2
		SLNA-4	688250 5808518	9/5/2004	18:00	2.75	-	<0.006	0.007	0.64	0.010	0.63	0.643	0.004	0.013	5.5	1.7	-	-	3	0.13	<0.06	<0.01	5.2	16.2	7.1	35.8	63	12.9	92.8	343	613	188	8.9	341	342	37	<5	-	-	6.1
		SLNA-5	688107 5808392	9/5/2004	18:15	2.25	-	<0.006	0.009	0.65	0.012	0.64	0.653	0.004	0.016	6.6	1.7	-	-	4	0.13	<0.06	<0.01	3.5	17.0	7.4	36.7	65	13.5	95.7	348	612	194	8.9	341	342	36	<5	-	-	6.0
Summer Village of Sunbreaker Cove	SBC	SBC-1	691412 5807514	9/5/2004	16:35	2.75	-	<0.006	0.013	0.65	0.016	0.64	0.653	0.004	0.017	8.8	2.1	-	-	3	0.13	<0.06	<0.01	3.2	17.0	7.5	36.7	67	13.9	96.7	350	614	194	8.9	341	344	36	<5	<1	<1	5.3

- Notes:
- 1 Abbreviations in Table Cs follows: TKN = total kjeldahl nitrogen; DIN = dissolved inorganic nitrogen; TN = total nitrogen; DP = dissolved phosphorus; TP = total phosphorus; DOC = dissolved organic carbon; TSS = total suspended solids; TDS = total dissolved solids.

2 Calculated as sum of ammonia and nitrate/nitrite nitrogen.

3 Calculated as the difference between TKN and ammonia.

4 Calculated as the sum of TKN and nitrate/nitrite nitrogen.

5 Calculated.

Table C-5 Results of Laboratory Water Quality Analyses for Samples Collected from Nearshore Areas of Sylvan Lake in September 2004¹

Site Area	Location			Date	Time	Total Depth	Sample Depth	Nitrogen					Phosphorus		Molar Ratio ⁵		DOC	TSS	Major Ions										Ion Balance	TDS (Calc.)	Cond	Hardness (as CaCO ₃)	pH	Alkalinity				Bacteriological Parameters																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
	Site ID	Site #	Lat/Long					Nitrate/ Nitrite- N	Ammonia- N	TKN	DIN ²	Org ₃ N	TN ⁴	DP	TP	DIN: DP			DIN: TP	Cl	F	Diss. Fe	Diss. Mn	Si (as SiO ₂)	Ca	K	Mg	Na						SO ₄	Total (as CaCO ₃)	HCO ₃	CO ₃	OH	E. Coli (CFU/100 mL)	Fecal Coliforms (CFU/100 mL)	Chlorophyll a (ug/L)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
(m)	(m)	(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)	(%)	(mg/L)	(uS/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)	(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)	(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)	(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)	(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)	(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)	(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)	(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)	(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)	(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)	(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)	(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)	(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)	(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)	(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)	(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)	(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)	(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)	(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)	(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)	(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)	(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)	(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)	(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)	(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)	(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)	(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)	(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)	(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)	(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)	(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)	(mg/L)	(mg/L)	(mg/L)

Notes: 1 Abbreviations in Table Cs follows: TKN = total kjeldahl nitrogen; DIN = dissolved inorganic nitrogen; TN = total nitrogen; DP = dissolved phosphorus; TP = total phosphorus; DOC = dissolved organic carbon; TSS = total suspended solids; TDS = total dissolved solids.
 2 Calculated as sum of ammonia and nitrate/nitrite nitrogen.
 3 Calculated as the difference between TKN and ammonia.
 4 Calculated as the sum of TKN and nitrate/nitrite nitrogen.
 5 Calculated.

Table C-6 Results of laboratory water quality analyses for samples collected from nearshore areas of Sylvan Lake in September 2004.¹

Site Area	Location			Date	Time	Total Depth	Sample Depth	Nitrogen					Phosphorus		Molar Ratio ⁵		DOC	TSS	Major Ions										Ion Balance	TDS (Calc)	Cond	Hardness (as CaCO ₃)	pH	Alkalinity				Bacteriological Parameters			
	Site ID	Site #	UTM					Nitrate/ Nitrite- N	Ammonia- N	TKN	DIN ²	Org. N ³	TN ⁴	DP	TP	DIN:DP			DIN:TP	Cl	FI	Diss. Fe	Diss. Mn	Silica (as SiO ₂)	Ca	K	Mg	Na						SO ₄	Total (as CaCO ₃)	HCO ₃	CO ₃	OH	E. Coli	Fecal Coliforms	Chlorophyll a
						(m)	(m)	(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)	(μS/cm)	(mg/L)		(mg/L)	(mg/L)	(mg/L)	(mg/L)	(CFU/100 mL)	(CFU/100 mL)	(μg/L)			
TRIBUTARY SITES																																									
Golf Course Creek	GCCR	GCCR-1	11U 697093 5799860	9/3/2004	8:00	-	-	0.628	0.038	0.88	0.666	0.84	1.508	0.037	0.096	39.8	15.3	-	37	11	0.13	0.67	0.04	5.4	32.3	2.8	8.6	19	12.4	99.0	168	308	116	8.1	132	161	<5	<5	620	820	
Northwest Creek	NWCR	NWCR-1	11U 688026 5809906	9/3/2004	9:30	-	-	0.009	0.050	1.60	0.059	1.55	1.609	0.111	0.125	1.2	1.0	-	5	6	0.10	0.30	0.03	12.2	55.5	5.1	26.2	49	14.6	99.9	361	632	246	8.3	341	410	<5	<5	1000	1000	

Notes: 1 Abbreviations in Table Cs follows: TKN = total kjeldahl nitrogen; DIN = dissolved inorganic nitrogen; TN = total nitrogen; DP = dissolved phosphorus; TP = total phosphorus; DOC = dissolved organic carbon; TSS = total suspended solids; TDS = total dissolved solids.
2 Calculated as sum of ammonia and nitrate/nitrite nitrogen.
3 Calculated as the difference between TKN and ammonia.
4 Calculated as the sum of TKN and nitrate/nitrite nitrogen.
5 Calculated

Table C-7 Analytical Results Sediment Quality Samples Collected from Nearshore and Deep Water Sites in Sylvan Lake in September 2004

Site Area	Site ID	Site #	Location UTM 11U	Date	Time	Total Depth	Sediment Depth Interval	Texture	Moisture	Particle Size			Carbon			Total Nitrogen	Total Phosphorus	Phosphorus Sorption Capacity
										Sand	Silt	Clay	Inorganic	Total Organic	Total by Combustion			
						(m)	(cm)		(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)
Nearhsore Sites																		
Sylvan Lake Natural Area	SLNA	SLNA-3	688358 5808600	23-Sep-04	17:05	2.9	0-5	Sandy loam	63.6	56	32	13	4.03	2.3	6.3	0.27	450	944
Sylvan Lake Natural Area	SLNA	SLNA-4	688260 5808510	23-Sep-04	16:56	2.7	0-5	Sandy loam	66.8	61	28	11	4.01	2.5	6.5	0.25	480	949
Sylvan Lake Natural Area	SLNA	SLNA-5	688110 5808392	23-Sep-04	16:40	2.2	0-5	Sand	44.7	90	7	3	0.95	0.8	1.8	0.11	440	329
Town of Sylvan Lake	TSL	TSL-1	698480 5800414	23-Sep-04	9:00	2.7	0-5	Loamy sand	47.9	83	13	4	1.58	0.9	2.5	0.14	610	416
Town of Sylvan Lake	TSL	TSL-3	698320 5800120	23-Sep-04	10:39	1.9	0-5	Sand	35.6	91	6	3	1.48	0.6	2.1	0.08	480	388
Town of Sylvan Lake	TSL	TSL-4	698106 5799954	23-Sep-04	11:00	2.5	0-5	Loamy sand	49.0	85	9	5	1.84	1.0	2.9	0.14	480	446
Summer Village of Half Moon Bay	HB	HB-3	692679 5803617	23-Sep-04	12:20	1.4	0-5	Sand	42.4	94	3	2	0.13	1.7	1.9	0.06	390	244
Summer Village of Half Moon Bay	HB	HB-4	692529 5803714	23-Sep-04	12:35	1.5	0-5	Sand	28.3	96	2	2	1.65	0.3	2.0	0.06	300	221
Summer Village of Half Moon Bay	HB	HB-5	692352 5803799	23-Sep-04	12:50	1.7	0-5	Sand	46.0	91	5	4	1.33	0.6	1.9	0.08	430	547
Summer Village of Birchcliff	BC	BC-3	695919 5805147	23-Sep-04	14:47	1.9	0-5	Loamy sand	56.2	84	8	8	0.9	1.2	2.1	0.16	580	469
Summer Village of Birchcliff	BC	BC-4	695693 5805189	23-Sep-04	15:17	1.6	0-5	Sand	45.9	89	6	4	1.15	0.9	2.1	0.10	460	453
Summer Village of Birchcliff	BC	BC-5	695269 5805298	23-Sep-04	14:30	1.5	0-5	Sand	41.7	94	5	1	1.53	0.2	1.7	0.04	340	236
Deep Water Sites																		
Sylvan Lake - 16 m contour	SL	SLB	691948 5805602	23-Sep-04	17:52	16	0-5	Clay loam	91.9	40	28	32	1.06	3.6	4.7	0.43	740	456
Sylvan Lake - 14 m contour	SL	SLC	696075 5802787	24-Sep-04	10:55	14.2	0-5	Silty clay	92.2	4	45	50	2.47	9.6	12.1	1.25	1210	650
Sylvan Lake - Core Site near Town of Sylvan Lake	SLE	SLE	697864 5801277	24-Sep-04	13:09	7.7	0-5	Clay loam	82.9	22	49	29	2.65	5.4	8.1	0.66	850	553
			697864 5801277	24-Sep-04	13:09	7.7	5-10	Silty clay	80.2	19	50	30	2.89	4.9	7.8	0.57	790	569
			697864 5801277	24-Sep-04	13:09	7.7	10-15	Silty clay	83.0	16	52	32	3.04	5.2	8.2	0.52	730	561
			697864 5801277	24-Sep-04	13:09	7.7	15-20	Silty clay	77.6	11	52	37	3.14	4.5	7.7	0.46	740	571
			697864 5801277	24-Sep-04	13:09	7.7	20-30	Silty clay	73.6	6	55	39	2.21	4.3	6.5	0.43	710	620

Table C-8 Phytoplankton Species Biomass (mg/m³) Measured in a Composite Surface Water Sample Collected from Sylvan Lake, September 06, 3004

		Cells/L	Cells/mL	Biomass (mg/m ³)	Relative Abundance (%)	
					Based on Biomass	Based on Cells/mL
Diatoms	<i>Asterionella</i> sp.	11400	114	14.592	0.1	1.7
Bacillariophyceae	<i>Cyclotella</i> sp.	9800	98	39.2	0.2	1.5
	<i>Cymatopleura</i> sp.	1600	16	72	0.4	0.2
	<i>Fragilaria crotonensis</i>	148000	1480	639.36	3.4	22.7
	<i>Melosira</i> sp.	3300	33	8.25	0.0	0.5
	<i>Stephanodiscus</i> sp.	8200	82	410	2.2	1.3
	<i>Synedra acus</i>	1600	16	0.448	0.0	0.2
	<i>Synedra ulna</i>	1600	16	10.24	0.1	0.2
	Total	185500	1855	1194.1	6.3	28.4
Chlorophyceae	<i>Closterium</i> sp.	6500	65	23.4	0.1	1.0
	<i>Oedogonium</i> sp.	14700	147	36.75	0.2	2.2
	<i>Pediastrum boryanum</i>	1600	16	129.6	0.7	0.2
	Total	22800	228	189.8	1.0	3.5
Cryptophyceae	<i>Cryptomonas</i> sp.	6500	65	19.5	0.1	1.0
	<i>Rhodomonas</i> sp.	1600	16	2.4	0.0	0.2
	Total	8100	81	21.9	0.1	1.2
Cyanophyceae	<i>Anabaena</i> sp.	6500	65	65	0.3	1.0
	<i>Aphanizomenon flos-aquae</i>	233000	2330	447.36	2.4	35.7
	<i>Aphanocapsa</i> sp.	45600	456	9849.6	51.8	7.0
	<i>Chroococcus</i> sp.	17900	179	143.2	0.8	2.7
	<i>Gomphosphaeria</i> sp.	116000	1160	3132	16.5	17.8
	Total	419000	4190	13637.2	71.7	64.1
Peridineae	<i>Ceratium</i> sp.	14700	147	3763.2	19.8	2.2
	<i>Peridinium</i> sp.	3300	33	211.2	1.1	0.5
	Total	18000	180	3974.4	20.9	2.8
All Phytoplankton		653400	6534	19017.3	100.0	100.0

ANALYTICAL REPORT

NORTH/SOUTH CONSULTANTS

DATE: 09-MAR-05 04:28 PM

Revision: 2

ATTN: MEGAN COOLEY

83 SCURFIELD BLVD

WINNIPEG MB R3Y 1G4

Lab Work Order #: L203708

Sampled By: CRAIG

Date Received: 04-SEP-04

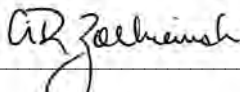
Project P.O. #:

Project Reference: NS174

Comments:



DOUG JOHNSON
Director of Operations, Edmonton



RICK ZOLKIEWSKI
Client Service Specialist

THIS REPORT SHALL NOT BE REPRODUCED EXCEPT IN FULL WITHOUT THE WRITTEN AUTHORITY OF THE LABORATORY.
ANY REMAINING SAMPLES WILL BE DISPOSED OF AFTER 30 DAYS FOLLOWING ANALYSIS. PLEASE CONTACT THE LAB IF YOU
REQUIRE ADDITIONAL SAMPLE STORAGE TIME.

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L203708-1 GOLFCOURSE CREEK SYLVAN LAKE Sample Date: 03-SEP-04 Matrix: WATER Phosphorus, Dissolved 0.037 Phosphorus, Total 0.096 Ammonia-N 0.038 MF - E. Coli 620 MF - Fecal Coliforms 820 Total Kjeldahl Nitrogen 0.88 Total Suspended Solids 37 Routine Water: Majors,F,Fe,Mn (Dis)&SiO2 Iron (Fe)-Dissolved 0.67 Manganese(Mn)-Dissolved 0.04 Chloride (Cl) 11 Fluoride (F) 0.13 Nitrate+Nitrite-N 0.628 Silica (as SiO2) 5.4 pH, Conductivity and Total Alkalinity pH 8.1 Conductivity (EC) 308 Bicarbonate (HCO3) 161 Carbonate (CO3) <5 Hydroxide (OH) <5 Alkalinity, Total (as CaCO3) 132 Ion Balance Calculation Ion Balance 99.0 TDS (Calculated) 168 Hardness (as CaCO3) 116 ICP metals and SO4 for routine water Calcium (Ca) 32.3 Potassium (K) 2.8 Magnesium (Mg) 8.6 Sodium (Na) 19 Sulfate (SO4) 12.4								
			0.001	mg/L		13-SEP-04	TL	R217788
			0.001	mg/L		13-SEP-04	TL	R217788
			0.005	mg/L		09-SEP-04	TL/SHC	R216871
			1	CFU/100mL		07-SEP-04	S V N	R215501
			1	CFU/100mL		07-SEP-04	S V N	R215501
		RAMB	0.05	mg/L		14-SEP-04	TL	R218230
			1	mg/L		17-SEP-04	ZOW	R219314
			0.06	mg/L		08-SEP-04	HAS	R216606
			0.01	mg/L		08-SEP-04	HAS	R216606
			1	mg/L		08-SEP-04	JTV	R216410
			0.05	mg/L		11-SEP-04	RWR	R217854
			0.006	mg/L		08-SEP-04	TL	R217051
			0.1	mg/L		08-SEP-04	BMA	R216241
			0.1	pH		07-SEP-04	PTT	R216051
			0.2	uS/cm		07-SEP-04	PTT	R216051
			5	mg/L		07-SEP-04	PTT	R216051
			5	mg/L		07-SEP-04	PTT	R216051
			5	mg/L		07-SEP-04	PTT	R216051
			5	mg/L		07-SEP-04	PTT	R216051
				%		10-SEP-04		
				mg/L		10-SEP-04		
				mg/L		10-SEP-04		
			0.5	mg/L		08-SEP-04	BMA	R216241
			0.1	mg/L		08-SEP-04	BMA	R216241
			0.1	mg/L		08-SEP-04	BMA	R216241
			1	mg/L		08-SEP-04	BMA	R216241
			0.5	mg/L		08-SEP-04	BMA	R216241
L203708-2 NORTHWEST CREEK SYLVAN LAKE Sample Date: 03-SEP-04 Matrix: WATER Phosphorus, Dissolved 0.111 Phosphorus, Total 0.125 Ammonia-N 0.050 MF - E. Coli 1000 MF - Fecal Coliforms 1000 Total Kjeldahl Nitrogen 1.60 Total Suspended Solids 5 Routine Water: Majors,F,Fe,Mn (Dis)&SiO2 Iron (Fe)-Dissolved 0.30 Manganese(Mn)-Dissolved 0.03 Chloride (Cl) 6 Fluoride (F) 0.10 Nitrate+Nitrite-N 0.009								
			0.001	mg/L		13-SEP-04	TL	R217788
			0.001	mg/L		13-SEP-04	TL	R217788
			0.005	mg/L		09-SEP-04	TL/SHC	R216871
			1	CFU/100mL		07-SEP-04	S V N	R215501
			1	CFU/100mL		07-SEP-04	S V N	R215501
			0.05	mg/L		09-SEP-04	TL	R216854
			1	mg/L		17-SEP-04	ZOW	R219314
			0.06	mg/L		08-SEP-04	HAS	R216606
			0.01	mg/L		08-SEP-04	HAS	R216606
			1	mg/L		08-SEP-04	JTV	R216410
			0.05	mg/L		11-SEP-04	RWR	R217854
			0.006	mg/L		08-SEP-04	TL	R217051

Sample Details/Parameters		Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L203708-2	NORTHWEST CREEK SYLVAN LAKE								
Sample Date: 03-SEP-04									
Matrix: WATER									
Routine Water: Majors,F,Fe,Mn (Dis)&SiO2									
Silica (as SiO2)		12.2		0.1	mg/L		08-SEP-04	BMA	R216241
pH, Conductivity and Total Alkalinity									
pH		8.3		0.1	pH		07-SEP-04	PTT	R216051
Conductivity (EC)		632		0.2	uS/cm		07-SEP-04	PTT	R216051
Bicarbonate (HCO3)		410		5	mg/L		07-SEP-04	PTT	R216051
Carbonate (CO3)		<5		5	mg/L		07-SEP-04	PTT	R216051
Hydroxide (OH)		<5		5	mg/L		07-SEP-04	PTT	R216051
Alkalinity, Total (as CaCO3)		341		5	mg/L		07-SEP-04	PTT	R216051
Ion Balance Calculation									
Ion Balance		99.9			%		10-SEP-04		
TDS (Calculated)		361			mg/L		10-SEP-04		
Hardness (as CaCO3)		246			mg/L		10-SEP-04		
ICP metals and SO4 for routine water									
Calcium (Ca)		55.5		0.5	mg/L		08-SEP-04	BMA	R216241
Potassium (K)		5.1		0.1	mg/L		08-SEP-04	BMA	R216241
Magnesium (Mg)		26.2		0.1	mg/L		08-SEP-04	BMA	R216241
Sodium (Na)		49		1	mg/L		08-SEP-04	BMA	R216241
Sulfate (SO4)		14.6		0.5	mg/L		08-SEP-04	BMA	R216241
L203708-3	TSL-SITE #1-REP #1 SYLVAN LAKE								
Sample Date: 03-SEP-04									
Matrix: WATER									
Phosphorus, Dissolved		0.003		0.001	mg/L		13-SEP-04	TL	R217788
Phosphorus, Total		0.013		0.001	mg/L		13-SEP-04	TL	R217788
Ammonia-N		0.011		0.005	mg/L		09-SEP-04	TL/SHC	R216871
Dissolved Organic Carbon		6		1	mg/L		09-SEP-04	RJK	R217022
MF - E. Coli		1		1	CFU/100mL		07-SEP-04	S V N	R215501
MF - Fecal Coliforms		4		1	CFU/100mL		07-SEP-04	S V N	R215501
Total Kjeldahl Nitrogen		0.56		0.05	mg/L		09-SEP-04	TL	R216854
Total Suspended Solids		2		1	mg/L		17-SEP-04	ZOW	R219314
Routine Water: Majors,F,Fe,Mn (Dis)&SiO2									
Iron (Fe)-Dissolved		<0.06		0.06	mg/L		08-SEP-04	HAS	R216606
Manganese(Mn)-Dissolved		<0.01		0.01	mg/L		08-SEP-04	HAS	R216606
Chloride (Cl)		4		1	mg/L		08-SEP-04	JTV	R216410
Fluoride (F)		0.13		0.05	mg/L		11-SEP-04	RWR	R217854
Nitrate+Nitrite-N		<0.006		0.006	mg/L		08-SEP-04	TL	R217051
Silica (as SiO2)		5.4		0.1	mg/L		08-SEP-04	BMA	R216241
pH, Conductivity and Total Alkalinity									
pH		8.9		0.1	pH		07-SEP-04	PTT	R216051
Conductivity (EC)		612		0.2	uS/cm		07-SEP-04	PTT	R216051
Bicarbonate (HCO3)		344		5	mg/L		07-SEP-04	PTT	R216051
Carbonate (CO3)		35		5	mg/L		07-SEP-04	PTT	R216051
Hydroxide (OH)		<5		5	mg/L		07-SEP-04	PTT	R216051
Alkalinity, Total (as CaCO3)		340		5	mg/L		07-SEP-04	PTT	R216051
Ion Balance Calculation									
Ion Balance		100			%		10-SEP-04		
TDS (Calculated)		355			mg/L		10-SEP-04		
Hardness (as CaCO3)		202			mg/L		10-SEP-04		
ICP metals and SO4 for routine water									
Calcium (Ca)		17.0		0.5	mg/L		08-SEP-04	BMA	R216241

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L203708-3 TSL-SITE #1-REP #1 SYLVAN LAKE Sample Date: 03-SEP-04 Matrix: WATER Routine Water: Majors,F,Fe,Mn (Dis)&SiO2 ICP metals and SO4 for routine water Potassium (K) Magnesium (Mg) Sodium (Na) Sulfate (SO4)	 7.9 38.8 69 14.2		 0.1 0.1 1 0.5	 mg/L mg/L mg/L mg/L		 08-SEP-04 08-SEP-04 08-SEP-04 08-SEP-04	 BMA BMA BMA BMA	 R216241 R216241 R216241 R216241
L203708-4 TSL-SITE #1-REP #2 SYLVAN LAKE Sample Date: 03-SEP-04 Matrix: WATER Phosphorus, Dissolved Phosphorus, Total Ammonia-N Total Kjeldahl Nitrogen Total Suspended Solids Routine Water: Majors,F,Fe,Mn (Dis)&SiO2 Iron (Fe)-Dissolved Manganese(Mn)-Dissolved Chloride (Cl) Fluoride (F) Nitrate+Nitrite-N Silica (as SiO2) pH, Conductivity and Total Alkalinity pH Conductivity (EC) Bicarbonate (HCO3) Carbonate (CO3) Hydroxide (OH) Alkalinity, Total (as CaCO3) Ion Balance Calculation Ion Balance TDS (Calculated) Hardness (as CaCO3) ICP metals and SO4 for routine water Calcium (Ca) Potassium (K) Magnesium (Mg) Sodium (Na) Sulfate (SO4)	 0.001 0.014 0.008 0.59 4 0.06 0.01 4 0.13 0.006 5.3 8.9 611 343 34 0.006 5.3 101 354 200 16.9 7.6 38.2 70 14.2		 0.001 0.001 0.005 0.05 1 0.06 0.01 1 0.05 0.006 0.1 0.1 0.2 5 5 5 5 0.5 0.1 0.1 1 0.5	 mg/L mg/L mg/L mg/L mg/L mg/L mg/L mg/L mg/L mg/L mg/L pH uS/cm mg/L mg/L mg/L mg/L % mg/L mg/L mg/L mg/L mg/L mg/L mg/L		 13-SEP-04 13-SEP-04 09-SEP-04 09-SEP-04 17-SEP-04 08-SEP-04 08-SEP-04 08-SEP-04 11-SEP-04 08-SEP-04 08-SEP-04 07-SEP-04 07-SEP-04 07-SEP-04 07-SEP-04 07-SEP-04 07-SEP-04 10-SEP-04 10-SEP-04 10-SEP-04 08-SEP-04 08-SEP-04 08-SEP-04 08-SEP-04 08-SEP-04	 TL TL TL/SHC TL ZOW HAS HAS JTV RWR TL BMA PTT PTT PTT PTT PTT PTT BMA BMA BMA BMA BMA	 R217788 R217788 R216871 R216854 R219314 R216606 R216606 R216410 R217854 R217051 R216241 R216051 R216051 R216051 R216051 R216051 R216051 R216241 R216241 R216241 R216241 R216241
L203708-5 TSL-SITE #1-REP #3 SYLVAN LAKE Sample Date: 03-SEP-04 Matrix: WATER Phosphorus, Dissolved Phosphorus, Total Ammonia-N Total Kjeldahl Nitrogen Total Suspended Solids Routine Water: Majors,F,Fe,Mn (Dis)&SiO2 Iron (Fe)-Dissolved	 0.005 0.014 0.008 0.63 5 0.006		 0.001 0.001 0.005 0.05 1 0.06	 mg/L mg/L mg/L mg/L mg/L mg/L		 13-SEP-04 13-SEP-04 09-SEP-04 09-SEP-04 17-SEP-04 08-SEP-04	 TL TL TL/SHC TL ZOW HAS	 R217788 R217788 R216871 R216854 R219314 R216606

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L203708-5 TSL-SITE #1-REP #3 SYLVAN LAKE Sample Date: 03-SEP-04 Matrix: WATER Routine Water: Majors,F,Fe,Mn (Dis)&SiO2 Manganese(Mn)-Dissolved <0.01 0.01 mg/L 08-SEP-04 HAS R216606 Chloride (Cl) 4 1 mg/L 08-SEP-04 JTV R216410 Fluoride (F) 0.13 0.05 mg/L 11-SEP-04 RWR R217854 Nitrate+Nitrite-N <0.006 0.006 mg/L 08-SEP-04 TL R217051 Silica (as SiO2) 5.2 0.1 mg/L 08-SEP-04 BMA R216241 pH, Conductivity and Total Alkalinity pH 8.9 0.1 pH 07-SEP-04 PTT R216051 Conductivity (EC) 612 0.2 uS/cm 07-SEP-04 PTT R216051 Bicarbonate (HCO3) 341 5 mg/L 07-SEP-04 PTT R216051 Carbonate (CO3) 36 5 mg/L 07-SEP-04 PTT R216051 Hydroxide (OH) <5 5 mg/L 07-SEP-04 PTT R216051 Alkalinity, Total (as CaCO3) 339 5 mg/L 07-SEP-04 PTT R216051 Ion Balance Calculation Ion Balance 96.6 % 10-SEP-04 TDS (Calculated) 348 mg/L 10-SEP-04 Hardness (as CaCO3) 194 mg/L 10-SEP-04 ICP metals and SO4 for routine water Calcium (Ca) 16.5 0.5 mg/L 08-SEP-04 BMA R216241 Potassium (K) 7.2 0.1 mg/L 08-SEP-04 BMA R216241 Magnesium (Mg) 37.2 0.1 mg/L 08-SEP-04 BMA R216241 Sodium (Na) 66 1 mg/L 08-SEP-04 BMA R216241 Sulfate (SO4) 13.6 0.5 mg/L 08-SEP-04 BMA R216241								
L203708-6 TSL-SITE #2 SYLVAN LAKE Sample Date: 03-SEP-04 Matrix: WATER Phosphorus, Dissolved 0.004 0.001 mg/L 13-SEP-04 TL R217788 Phosphorus, Total 0.013 0.001 mg/L 13-SEP-04 TL R217788 Ammonia-N 0.007 0.005 mg/L 09-SEP-04 TL/SHC R216871 MF - E. Coli 1 1 CFU/100mL 07-SEP-04 S V N R215501 MF - Fecal Coliforms 6 1 CFU/100mL 07-SEP-04 S V N R215501 Total Kjeldahl Nitrogen 0.66 0.05 mg/L 09-SEP-04 TL R216854 Routine Water: Majors,F,Fe,Mn (Dis)&SiO2 Iron (Fe)-Dissolved <0.06 0.06 mg/L 08-SEP-04 HAS R216606 Manganese(Mn)-Dissolved <0.01 0.01 mg/L 08-SEP-04 HAS R216606 Chloride (Cl) 4 1 mg/L 08-SEP-04 JTV R216410 Fluoride (F) 0.13 0.05 mg/L 11-SEP-04 RWR R217854 Nitrate+Nitrite-N <0.006 0.006 mg/L 08-SEP-04 TL R217051 Silica (as SiO2) 5.3 0.1 mg/L 08-SEP-04 BMA R216241 pH, Conductivity and Total Alkalinity pH 8.9 0.1 pH 07-SEP-04 PTT R216051 Conductivity (EC) 611 0.2 uS/cm 07-SEP-04 PTT R216051 Bicarbonate (HCO3) 341 5 mg/L 07-SEP-04 PTT R216051 Carbonate (CO3) 35 5 mg/L 07-SEP-04 PTT R216051 Hydroxide (OH) <5 5 mg/L 07-SEP-04 PTT R216051 Alkalinity, Total (as CaCO3) 338 5 mg/L 07-SEP-04 PTT R216051 Ion Balance Calculation Ion Balance 99.1 % 10-SEP-04 TDS (Calculated) 351 mg/L 10-SEP-04								

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L203708-6TSL-SITE #2 SYLVAN LAKE Sample Date: 03-SEP-04 Matrix: WATER Routine Water: Majors,F,Fe,Mn (Dis)&SiO2 Ion Balance Calculation Hardness (as CaCO3) ICP metals and SO4 for routine water Calcium (Ca) Potassium (K) Magnesium (Mg) Sodium (Na) Sulfate (SO4)	 197 16.7 7.4 37.8 68 14.0		 0.5 0.1 0.1 1 0.5	 mg/L mg/L mg/L mg/L mg/L		 10-SEP-04 08-SEP-04 08-SEP-04 08-SEP-04 08-SEP-04 08-SEP-04	 BMA BMA BMA BMA BMA	 R216241 R216241 R216241 R216241 R216241
L203708-7TSL-SITE #3 SYLVAN LAKE Sample Date: 03-SEP-04 Matrix: WATER Phosphorus, Dissolved Phosphorus, Total Ammonia-N MF - E. Coli MF - Fecal Coliforms Total Kjeldahl Nitrogen Routine Water: Majors,F,Fe,Mn (Dis)&SiO2 Iron (Fe)-Dissolved Manganese(Mn)-Dissolved Chloride (Cl) Fluoride (F) Nitrate+Nitrite-N Silica (as SiO2) pH, Conductivity and Total Alkalinity pH Conductivity (EC) Bicarbonate (HCO3) Carbonate (CO3) Hydroxide (OH) Alkalinity, Total (as CaCO3) Ion Balance Calculation Ion Balance TDS (Calculated) Hardness (as CaCO3) ICP metals and SO4 for routine water Calcium (Ca) Potassium (K) Magnesium (Mg) Sodium (Na) Sulfate (SO4)	 0.004 0.016 0.008 1 4 0.62 <0.06 <0.01 4 0.13 <0.006 5.1 8.9 612 341 34 <5 337 97.8 347 195 16.6 7.3 37.3 66 13.5		 0.001 0.001 0.005 1 1 0.05 0.06 0.01 1 0.05 0.006 0.1 0.1 0.2 5 5 5 5 0.5 0.1 0.1 1 0.5	 mg/L mg/L mg/L CFU/100mL CFU/100mL mg/L mg/L mg/L mg/L mg/L mg/L mg/L pH uS/cm mg/L mg/L mg/L mg/L % mg/L mg/L mg/L mg/L mg/L		 13-SEP-04 13-SEP-04 09-SEP-04 07-SEP-04 07-SEP-04 09-SEP-04 08-SEP-04 08-SEP-04 08-SEP-04 11-SEP-04 08-SEP-04 08-SEP-04 07-SEP-04 07-SEP-04 07-SEP-04 07-SEP-04 07-SEP-04 07-SEP-04 10-SEP-04 10-SEP-04 10-SEP-04 08-SEP-04 08-SEP-04 08-SEP-04 08-SEP-04 08-SEP-04	 TL TL TL/SHC S V N S V N TL HAS HAS JTV RWR TL BMA PTT PTT PTT PTT PTT PTT BMA BMA BMA BMA BMA	 R217788 R217788 R216871 R215501 R215501 R216854 R216606 R216606 R216410 R217854 R217051 R216241 R216051 R216051 R216051 R216051 R216051 R216051 R216241 R216241 R216241 R216241 R216241
L203708-8TSL-SITE #4 SYLVAN LAKE Sample Date: 03-SEP-04 Matrix: WATER Phosphorus, Dissolved Phosphorus, Total Ammonia-N	 0.005 0.015 0.011		 0.001 0.001 0.005	 mg/L mg/L mg/L		 13-SEP-04 13-SEP-04 09-SEP-04	 TL TL TL/SHC	 R217788 R217788 R216871

Sample Details/Parameters		Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L203708-8	TSL-SITE #4 SYLVAN LAKE								
Sample Date: 03-SEP-04									
Matrix: WATER									
Total Kjeldahl Nitrogen		0.67		0.05	mg/L		09-SEP-04	TL	R216854
Routine Water: Majors,F,Fe,Mn (Dis)&SiO2									
Iron (Fe)-Dissolved		<0.06		0.06	mg/L		08-SEP-04	HAS	R216606
Manganese(Mn)-Dissolved		<0.01		0.01	mg/L		08-SEP-04	HAS	R216606
Chloride (Cl)		4		1	mg/L		08-SEP-04	JTV	R216410
Fluoride (F)		0.13		0.05	mg/L		11-SEP-04	RWR	R217854
Nitrate+Nitrite-N		<0.006		0.006	mg/L		08-SEP-04	TL	R217051
Silica (as SiO2)		5.3		0.1	mg/L		08-SEP-04	BMA	R216241
pH, Conductivity and Total Alkalinity									
pH		8.9		0.1	pH		07-SEP-04	PTT	R216051
Conductivity (EC)		612		0.2	uS/cm		07-SEP-04	PTT	R216051
Bicarbonate (HCO3)		339		5	mg/L		07-SEP-04	PTT	R216051
Carbonate (CO3)		34		5	mg/L		07-SEP-04	PTT	R216051
Hydroxide (OH)		<5		5	mg/L		07-SEP-04	PTT	R216051
Alkalinity, Total (as CaCO3)		334		5	mg/L		07-SEP-04	PTT	R216051
Ion Balance Calculation									
Ion Balance		99.7			%		10-SEP-04		
TDS (Calculated)		347			mg/L		10-SEP-04		
Hardness (as CaCO3)		198			mg/L		10-SEP-04		
ICP metals and SO4 for routine water									
Calcium (Ca)		17.0		0.5	mg/L		08-SEP-04	BMA	R216241
Potassium (K)		7.4		0.1	mg/L		08-SEP-04	BMA	R216241
Magnesium (Mg)		37.8		0.1	mg/L		08-SEP-04	BMA	R216241
Sodium (Na)		67		1	mg/L		08-SEP-04	BMA	R216241
Sulfate (SO4)		13.5		0.5	mg/L		08-SEP-04	BMA	R216241
L203708-9	TSL-SITE #5 SYLVAN LAKE								
Sample Date: 03-SEP-04									
Matrix: WATER									
Phosphorus, Dissolved		0.005		0.001	mg/L		13-SEP-04	TL	R217788
Phosphorus, Total		0.016		0.001	mg/L		13-SEP-04	TL	R217788
Ammonia-N		0.009		0.005	mg/L		09-SEP-04	TL/SHC	R216871
Total Kjeldahl Nitrogen		0.64		0.05	mg/L		09-SEP-04	TL	R216854
Routine Water: Majors,F,Fe,Mn (Dis)&SiO2									
Iron (Fe)-Dissolved		<0.06		0.06	mg/L		08-SEP-04	HAS	R216606
Manganese(Mn)-Dissolved		<0.01		0.01	mg/L		08-SEP-04	HAS	R216606
Chloride (Cl)		4		1	mg/L		08-SEP-04	JTV	R216410
Fluoride (F)		0.13		0.05	mg/L		11-SEP-04	RWR	R217854
Nitrate+Nitrite-N		<0.006		0.006	mg/L		08-SEP-04	TL	R217051
Silica (as SiO2)		5.1		0.1	mg/L		08-SEP-04	BMA	R216241
pH, Conductivity and Total Alkalinity									
pH		8.9		0.1	pH		07-SEP-04	PTT	R216051
Conductivity (EC)		612		0.2	uS/cm		07-SEP-04	PTT	R216051
Bicarbonate (HCO3)		343		5	mg/L		07-SEP-04	PTT	R216051
Carbonate (CO3)		34		5	mg/L		07-SEP-04	PTT	R216051
Hydroxide (OH)		<5		5	mg/L		07-SEP-04	PTT	R216051
Alkalinity, Total (as CaCO3)		338		5	mg/L		07-SEP-04	PTT	R216051
Ion Balance Calculation									
Ion Balance		95.0			%		10-SEP-04		

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L203708-9 TSL-SITE #5 SYLVAN LAKE Sample Date: 03-SEP-04 Matrix: WATER Routine Water: Majors,F,Fe,Mn (Dis)&SiO2 Ion Balance Calculation TDS (Calculated) Hardness (as CaCO3) ICP metals and SO4 for routine water Calcium (Ca) Potassium (K) Magnesium (Mg) Sodium (Na) Sulfate (SO4)	 344 191 16.5 7.1 36.4 64 13.2		 0.5 0.1 0.1 1 0.5	 mg/L mg/L mg/L mg/L mg/L mg/L mg/L		 10-SEP-04 10-SEP-04 08-SEP-04 08-SEP-04 08-SEP-04 08-SEP-04 08-SEP-04	 BMA BMA BMA BMA BMA	 R216241 R216241 R216241 R216241 R216241
L203708-10 NORGLENWOLD SYLVAN LAKE Sample Date: 03-SEP-04 Matrix: WATER Phosphorus, Dissolved Phosphorus, Total Ammonia-N MF - E. Coli MF - Fecal Coliforms Total Kjeldahl Nitrogen Routine Water: Majors,F,Fe,Mn (Dis)&SiO2 Iron (Fe)-Dissolved Manganese(Mn)-Dissolved Chloride (Cl) Fluoride (F) Nitrate+Nitrite-N Silica (as SiO2) pH, Conductivity and Total Alkalinity pH Conductivity (EC) Bicarbonate (HCO3) Carbonate (CO3) Hydroxide (OH) Alkalinity, Total (as CaCO3) Ion Balance Calculation Ion Balance TDS (Calculated) Hardness (as CaCO3) ICP metals and SO4 for routine water Calcium (Ca) Potassium (K) Magnesium (Mg) Sodium (Na) Sulfate (SO4)	 0.003 0.014 0.010 2 7 0.83 <0.06 <0.01 4 0.13 <0.006 5.4 8.9 614 340 35 <5 337 100 351 200 17.2 7.5 38.2 68 13.7		 0.001 0.001 0.005 1 1 0.05 0.06 0.01 1 0.05 0.006 0.1 0.1 0.2 5 5 5 5 0.5 0.1 0.1 1 0.5	 mg/L mg/L mg/L CFU/100mL CFU/100mL mg/L mg/L mg/L mg/L mg/L mg/L mg/L pH uS/cm mg/L mg/L mg/L mg/L % mg/L mg/L mg/L mg/L mg/L		 13-SEP-04 13-SEP-04 09-SEP-04 07-SEP-04 07-SEP-04 09-SEP-04 08-SEP-04 08-SEP-04 08-SEP-04 11-SEP-04 08-SEP-04 08-SEP-04 07-SEP-04 07-SEP-04 07-SEP-04 07-SEP-04 07-SEP-04 07-SEP-04 10-SEP-04 10-SEP-04 10-SEP-04 08-SEP-04 08-SEP-04 08-SEP-04 08-SEP-04 08-SEP-04	 TL TL TL/SHC S V N S V N TL HAS HAS JTV RWR TL BMA PTT PTT PTT PTT PTT PTT BMA BMA BMA BMA BMA	 R217792 R217792 R216871 R215501 R215501 R216854 R216606 R216606 R216410 R217854 R217051 R216241 R216051 R216051 R216051 R216051 R216051 R216051 R216241 R216241 R216241 R216241 R216241
L203708-11 HB-SITE #1 SYLVAN LAKE Sample Date: 03-SEP-04 Matrix: WATER Phosphorus, Dissolved Phosphorus, Total	 0.004 0.013		 0.001 0.001	 mg/L mg/L		 13-SEP-04 13-SEP-04	 TL TL	 R217792 R217792

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L203708-11 HB-SITE #1 SYLVAN LAKE Sample Date: 03-SEP-04 Matrix: WATER								
Ammonia-N	0.011		0.005	mg/L		09-SEP-04	TL/SHC	R216871
Dissolved Organic Carbon	6		1	mg/L		09-SEP-04	RJK	R217022
MF - E. Coli	1		1	CFU/100mL		07-SEP-04	S V N	R215501
MF - Fecal Coliforms	2		1	CFU/100mL		07-SEP-04	S V N	R215501
Total Kjeldahl Nitrogen	0.62		0.05	mg/L		09-SEP-04	TL	R216854
Total Suspended Solids	3		1	mg/L		17-SEP-04	ZOW	R219314
Routine Water: Majors,F,Fe,Mn (Dis)&SiO2								
Iron (Fe)-Dissolved	<0.06		0.06	mg/L		08-SEP-04	HAS	R216606
Manganese(Mn)-Dissolved	<0.01		0.01	mg/L		08-SEP-04	HAS	R216606
Chloride (Cl)	4		1	mg/L		08-SEP-04	JTV	R216410
Fluoride (F)	0.13		0.05	mg/L		11-SEP-04	RWR	R217854
Nitrate+Nitrite-N	<0.006		0.006	mg/L		08-SEP-04	TL	R217051
Silica (as SiO2)	5.5		0.1	mg/L		08-SEP-04	BMA	R216241
pH, Conductivity and Total Alkalinity								
pH	8.9		0.1	pH		07-SEP-04	PTT	R216051
Conductivity (EC)	613		0.2	uS/cm		07-SEP-04	PTT	R216051
Bicarbonate (HCO3)	340		5	mg/L		07-SEP-04	PTT	R216051
Carbonate (CO3)	36		5	mg/L		07-SEP-04	PTT	R216051
Hydroxide (OH)	<5		5	mg/L		07-SEP-04	PTT	R216051
Alkalinity, Total (as CaCO3)	338		5	mg/L		07-SEP-04	PTT	R216051
Ion Balance Calculation								
Ion Balance	98.8			%		10-SEP-04		
TDS (Calculated)	350			mg/L		10-SEP-04		
Hardness (as CaCO3)	199			mg/L		10-SEP-04		
ICP metals and SO4 for routine water								
Calcium (Ca)	17.2		0.5	mg/L		08-SEP-04	BMA	R216241
Potassium (K)	7.6		0.1	mg/L		08-SEP-04	BMA	R216241
Magnesium (Mg)	37.9		0.1	mg/L		08-SEP-04	BMA	R216241
Sodium (Na)	67		1	mg/L		08-SEP-04	BMA	R216241
Sulfate (SO4)	13.9		0.5	mg/L		08-SEP-04	BMA	R216241
L203708-12 HB SITE#2 SYLVAN LAKE Sample Date: 03-SEP-04 Matrix: WATER								
Phosphorus, Dissolved	0.003		0.001	mg/L		13-SEP-04	TL	R217792
Phosphorus, Total	0.016		0.001	mg/L		13-SEP-04	TL	R217792
Ammonia-N	0.011		0.005	mg/L		09-SEP-04	TL/SHC	R216871
MF - E. Coli	<1		1	CFU/100mL		07-SEP-04	S V N	R215501
MF - Fecal Coliforms	<1		1	CFU/100mL		07-SEP-04	S V N	R215501
Total Kjeldahl Nitrogen	0.65		0.05	mg/L		09-SEP-04	TL	R216854
Routine Water: Majors,F,Fe,Mn (Dis)&SiO2								
Iron (Fe)-Dissolved	<0.06		0.06	mg/L		08-SEP-04	HAS	R216606
Manganese(Mn)-Dissolved	<0.01		0.01	mg/L		08-SEP-04	HAS	R216606
Chloride (Cl)	4		1	mg/L		08-SEP-04	JTV	R216410
Fluoride (F)	0.13		0.05	mg/L		11-SEP-04	RWR	R217854
Nitrate+Nitrite-N	<0.006		0.006	mg/L		08-SEP-04	TL	R217051
Silica (as SiO2)	5.3		0.1	mg/L		08-SEP-04	BMA	R216241
pH, Conductivity and Total Alkalinity								
pH	8.9		0.1	pH		07-SEP-04	PTT	R216051

Sample Details/Parameters		Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L203708-12 HB SITE#2 SYLVAN LAKE Sample Date: 03-SEP-04 Matrix: WATER Routine Water: Majors,F,Fe,Mn (Dis)&SiO2 pH, Conductivity and Total Alkalinity Conductivity (EC) Bicarbonate (HCO3) Carbonate (CO3) Hydroxide (OH) Alkalinity, Total (as CaCO3) Ion Balance Calculation Ion Balance TDS (Calculated) Hardness (as CaCO3) ICP metals and SO4 for routine water Calcium (Ca) Potassium (K) Magnesium (Mg) Sodium (Na) Sulfate (SO4)		613 341 36 <5 340 97.3 349 196 17.0 7.4 37.4 66 13.5		0.2 5 5 5 5 0.5 0.1 0.1 1 0.5	uS/cm mg/L mg/L mg/L mg/L % mg/L mg/L mg/L mg/L mg/L mg/L mg/L		07-SEP-04 07-SEP-04 07-SEP-04 07-SEP-04 07-SEP-04 10-SEP-04 10-SEP-04 10-SEP-04 08-SEP-04 08-SEP-04 08-SEP-04 08-SEP-04 08-SEP-04	PTT PTT PTT PTT PTT BMA BMA BMA BMA BMA	R216051 R216051 R216051 R216051 R216051 R216241 R216241 R216241 R216241 R216241
L203708-13 HB SITE#3 SYLVAN LAKE Sample Date: 03-SEP-04 Matrix: WATER Phosphorus, Dissolved Phosphorus, Total Ammonia-N MF - E. Coli MF - Fecal Coliforms Total Kjeldahl Nitrogen Routine Water: Majors,F,Fe,Mn (Dis)&SiO2 Iron (Fe)-Dissolved Manganese(Mn)-Dissolved Chloride (Cl) Fluoride (F) Nitrate+Nitrite-N Silica (as SiO2) pH, Conductivity and Total Alkalinity pH Conductivity (EC) Bicarbonate (HCO3) Carbonate (CO3) Hydroxide (OH) Alkalinity, Total (as CaCO3) Ion Balance Calculation Ion Balance TDS (Calculated) Hardness (as CaCO3) ICP metals and SO4 for routine water Calcium (Ca) Potassium (K) Magnesium (Mg) Sodium (Na) Sulfate (SO4)		0.004 0.015 0.010 <1 <1 0.63 <0.06 <0.01 4 0.13 <0.006 5.5 8.9 615 345 36 <5 343 97.5 353 199 17.2 7.5 37.8 67 14.0		0.001 0.001 0.005 1 1 0.05 0.06 0.01 1 0.05 0.006 0.1 0.1 0.2 5 5 5 5 0.5 0.1 0.1 1 0.5	mg/L mg/L mg/L CFU/100mL CFU/100mL mg/L mg/L mg/L mg/L mg/L mg/L mg/L pH uS/cm mg/L mg/L mg/L mg/L % mg/L mg/L mg/L mg/L mg/L		13-SEP-04 13-SEP-04 09-SEP-04 07-SEP-04 07-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04 08-SEP-04 11-SEP-04 08-SEP-04 08-SEP-04 07-SEP-04 07-SEP-04 07-SEP-04 07-SEP-04 07-SEP-04 07-SEP-04 10-SEP-04 10-SEP-04 10-SEP-04 08-SEP-04 08-SEP-04 08-SEP-04 08-SEP-04 08-SEP-04	TL TL TL/SHC S V N S V N TL HAS HAS JTV RWR TL BMA PTT PTT PTT PTT PTT PTT BMA BMA BMA BMA BMA	R217792 R217792 R216871 R215501 R215501 R216854 R216606 R216606 R216410 R217854 R217051 R216241 R216051 R216051 R216051 R216051 R216051 R216051 R216241 R216241 R216241 R216241 R216241

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L203708-13HB SITE#3 SYLVAN LAKE Sample Date: 03-SEP-04 Matrix: WATER Routine Water: Majors,F,Fe,Mn (Dis)&SiO2								
L203708-14HB SITE#4-REP#1 SYLVAN LAKE Sample Date: 03-SEP-04 Matrix: WATER								
Phosphorus, Dissolved	0.004		0.001	mg/L		13-SEP-04	TL	R217792
Phosphorus, Total	0.015		0.001	mg/L		13-SEP-04	TL	R217792
Ammonia-N	0.008		0.005	mg/L		09-SEP-04	TL/SHC	R216871
Total Kjeldahl Nitrogen	0.59		0.05	mg/L		09-SEP-04	TL	R216854
Routine Water: Majors,F,Fe,Mn (Dis)&SiO2								
Iron (Fe)-Dissolved	<0.06		0.06	mg/L		09-SEP-04	HAS	R216606
Manganese(Mn)-Dissolved	<0.01		0.01	mg/L		09-SEP-04	HAS	R216606
Chloride (Cl)	4		1	mg/L		08-SEP-04	JTV	R216410
Fluoride (F)	0.13		0.05	mg/L		11-SEP-04	RWR	R217854
Nitrate+Nitrite-N	<0.006		0.006	mg/L		08-SEP-04	TL	R217051
Silica (as SiO2)	5.4		0.1	mg/L		08-SEP-04	BMA	R216241
pH, Conductivity and Total Alkalinity								
pH	8.9		0.1	pH		07-SEP-04	PTT	R216051
Conductivity (EC)	615		0.2	uS/cm		07-SEP-04	PTT	R216051
Bicarbonate (HCO3)	343		5	mg/L		07-SEP-04	PTT	R216051
Carbonate (CO3)	37		5	mg/L		07-SEP-04	PTT	R216051
Hydroxide (OH)	<5		5	mg/L		07-SEP-04	PTT	R216051
Alkalinity, Total (as CaCO3)	343		5	mg/L		07-SEP-04	PTT	R216051
Ion Balance Calculation								
Ion Balance	96.8			%		10-SEP-04		
TDS (Calculated)	352			mg/L		10-SEP-04		
Hardness (as CaCO3)	198			mg/L		10-SEP-04		
ICP metals and SO4 for routine water								
Calcium (Ca)	17.1		0.5	mg/L		08-SEP-04	BMA	R216241
Potassium (K)	7.3		0.1	mg/L		08-SEP-04	BMA	R216241
Magnesium (Mg)	37.8		0.1	mg/L		08-SEP-04	BMA	R216241
Sodium (Na)	66		1	mg/L		08-SEP-04	BMA	R216241
Sulfate (SO4)	13.7		0.5	mg/L		08-SEP-04	BMA	R216241
L203708-15HB SITE#4-REP#2 SYLVAN LAKE Sample Date: 03-SEP-04 Matrix: WATER								
Phosphorus, Dissolved	0.005		0.001	mg/L		13-SEP-04	TL	R217792
Phosphorus, Total	0.014		0.001	mg/L		13-SEP-04	TL	R217792
Ammonia-N	0.022		0.005	mg/L		09-SEP-04	TL/SHC	R216871
Total Kjeldahl Nitrogen	0.58		0.05	mg/L		09-SEP-04	TL	R216854
Routine Water: Majors,F,Fe,Mn (Dis)&SiO2								
Iron (Fe)-Dissolved	<0.06		0.06	mg/L		09-SEP-04	HAS	R216606
Manganese(Mn)-Dissolved	<0.01		0.01	mg/L		09-SEP-04	HAS	R216606
Chloride (Cl)	3		1	mg/L		08-SEP-04	JTV	R216410
Fluoride (F)	0.13		0.05	mg/L		11-SEP-04	RWR	R217854
Nitrate+Nitrite-N	<0.006		0.006	mg/L		08-SEP-04	TL	R217051
Silica (as SiO2)	5.1		0.1	mg/L		08-SEP-04	BMA	R216241
pH, Conductivity and Total Alkalinity								
pH	8.9		0.1	pH		07-SEP-04	PTT	R216051

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L203708-15 HB SITE#4-REP#2 SYLVAN LAKE Sample Date: 03-SEP-04 Matrix: WATER Routine Water: Majors,F,Fe,Mn (Dis)&SiO2 pH, Conductivity and Total Alkalinity Conductivity (EC)								

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L203708-17HB SITE#5 SYLVAN LAKE Sample Date: 03-SEP-04 Matrix: WATER								
Phosphorus, Dissolved	0.003		0.001	mg/L		13-SEP-04	TL	R217792
Phosphorus, Total	0.014		0.001	mg/L		13-SEP-04	TL	R217792
Ammonia-N	0.010		0.005	mg/L		09-SEP-04	TL/SHC	R216871
Total Kjeldahl Nitrogen	0.59		0.05	mg/L		09-SEP-04	TL	R216854
Routine Water: Majors,F,Fe,Mn (Dis)&SiO2								
Iron (Fe)-Dissolved	<0.06		0.06	mg/L		09-SEP-04	HAS	R216606
Manganese(Mn)-Dissolved	<0.01		0.01	mg/L		09-SEP-04	HAS	R216606
Chloride (Cl)	3		1	mg/L		08-SEP-04	JTV	R216410
Fluoride (F)	0.13		0.05	mg/L		11-SEP-04	RWR	R217854
Nitrate+Nitrite-N	<0.006		0.006	mg/L		08-SEP-04	TL	R217051
Silica (as SiO2)	5.1		0.1	mg/L		08-SEP-04	BMA	R216241
pH, Conductivity and Total Alkalinity								
pH	8.9		0.1	pH		07-SEP-04	PTT	R216051
Conductivity (EC)	614		0.2	uS/cm		07-SEP-04	PTT	R216051
Bicarbonate (HCO3)	345		5	mg/L		07-SEP-04	PTT	R216051
Carbonate (CO3)	36		5	mg/L		07-SEP-04	PTT	R216051
Hydroxide (OH)	<5		5	mg/L		07-SEP-04	PTT	R216051
Alkalinity, Total (as CaCO3)	343		5	mg/L		07-SEP-04	PTT	R216051
Ion Balance Calculation								
Ion Balance	92.3			%		10-SEP-04		
TDS (Calculated)	343			mg/L		10-SEP-04		
Hardness (as CaCO3)	187			mg/L		10-SEP-04		
ICP metals and SO4 for routine water								
Calcium (Ca)	16.1		0.5	mg/L		08-SEP-04	BMA	R216241
Potassium (K)	7.0		0.1	mg/L		08-SEP-04	BMA	R216241
Magnesium (Mg)	35.6		0.1	mg/L		08-SEP-04	BMA	R216241
Sodium (Na)	63		1	mg/L		08-SEP-04	BMA	R216241
Sulfate (SO4)	12.9		0.5	mg/L		08-SEP-04	BMA	R216241
L203708-18HB SITE#1-REP#1 SYLVAN LAKE Sample Date: 03-SEP-04 Matrix: WATER								
Phosphorus, Dissolved	0.004		0.001	mg/L		13-SEP-04	TL	R217792
Phosphorus, Total	0.015		0.001	mg/L		13-SEP-04	TL	R217792
Ammonia-N	0.009		0.005	mg/L		09-SEP-04	TL/SHC	R216871
Dissolved Organic Carbon	6		1	mg/L		09-SEP-04	RJK	R217022
MF - E. Coli	<1		1	CFU/100mL		07-SEP-04	S V N	R215501
MF - Fecal Coliforms	3		1	CFU/100mL		07-SEP-04	S V N	R215501
Total Kjeldahl Nitrogen	0.60		0.05	mg/L		09-SEP-04	TL	R216854
Total Suspended Solids	4		1	mg/L		17-SEP-04	ZOW	R219314
Routine Water: Majors,F,Fe,Mn (Dis)&SiO2								
Iron (Fe)-Dissolved	<0.06		0.06	mg/L		09-SEP-04	HAS	R216606
Manganese(Mn)-Dissolved	<0.01		0.01	mg/L		09-SEP-04	HAS	R216606
Chloride (Cl)	3		1	mg/L		08-SEP-04	JTV	R216410
Fluoride (F)	0.13		0.05	mg/L		11-SEP-04	RWR	R217854
Nitrate+Nitrite-N	<0.006		0.006	mg/L		08-SEP-04	TL	R217051
Silica (as SiO2)	5.2		0.1	mg/L		08-SEP-04	BMA	R216241
pH, Conductivity and Total Alkalinity								
pH	8.9		0.1	pH		07-SEP-04	PTT	R216051

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L203708-18 HB SITE#1-REP#1 SYLVAN LAKE Sample Date: 03-SEP-04 Matrix: WATER Routine Water: Majors,F,Fe,Mn (Dis)&SiO2 pH, Conductivity and Total Alkalinity Conductivity (EC) 614 0.2 uS/cm 07-SEP-04 PTT R216051 Bicarbonate (HCO3) 345 5 mg/L 07-SEP-04 PTT R216051 Carbonate (CO3) 34 5 mg/L 07-SEP-04 PTT R216051 Hydroxide (OH) <5 5 mg/L 07-SEP-04 PTT R216051 Alkalinity, Total (as CaCO3) 340 5 mg/L 07-SEP-04 PTT R216051 Ion Balance Calculation Ion Balance 92.6 % 10-SEP-04 TDS (Calculated) 341 mg/L 10-SEP-04 Hardness (as CaCO3) 185 mg/L 10-SEP-04 ICP metals and SO4 for routine water Calcium (Ca) 16.0 0.5 mg/L 08-SEP-04 BMA R216241 Potassium (K) 6.9 0.1 mg/L 08-SEP-04 BMA R216241 Magnesium (Mg) 35.2 0.1 mg/L 08-SEP-04 BMA R216241 Sodium (Na) 63 1 mg/L 08-SEP-04 BMA R216241 Sulfate (SO4) 12.8 0.5 mg/L 08-SEP-04 BMA R216241								
L203708-19 HB SITE#1-REP#2 SYLVAN LAKE Sample Date: 03-SEP-04 Matrix: WATER Phosphorus, Dissolved 0.003 0.001 mg/L 13-SEP-04 TL R217792 Phosphorus, Total 0.014 0.001 mg/L 13-SEP-04 TL R217792 Ammonia-N 0.010 0.005 mg/L 09-SEP-04 TL/SHC R216871 MF - E. Coli 1 1 CFU/100mL 07-SEP-04 S V N R215501 MF - Fecal Coliforms 1 1 CFU/100mL 07-SEP-04 S V N R215501 Total Kjeldahl Nitrogen 0.51 0.05 mg/L 09-SEP-04 TL R216854 Total Suspended Solids 2 1 mg/L 17-SEP-04 ZOW R219314 Routine Water: Majors,F,Fe,Mn (Dis)&SiO2 Iron (Fe)-Dissolved <0.06 0.06 mg/L 09-SEP-04 HAS R216606 Manganese(Mn)-Dissolved <0.01 0.01 mg/L 09-SEP-04 HAS R216606 Chloride (Cl) 3 1 mg/L 08-SEP-04 JTV R216410 Fluoride (F) 0.14 0.05 mg/L 11-SEP-04 RWR R217854 Nitrate+Nitrite-N <0.006 0.006 mg/L 08-SEP-04 TL R217051 Silica (as SiO2) 5.1 0.1 mg/L 08-SEP-04 BMA R216241 pH, Conductivity and Total Alkalinity pH 8.9 0.1 pH 07-SEP-04 PTT R216051 Conductivity (EC) 613 0.2 uS/cm 07-SEP-04 PTT R216051 Bicarbonate (HCO3) 340 5 mg/L 07-SEP-04 PTT R216051 Carbonate (CO3) 36 5 mg/L 07-SEP-04 PTT R216051 Hydroxide (OH) <5 5 mg/L 07-SEP-04 PTT R216051 Alkalinity, Total (as CaCO3) 340 5 mg/L 07-SEP-04 PTT R216051 Ion Balance Calculation Ion Balance 92.2 % 10-SEP-04 TDS (Calculated) 340 mg/L 10-SEP-04 Hardness (as CaCO3) 185 mg/L 10-SEP-04 ICP metals and SO4 for routine water Calcium (Ca) 15.9 0.5 mg/L 08-SEP-04 BMA R216241 Potassium (K) 6.9 0.1 mg/L 08-SEP-04 BMA R216241 Magnesium (Mg) 35.2 0.1 mg/L 08-SEP-04 BMA R216241 Sodium (Na) 62 1 mg/L 08-SEP-04 BMA R216241								

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L203708-19 HB SITE#1-REP#2 SYLVAN LAKE Sample Date: 03-SEP-04 Matrix: WATER Routine Water: Majors,F,Fe,Mn (Dis)&SiO2 ICP metals and SO4 for routine water Sulfate (SO4)	12.7		0.5	mg/L		08-SEP-04	BMA	R216241
L203708-20 HB SITE#1-REP#3 SYLVAN LAKE Sample Date: 03-SEP-04 Matrix: WATER Phosphorus, Dissolved 0.003 Phosphorus, Total 0.015 Ammonia-N 0.008 MF - E. Coli 2 MF - Fecal Coliforms 2 Total Kjeldahl Nitrogen 0.57 Total Suspended Solids 3 Routine Water: Majors,F,Fe,Mn (Dis)&SiO2 Iron (Fe)-Dissolved <0.06 Manganese(Mn)-Dissolved <0.01 Chloride (Cl) 3 Fluoride (F) 0.14 Nitrate+Nitrite-N <0.006 Silica (as SiO2) 5.1 pH, Conductivity and Total Alkalinity pH 8.9 Conductivity (EC) 615 Bicarbonate (HCO3) 341 Carbonate (CO3) 36 Hydroxide (OH) <5 Alkalinity, Total (as CaCO3) 340 Ion Balance Calculation Ion Balance 93.3 TDS (Calculated) 342 Hardness (as CaCO3) 187 ICP metals and SO4 for routine water Calcium (Ca) 16.1 Potassium (K) 7.1 Magnesium (Mg) 35.7 Sodium (Na) 63 Sulfate (SO4) 12.8	0.003 0.015 0.008 2 2 0.57 3 <0.06 <0.01 3 0.14 <0.006 5.1 8.9 615 341 36 <5 340 93.3 342 187 16.1 7.1 35.7 63 12.8		0.001 0.001 0.005 1 1 0.05 1 0.06 0.01 1 0.05 0.006 0.1 0.1 0.2 5 5 5 5 0.5 0.1 0.1 0.1 1 0.5	mg/L mg/L mg/L CFU/100mL CFU/100mL mg/L mg/L mg/L mg/L mg/L mg/L pH uS/cm mg/L mg/L mg/L mg/L % mg/L mg/L mg/L mg/L mg/L mg/L mg/L		13-SEP-04 13-SEP-04 13-SEP-04 07-SEP-04 07-SEP-04 09-SEP-04 17-SEP-04 09-SEP-04 09-SEP-04 08-SEP-04 11-SEP-04 08-SEP-04 08-SEP-04 07-SEP-04 07-SEP-04 07-SEP-04 07-SEP-04 07-SEP-04 07-SEP-04 10-SEP-04 10-SEP-04 10-SEP-04 08-SEP-04 08-SEP-04 08-SEP-04 08-SEP-04 08-SEP-04 08-SEP-04	TL TL TL/S S V N S V N TL ZOW HAS HAS JTV RWR TL BMA PTT PTT PTT PTT PTT PTT BMA BMA BMA BMA BMA BMA	R217793 R217793 R217770 R215501 R215501 R216854 R219314 R216606 R216606 R216410 R217854 R217051 R216241 R216051 R216051 R216051 R216051 R216051 R216051 R216241 R216241 R216241 R216241 R216241 R216241
L203708-21 #2 SYLVAN LAKE Sample Date: 03-SEP-04 Matrix: WATER Phosphorus, Dissolved 0.003 Phosphorus, Total 0.015 Ammonia-N 0.014 MF - E. Coli <1 MF - Fecal Coliforms <1 Total Kjeldahl Nitrogen 0.60 Routine Water: Majors,F,Fe,Mn (Dis)&SiO2 Iron (Fe)-Dissolved <0.06	0.003 0.015 0.014 <1 <1 0.60 <0.06		0.001 0.001 0.005 1 1 0.05 0.06	mg/L mg/L mg/L CFU/100mL CFU/100mL mg/L mg/L		13-SEP-04 13-SEP-04 09-SEP-04 07-SEP-04 07-SEP-04 09-SEP-04 09-SEP-04	TL TL TL/SHC S V N S V N TL HAS	R217793 R217793 R216871 R215501 R215501 R216854 R216606

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L203708-21 #2 SYLVAN LAKE Sample Date: 03-SEP-04 Matrix: WATER Routine Water: Majors,F,Fe,Mn (Dis)&SiO2 Manganese(Mn)-Dissolved <0.01 0.01 mg/L 09-SEP-04 HAS R216606 Chloride (Cl) 3 1 mg/L 08-SEP-04 JTV R216410 Fluoride (F) 0.13 0.05 mg/L 11-SEP-04 RWR R217854 Nitrate+Nitrite-N <0.006 0.006 mg/L 08-SEP-04 TL R217051 Silica (as SiO2) 5.4 0.1 mg/L 08-SEP-04 BMA R216241 pH, Conductivity and Total Alkalinity pH 8.9 0.1 pH 07-SEP-04 PTT R216051 Conductivity (EC) 615 0.2 uS/cm 07-SEP-04 PTT R216051 Bicarbonate (HCO3) 342 5 mg/L 07-SEP-04 PTT R216051 Carbonate (CO3) 36 5 mg/L 07-SEP-04 PTT R216051 Hydroxide (OH) <5 5 mg/L 07-SEP-04 PTT R216051 Alkalinity, Total (as CaCO3) 340 5 mg/L 07-SEP-04 PTT R216051 Ion Balance Calculation Ion Balance 92.6 % 10-SEP-04 TDS (Calculated) 342 mg/L 10-SEP-04 Hardness (as CaCO3) 184 mg/L 10-SEP-04 ICP metals and SO4 for routine water Calcium (Ca) 15.8 0.5 mg/L 08-SEP-04 BMA R216241 Potassium (K) 6.9 0.1 mg/L 08-SEP-04 BMA R216241 Magnesium (Mg) 35.0 0.1 mg/L 08-SEP-04 BMA R216241 Sodium (Na) 64 1 mg/L 08-SEP-04 BMA R216241 Sulfate (SO4) 12.9 0.5 mg/L 08-SEP-04 BMA R216241								
L203708-22 #3 SYLVAN LAKE Sample Date: 03-SEP-04 Matrix: WATER Phosphorus, Dissolved 0.003 0.001 mg/L 13-SEP-04 TL R217793 Phosphorus, Total 0.013 0.001 mg/L 13-SEP-04 TL R217793 Ammonia-N 0.011 0.005 mg/L 09-SEP-04 TL/SHC R216871 MF - E. Coli <1 1 CFU/100mL 07-SEP-04 S V N R215501 MF - Fecal Coliforms 1 1 CFU/100mL 07-SEP-04 S V N R215501 Total Kjeldahl Nitrogen 0.61 0.05 mg/L 09-SEP-04 TL R216854 Routine Water: Majors,F,Fe,Mn (Dis)&SiO2 Iron (Fe)-Dissolved <0.06 0.06 mg/L 09-SEP-04 HAS R216606 Manganese(Mn)-Dissolved <0.01 0.01 mg/L 09-SEP-04 HAS R216606 Chloride (Cl) 3 1 mg/L 08-SEP-04 JTV R216410 Fluoride (F) 0.13 0.05 mg/L 11-SEP-04 RWR R217854 Nitrate+Nitrite-N <0.006 0.006 mg/L 08-SEP-04 TL R217051 Silica (as SiO2) 5.4 0.1 mg/L 08-SEP-04 BMA R216241 pH, Conductivity and Total Alkalinity pH 8.9 0.1 pH 07-SEP-04 PTT R216051 Conductivity (EC) 611 0.2 uS/cm 07-SEP-04 PTT R216051 Bicarbonate (HCO3) 339 5 mg/L 07-SEP-04 PTT R216051 Carbonate (CO3) 37 5 mg/L 07-SEP-04 PTT R216051 Hydroxide (OH) <5 5 mg/L 07-SEP-04 PTT R216051 Alkalinity, Total (as CaCO3) 339 5 mg/L 07-SEP-04 PTT R216051 Ion Balance Calculation Ion Balance 93.5 % 10-SEP-04 TDS (Calculated) 342 mg/L 10-SEP-04								

ENVIRO-TEST ANALYTICAL REPORT

[illegible]

Sample Details/Parameters		Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L203708-24	SUNBREAKER COVE SYLVAN LAKE								
Sample Date: 03-SEP-04									
Matrix: WATER									
Total Kjeldahl Nitrogen		0.65		0.05	mg/L		09-SEP-04	TL	R216854
Routine Water: Majors,F,Fe,Mn (Dis)&SiO2									
Iron (Fe)-Dissolved		<0.06		0.06	mg/L		09-SEP-04	HAS	R216606
Manganese(Mn)-Dissolved		<0.01		0.01	mg/L		09-SEP-04	HAS	R216606
Chloride (Cl)		3		1	mg/L		08-SEP-04	JTV	R216410
Fluoride (F)		0.13		0.05	mg/L		11-SEP-04	RWR	R217854
Nitrate+Nitrite-N		<0.006		0.006	mg/L		08-SEP-04	TL	R217051
Silica (as SiO2)		3.2		0.1	mg/L		08-SEP-04	BMA	R216241
pH, Conductivity and Total Alkalinity									
pH		8.9		0.1	pH		07-SEP-04	PTT	R216051
Conductivity (EC)		614		0.2	uS/cm		07-SEP-04	PTT	R216051
Bicarbonate (HCO3)		344		5	mg/L		07-SEP-04	PTT	R216051
Carbonate (CO3)		36		5	mg/L		07-SEP-04	PTT	R216051
Hydroxide (OH)		<5		5	mg/L		07-SEP-04	PTT	R216051
Alkalinity, Total (as CaCO3)		341		5	mg/L		07-SEP-04	PTT	R216051
Ion Balance Calculation									
Ion Balance		96.7			%		13-SEP-04		
TDS (Calculated)		350			mg/L		13-SEP-04		
Hardness (as CaCO3)		194			mg/L		13-SEP-04		
ICP metals and SO4 for routine water									
Calcium (Ca)		17.0		0.5	mg/L		10-SEP-04	BMA	R217114
Potassium (K)		7.5		0.1	mg/L		10-SEP-04	BMA	R217114
Magnesium (Mg)		36.7		0.1	mg/L		10-SEP-04	BMA	R217114
Sodium (Na)		67		1	mg/L		10-SEP-04	BMA	R217114
Sulfate (SO4)		13.9		0.5	mg/L		10-SEP-04	BMA	R217114
L203708-25	SITE #5 SYLVAN LAKE								
Sample Date: 03-SEP-04									
Matrix: WATER									
Phosphorus, Dissolved		0.004		0.001	mg/L		13-SEP-04	TL	R217793
Phosphorus, Total		0.016		0.001	mg/L		13-SEP-04	TL	R217793
Ammonia-N		0.009		0.005	mg/L		09-SEP-04	TL/SHC	R216871
Total Kjeldahl Nitrogen		0.65		0.05	mg/L		09-SEP-04	TL	R216854
Routine Water: Majors,F,Fe,Mn (Dis)&SiO2									
Iron (Fe)-Dissolved		<0.06		0.06	mg/L		09-SEP-04	HAS	R216606
Manganese(Mn)-Dissolved		<0.01		0.01	mg/L		09-SEP-04	HAS	R216606
Chloride (Cl)		4		1	mg/L		08-SEP-04	JTV	R216410
Fluoride (F)		0.13		0.05	mg/L		11-SEP-04	RWR	R217854
Nitrate+Nitrite-N		<0.006		0.006	mg/L		08-SEP-04	TL	R217051
Silica (as SiO2)		3.5		0.1	mg/L		08-SEP-04	BMA	R216241
pH, Conductivity and Total Alkalinity									
pH		8.9		0.1	pH		07-SEP-04	PTT	R216051
Conductivity (EC)		612		0.2	uS/cm		07-SEP-04	PTT	R216051
Bicarbonate (HCO3)		342		5	mg/L		07-SEP-04	PTT	R216051
Carbonate (CO3)		36		5	mg/L		07-SEP-04	PTT	R216051
Hydroxide (OH)		<5		5	mg/L		07-SEP-04	PTT	R216051
Alkalinity, Total (as CaCO3)		341		5	mg/L		07-SEP-04	PTT	R216051
Ion Balance Calculation									
Ion Balance		95.7			%		13-SEP-04		

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L203708-25 SITE #5 SYLVAN LAKE Sample Date: 03-SEP-04 Matrix: WATER Routine Water: Majors,F,Fe,Mn (Dis)&SiO2 Ion Balance Calculation TDS (Calculated) Hardness (as CaCO3) ICP metals and SO4 for routine water Calcium (Ca) Potassium (K) Magnesium (Mg) Sodium (Na) Sulfate (SO4)	 348 194 17.0 7.4 36.7 65 13.5			 mg/L mg/L mg/L mg/L mg/L mg/L mg/L		 13-SEP-04 13-SEP-04 10-SEP-04 10-SEP-04 10-SEP-04 10-SEP-04 10-SEP-04	 BMA BMA BMA BMA BMA	 R217114 R217114 R217114 R217114 R217114
Refer to Referenced Information for Qualifiers (if any) and Methodology.								

Reference Information

Sample Parameter Qualifier key listed:

Qualifier	Description
RAMB	Result Adjusted For Method Blank

Methods Listed (if applicable):

ETL Test Code	Matrix	Test Description	Preparation Method Reference(Based On)	Analytical Method Reference(Based On)
C-DIS-ORG-CL	Water	Dissolved Organic Carbon		APHA 5310 C-Instrumental
CL-ED	Water	Chloride (Cl)		APHA 4500 Cl E-Colorimetry
ECC-MF-RAW-ED	Water	Escherchia coli Count (E.coli)-MF		APHA 9221F MF
ETL-ROUTINE-ICP-ED	Water	ICP metals and SO4 for routine water		APHA 3120 B-ICP-OES
F-ED	Water	Fluoride (F)		APHA 4500 F-C-Electrode
FCC-MF-RAW-ED	Water	Fecal Coliform Count-MF		APHA 9222D MF
FE-DIS-HIGH-ED	Water	Iron (Fe)-Dissolved		EPA 200.7
IONBALANCE-ED	Water	Ion Balance Calculation		APHA 1030E
MN-DIS-HIGH-ED	Water	Manganese(Mn)-Dissolved		EPA 200.7
N-TOTKJ-LOW-ED	Water	Total Kjeldahl Nitrogen	TECHNICON	APHA 4500Norg C-Dig.-Auto-Colorimetry
N2N3-LOW-ED	Water	Nitrate+Nitrite-N		APHA 4500 NO3E-Colorimetry
NH4-LOW-ED	Water	Ammonia-N		APHA 4500 NH3F-Colorimetry
P-TOTAL-LOW-ED	Water	Phosphorus, Total		APHA 4500 P B,E-Auto-Colorimetry
P-TOTALDIS-LOW-ED	Water	Phosphorus, Dissolved		APHA 4500 P B,E-Auto-Colorimetry
PH/EC/ALK-ED	Water	pH, Conductivity and Total Alkalinity		APHA 4500-H, 2510, 2320
SIO2-CALC-ED	Water	Silica (as SIO2)		ICP/CALCULATION-ICP/CALCULATION
SOLIDS-TOTSUS-LOW-ED	Water	Total Suspended Solids		APHA 2540 D-Gravimetric

** Laboratory Methods employed follow in-house procedures, which are generally based on nationally or internationally accepted methodologies.

Chain of Custody numbers:

127917127918127919

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location	Laboratory Definition Code	Laboratory Location
CL	Enviro-Test Laboratories - Calgary, Alberta, Canada	ED	Enviro-Test Laboratories - Edmonton, Alberta, Canada

Reference Information

GLOSSARY OF REPORT TERMS

Surr - A surrogate is an organic compound that is similar to the target analyte(s) in chemical composition and behavior but not normally detected in environmental samples. Prior to sample processing, samples are fortified with one or more surrogate compounds.

The reported surrogate recovery value provides a measure of method efficiency. The Laboratory warning units are determined under column heading D.L.

mg/kg (units) - unit of concentration based on mass, parts per million

mg/L (units) - unit of concentration based on volume, parts per million

< - Less than

D.L. - Detection Limit

N/A - Result not available. Refer to qualifier code and definition for explanation

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

UNLESS OTHERWISE STATED, SAMPLES ARE NOT CORRECTED FOR CLIENT FIELD BLANKS.

Although test results are generated under strict QA/QC protocols, any unsigned test reports, faxes, or emails are considered preliminary.

Enviro-Test Laboratories has an extensive QA/QC program where all analytical data reported is analyzed using approved referenced procedures followed by checks and reviews by senior managers and quality assurance personnel. However, since the results are obtained from chemical measurements and thus cannot be guaranteed, Enviro-Test Laboratories assumes no liability for the use or interpretation of the results.

ANALYTICAL REPORT

NORTH/SOUTH CONSULTANTS

DATE: 09-MAR-05 04:38 PM

ATTN: MEGAN COOLEY

83 SCURFIELD BLVD

WINNIPEG MB R3Y 1G4

Lab Work Order #: L204046

Sampled By: CF/DK

Date Received: 07-SEP-04

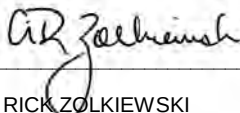
Project P.O. #:

Project Reference: NS174

Comments:



DOUG JOHNSON
Director of Operations, Edmonton



RICK ZOLKIEWSKI
Client Service Specialist

THIS REPORT SHALL NOT BE REPRODUCED EXCEPT IN FULL WITHOUT THE WRITTEN AUTHORITY OF THE LABORATORY.
ANY REMAINING SAMPLES WILL BE DISPOSED OF AFTER 30 DAYS FOLLOWING ANALYSIS. PLEASE CONTACT THE LAB IF YOU
REQUIRE ADDITIONAL SAMPLE STORAGE TIME.

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L204046-1SLF SYLVAN LAKE Sample Date: 06-SEP-04 Matrix: WATER								
Phosphorus, Dissolved	<0.001		0.001	mg/L		15-SEP-04	TL	R218611
Phosphorus, Total	<0.001		0.001	mg/L		15-SEP-04	TL	R218611
Ammonia-N	<0.005		0.005	mg/L		09-SEP-04	TL/SHC	R216871
Dissolved Organic Carbon	<1		1	mg/L		09-SEP-04	RJK	R217022
MF - E. Coli	<1		1	CFU/100mL		09-SEP-04	DEL	R216775
MF - Fecal Coliforms	<1		1	CFU/100mL		09-SEP-04	DEL	R216775
Total Kjeldahl Nitrogen	0.07		0.05	mg/L		09-SEP-04	TL/SHC	R216801
Total Suspended Solids	<1		1	mg/L		17-SEP-04	ZOW	R219314
Routine Water: Majors,F,Fe,Mn (Dis)&SiO2								
Iron (Fe)-Dissolved	<0.06		0.06	mg/L		09-SEP-04	HAS	R216606
Manganese(Mn)-Dissolved	<0.01		0.01	mg/L		09-SEP-04	HAS	R216606
Chloride (Cl)	<1		1	mg/L		09-SEP-04	JTV	R216810
Fluoride (F)	<0.05		0.05	mg/L		08-SEP-04	PTT	R216615
Nitrate+Nitrite-N	<0.006		0.006	mg/L		07-SEP-04	TL	R216462
Silica (as SiO2)	<0.1		0.1	mg/L		09-SEP-04	EOC	R216789
pH, Conductivity and Total Alkalinity								
pH	5.7		0.1	pH		08-SEP-04	PTT	R216615
Conductivity (EC)	1.0		0.2	uS/cm		08-SEP-04	PTT	R216615
Bicarbonate (HCO3)	<5		5	mg/L		08-SEP-04	PTT	R216615
Carbonate (CO3)	<5		5	mg/L		08-SEP-04	PTT	R216615
Hydroxide (OH)	<5		5	mg/L		08-SEP-04	PTT	R216615
Alkalinity, Total (as CaCO3)	<5		5	mg/L		08-SEP-04	PTT	R216615
Ion Balance Calculation								
Ion Balance	Low TDS			%		10-SEP-04		
TDS (Calculated)	<1			mg/L		10-SEP-04		
Hardness (as CaCO3)	<1			mg/L		10-SEP-04		
ICP metals and SO4 for routine water								
Calcium (Ca)	<0.5		0.5	mg/L		09-SEP-04	EOC	R216789
Potassium (K)	<0.1		0.1	mg/L		09-SEP-04	EOC	R216789
Magnesium (Mg)	<0.1		0.1	mg/L		09-SEP-04	EOC	R216789
Sodium (Na)	<1		1	mg/L		09-SEP-04	EOC	R216789
Sulfate (SO4)	<0.5		0.5	mg/L		09-SEP-04	EOC	R216789
L204046-3SLA-SURFACE SYLVAN LAKE Sample Date: 06-SEP-04 Matrix: WATER								
Phosphorus, Dissolved	0.004		0.001	mg/L		15-SEP-04	TL	R218611
Phosphorus, Total	0.014		0.001	mg/L		15-SEP-04	TL	R218611
Ammonia-N	0.015		0.005	mg/L		09-SEP-04	TL/SHC	R216871
Total Kjeldahl Nitrogen	0.59		0.05	mg/L		09-SEP-04	TL/SHC	R216801
Routine Water: Majors,F,Fe,Mn (Dis)&SiO2								
Iron (Fe)-Dissolved	<0.06		0.06	mg/L		09-SEP-04	HAS	R216606
Manganese(Mn)-Dissolved	<0.01		0.01	mg/L		09-SEP-04	HAS	R216606
Chloride (Cl)	4		1	mg/L		09-SEP-04	JTV	R216810
Fluoride (F)	0.16		0.05	mg/L		08-SEP-04	PTT	R216615
Nitrate+Nitrite-N	<0.006		0.006	mg/L		07-SEP-04	TL	R216462
Silica (as SiO2)	5.6		0.1	mg/L		09-SEP-04	EOC	R216789
pH, Conductivity and Total Alkalinity								
pH	8.9		0.1	pH		08-SEP-04	PTT	R216615

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L204046-3 SLA-SURFACE SYLVAN LAKE Sample Date: 06-SEP-04 Matrix: WATER Routine Water: Majors,F,Fe,Mn (Dis)&SiO2 pH, Conductivity and Total Alkalinity Conductivity (EC) 625 0.2 uS/cm 08-SEP-04 PTT R216615 Bicarbonate (HCO3) 332 5 mg/L 08-SEP-04 PTT R216615 Carbonate (CO3) 33 5 mg/L 08-SEP-04 PTT R216615 Hydroxide (OH) <5 5 mg/L 08-SEP-04 PTT R216615 Alkalinity, Total (as CaCO3) 326 5 mg/L 08-SEP-04 PTT R216615 Ion Balance Calculation Ion Balance 101 % 10-SEP-04 TDS (Calculated) 342 mg/L 10-SEP-04 Hardness (as CaCO3) 196 mg/L 10-SEP-04 ICP metals and SO4 for routine water Calcium (Ca) 17.0 0.5 mg/L 09-SEP-04 EOC R216789 Potassium (K) 7.6 0.1 mg/L 09-SEP-04 EOC R216789 Magnesium (Mg) 37.2 0.1 mg/L 09-SEP-04 EOC R216789 Sodium (Na) 67 1 mg/L 09-SEP-04 EOC R216789 Sulfate (SO4) 13.2 0.5 mg/L 09-SEP-04 EOC R216789								
L204046-4 SLA-2M SYLVAN LAKE Sample Date: 06-SEP-04 Matrix: WATER Phosphorus, Dissolved 0.005 0.001 mg/L 15-SEP-04 TL R218611 Phosphorus, Total 0.027 0.001 mg/L 15-SEP-04 TL R218611 Ammonia-N 0.008 0.005 mg/L 09-SEP-04 TL/SHC R216871 Total Kjeldahl Nitrogen 0.65 0.05 mg/L 09-SEP-04 TL/SHC R216801 Routine Water: Majors,F,Fe,Mn (Dis)&SiO2 Iron (Fe)-Dissolved <0.06 0.06 mg/L 09-SEP-04 HAS R216606 Manganese(Mn)-Dissolved <0.01 0.01 mg/L 09-SEP-04 HAS R216606 Chloride (Cl) 4 1 mg/L 09-SEP-04 JTV R216810 Fluoride (F) 0.16 0.05 mg/L 08-SEP-04 PTT R216615 Nitrate+Nitrite-N <0.006 0.006 mg/L 07-SEP-04 TL R216462 Silica (as SiO2) 5.7 0.1 mg/L 09-SEP-04 EOC R216789 pH, Conductivity and Total Alkalinity pH 8.9 0.1 pH 08-SEP-04 PTT R216615 Conductivity (EC) 634 0.2 uS/cm 08-SEP-04 PTT R216615 Bicarbonate (HCO3) 330 5 mg/L 08-SEP-04 PTT R216615 Carbonate (CO3) 35 5 mg/L 08-SEP-04 PTT R216615 Hydroxide (OH) <5 5 mg/L 08-SEP-04 PTT R216615 Alkalinity, Total (as CaCO3) 329 5 mg/L 08-SEP-04 PTT R216615 Ion Balance Calculation Ion Balance 104 % 10-SEP-04 TDS (Calculated) 348 mg/L 10-SEP-04 Hardness (as CaCO3) 202 mg/L 10-SEP-04 ICP metals and SO4 for routine water Calcium (Ca) 17.6 0.5 mg/L 09-SEP-04 EOC R216789 Potassium (K) 7.9 0.1 mg/L 09-SEP-04 EOC R216789 Magnesium (Mg) 38.4 0.1 mg/L 09-SEP-04 EOC R216789 Sodium (Na) 69 1 mg/L 09-SEP-04 EOC R216789 Sulfate (SO4) 13.9 0.5 mg/L 09-SEP-04 EOC R216789								

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L204046-5SLA-4M SYLVAN LAKE Sample Date: 06-SEP-04 Matrix: WATER								
Phosphorus, Dissolved	0.005		0.001	mg/L		15-SEP-04	TL	R218611
Phosphorus, Total	0.022		0.001	mg/L		15-SEP-04	TL	R218611
Ammonia-N	0.009		0.005	mg/L		09-SEP-04	TL/SHC	R216871
Total Kjeldahl Nitrogen	0.60		0.05	mg/L		09-SEP-04	TL/SHC	R216801
Routine Water: Majors,F,Fe,Mn (Dis)&SiO2								
Iron (Fe)-Dissolved	<0.06		0.06	mg/L		09-SEP-04	HAS	R216606
Manganese(Mn)-Dissolved	<0.01		0.01	mg/L		09-SEP-04	HAS	R216606
Chloride (Cl)	4		1	mg/L		09-SEP-04	JTV	R216810
Fluoride (F)	0.16		0.05	mg/L		08-SEP-04	PTT	R216615
Nitrate+Nitrite-N	<0.006		0.006	mg/L		07-SEP-04	TL	R216462
Silica (as SiO2)	5.6		0.1	mg/L		09-SEP-04	EOC	R216789
pH, Conductivity and Total Alkalinity								
pH	8.9		0.1	pH		08-SEP-04	PTT	R216615
Conductivity (EC)	624		0.2	uS/cm		08-SEP-04	PTT	R216615
Bicarbonate (HCO3)	326		5	mg/L		08-SEP-04	PTT	R216615
Carbonate (CO3)	35		5	mg/L		08-SEP-04	PTT	R216615
Hydroxide (OH)	<5		5	mg/L		08-SEP-04	PTT	R216615
Alkalinity, Total (as CaCO3)	325		5	mg/L		08-SEP-04	PTT	R216615
Ion Balance Calculation								
Ion Balance	104			%		10-SEP-04		
TDS (Calculated)	344			mg/L		10-SEP-04		
Hardness (as CaCO3)	200			mg/L		10-SEP-04		
ICP metals and SO4 for routine water								
Calcium (Ca)	17.4		0.5	mg/L		09-SEP-04	EOC	R216789
Potassium (K)	7.7		0.1	mg/L		09-SEP-04	EOC	R216789
Magnesium (Mg)	38.1		0.1	mg/L		09-SEP-04	EOC	R216789
Sodium (Na)	68		1	mg/L		09-SEP-04	EOC	R216789
Sulfate (SO4)	13.7		0.5	mg/L		09-SEP-04	EOC	R216789
L204046-6SLA-6M SYLVAN LAKE Sample Date: 06-SEP-04 Matrix: WATER								
Phosphorus, Dissolved	0.004		0.001	mg/L		15-SEP-04	TL	R218614
Phosphorus, Total	0.019		0.001	mg/L		15-SEP-04	TL	R218614
Ammonia-N	<0.005		0.005	mg/L		09-SEP-04	TL/SHC	R216871
Total Kjeldahl Nitrogen	0.48		0.05	mg/L		09-SEP-04	TL/SHC	R216801
Routine Water: Majors,F,Fe,Mn (Dis)&SiO2								
Iron (Fe)-Dissolved	<0.06		0.06	mg/L		09-SEP-04	HAS	R216606
Manganese(Mn)-Dissolved	<0.01		0.01	mg/L		09-SEP-04	HAS	R216606
Chloride (Cl)	4		1	mg/L		09-SEP-04	JTV	R216810
Fluoride (F)	0.16		0.05	mg/L		08-SEP-04	PTT	R216615
Nitrate+Nitrite-N	<0.006		0.006	mg/L		07-SEP-04	TL	R216462
Silica (as SiO2)	5.6		0.1	mg/L		09-SEP-04	EOC	R216789
pH, Conductivity and Total Alkalinity								
pH	8.9		0.1	pH		08-SEP-04	PTT	R216615
Conductivity (EC)	624		0.2	uS/cm		08-SEP-04	PTT	R216615
Bicarbonate (HCO3)	327		5	mg/L		08-SEP-04	PTT	R216615
Carbonate (CO3)	35		5	mg/L		08-SEP-04	PTT	R216615
Hydroxide (OH)	<5		5	mg/L		08-SEP-04	PTT	R216615

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L204046-6SLA-6M SYLVAN LAKE Sample Date: 06-SEP-04 Matrix: WATER Routine Water: Majors,F,Fe,Mn (Dis)&SiO2 pH, Conductivity and Total Alkalinity Alkalinity, Total (as CaCO3) Ion Balance Calculation Ion Balance TDS (Calculated) Hardness (as CaCO3) ICP metals and SO4 for routine water Calcium (Ca) Potassium (K) Magnesium (Mg) Sodium (Na) Sulfate (SO4)	 327 103 344 197 17.2 7.7 37.5 68 13.6		 5 0.5 0.1 0.1 1 0.5	 mg/L % mg/L mg/L mg/L mg/L mg/L mg/L mg/L		 08-SEP-04 10-SEP-04 10-SEP-04 10-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04	 PTT EOC EOC EOC EOC EOC	 R216615 R216789 R216789 R216789 R216789 R216789
L204046-7SLA-8M SYLVAN LAKE Sample Date: 06-SEP-04 Matrix: WATER Phosphorus, Dissolved Phosphorus, Total Ammonia-N Total Kjeldahl Nitrogen Routine Water: Majors,F,Fe,Mn (Dis)&SiO2 Iron (Fe)-Dissolved Manganese(Mn)-Dissolved Chloride (Cl) Fluoride (F) Nitrate+Nitrite-N Silica (as SiO2) pH, Conductivity and Total Alkalinity pH Conductivity (EC) Bicarbonate (HCO3) Carbonate (CO3) Hydroxide (OH) Alkalinity, Total (as CaCO3) Ion Balance Calculation Ion Balance TDS (Calculated) Hardness (as CaCO3) ICP metals and SO4 for routine water Calcium (Ca) Potassium (K) Magnesium (Mg) Sodium (Na) Sulfate (SO4)	 0.004 0.017 <0.005 0.52 <0.06 <0.01 4 0.16 <0.006 5.7 8.9 626 329 34 <5 327 102 344 196 17.1 8.0 37.3 68 13.6		 0.001 0.001 0.005 0.05 0.06 0.01 1 0.05 0.006 0.1 0.1 0.2 5 5 5 5 0.5 0.1 0.1 1 0.5	 mg/L mg/L mg/L mg/L mg/L mg/L mg/L mg/L mg/L mg/L pH uS/cm mg/L mg/L mg/L mg/L % mg/L mg/L mg/L mg/L mg/L mg/L mg/L		 15-SEP-04 15-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04 08-SEP-04 07-SEP-04 09-SEP-04 08-SEP-04 08-SEP-04 08-SEP-04 08-SEP-04 08-SEP-04 08-SEP-04 10-SEP-04 10-SEP-04 10-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04	 TL TL TL/SHC TL/SHC HAS HAS JTV PTT TL EOC PTT PTT PTT PTT PTT PTT EOC EOC EOC EOC EOC	 R218614 R218614 R216871 R216801 R216606 R216606 R216810 R216615 R216462 R216789 R216615 R216615 R216615 R216615 R216615 R216615 R216789 R216789 R216789 R216789 R216789
L204046-8SLA-10M SYLVAN LAKE Sample Date: 06-SEP-04 Matrix: WATER Phosphorus, Dissolved Phosphorus, Total	 0.005 0.017		 0.001 0.001	 mg/L mg/L		 15-SEP-04 15-SEP-04	 TL TL	 R218614 R218614

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L204046-8 SLA-10M SYLVAN LAKE Sample Date: 06-SEP-04 Matrix: WATER								
Ammonia-N	<0.005	RAMB	0.005	mg/L		09-SEP-04	TL/SHC	R216871
Total Kjeldahl Nitrogen	0.67		0.05	mg/L		14-SEP-04	TL	R218231
Routine Water: Majors,F,Fe,Mn (Dis)&SiO2								
Iron (Fe)-Dissolved	<0.06		0.06	mg/L		09-SEP-04	HAS	R216606
Manganese(Mn)-Dissolved	<0.01		0.01	mg/L		09-SEP-04	HAS	R216606
Chloride (Cl)	3		1	mg/L		09-SEP-04	JTV	R216810
Fluoride (F)	0.16		0.05	mg/L		08-SEP-04	PTT	R216615
Nitrate+Nitrite-N	<0.006		0.006	mg/L		07-SEP-04	TL	R216462
Silica (as SiO2)	5.6		0.1	mg/L		09-SEP-04	EOC	R216789
pH, Conductivity and Total Alkalinity								
pH	8.9		0.1	pH		08-SEP-04	PTT	R216615
Conductivity (EC)	624		0.2	uS/cm		08-SEP-04	PTT	R216615
Bicarbonate (HCO3)	336		5	mg/L		08-SEP-04	PTT	R216615
Carbonate (CO3)	34		5	mg/L		08-SEP-04	PTT	R216615
Hydroxide (OH)	<5		5	mg/L		08-SEP-04	PTT	R216615
Alkalinity, Total (as CaCO3)	332		5	mg/L		08-SEP-04	PTT	R216615
Ion Balance Calculation								
Ion Balance	102			%		10-SEP-04		
TDS (Calculated)	347			mg/L		10-SEP-04		
Hardness (as CaCO3)	200			mg/L		10-SEP-04		
ICP metals and SO4 for routine water								
Calcium (Ca)	17.4		0.5	mg/L		09-SEP-04	EOC	R216789
Potassium (K)	8.0		0.1	mg/L		09-SEP-04	EOC	R216789
Magnesium (Mg)	38.1		0.1	mg/L		09-SEP-04	EOC	R216789
Sodium (Na)	68		1	mg/L		09-SEP-04	EOC	R216789
Sulfate (SO4)	13.6		0.5	mg/L		09-SEP-04	EOC	R216789
L204046-9 SLA-12M SYLVAN LAKE Sample Date: 06-SEP-04 Matrix: WATER								
Phosphorus, Dissolved	0.004	RAMB	0.001	mg/L		15-SEP-04	TL	R218614
Phosphorus, Total	0.017		0.001	mg/L		15-SEP-04	TL	R218614
Ammonia-N	0.009		0.005	mg/L		09-SEP-04	TL/SHC	R216871
Total Kjeldahl Nitrogen	0.57		0.05	mg/L		14-SEP-04	TL	R218231
Routine Water: Majors,F,Fe,Mn (Dis)&SiO2								
Iron (Fe)-Dissolved	<0.06		0.06	mg/L		09-SEP-04	HAS	R216606
Manganese(Mn)-Dissolved	<0.01		0.01	mg/L		09-SEP-04	HAS	R216606
Chloride (Cl)	3		1	mg/L		09-SEP-04	JTV	R216810
Fluoride (F)	0.16		0.05	mg/L		08-SEP-04	PTT	R216615
Nitrate+Nitrite-N	<0.006		0.006	mg/L		07-SEP-04	TL	R216462
Silica (as SiO2)	5.5		0.1	mg/L		09-SEP-04	EOC	R216789
pH, Conductivity and Total Alkalinity								
pH	8.9		0.1	pH		08-SEP-04	PTT	R216615
Conductivity (EC)	625		0.2	uS/cm		08-SEP-04	PTT	R216615
Bicarbonate (HCO3)	327		5	mg/L		08-SEP-04	PTT	R216615
Carbonate (CO3)	35		5	mg/L		08-SEP-04	PTT	R216615
Hydroxide (OH)	<5		5	mg/L		08-SEP-04	PTT	R216615
Alkalinity, Total (as CaCO3)	327		5	mg/L		08-SEP-04	PTT	R216615
Ion Balance Calculation								

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L204046-9SLA-12M SYLVAN LAKE Sample Date: 06-SEP-04 Matrix: WATER Routine Water: Majors,F,Fe,Mn (Dis)&SiO2 Ion Balance Calculation Ion Balance102%10-SEP-04 TDS (Calculated)342mg/L10-SEP-04 Hardness (as CaCO3)197mg/L10-SEP-04 ICP metals and SO4 for routine water Calcium (Ca)17.10.5mg/L09-SEP-04EOCR216789 Potassium (K)7.70.1mg/L09-SEP-04EOCR216789 Magnesium (Mg)37.50.1mg/L09-SEP-04EOCR216789 Sodium (Na)671mg/L09-SEP-04EOCR216789 Sulfate (SO4)13.40.5mg/L09-SEP-04EOCR216789								
L204046-10SLA-14M SYLVAN LAKE Sample Date: 06-SEP-04 Matrix: WATER Phosphorus, Dissolved0.0040.001mg/L15-SEP-04TLR218614 Phosphorus, Total0.0190.001mg/L15-SEP-04TLR218614 Ammonia-N0.0060.005mg/L09-SEP-04TL/SHCR216871 Total Kjeldahl Nitrogen0.590.05mg/L14-SEP-04TLR218231 Routine Water: Majors,F,Fe,Mn (Dis)&SiO2 Iron (Fe)-Dissolved<0.060.06mg/L09-SEP-04HASR216606 Manganese(Mn)-Dissolved<0.010.01mg/L09-SEP-04HASR216606 Chloride (Cl)31mg/L09-SEP-04JTVR216810 Fluoride (F)0.160.05mg/L08-SEP-04PTTR216615 Nitrate+Nitrite-N<0.0060.006mg/L07-SEP-04TLR216462 Silica (as SiO2)5.60.1mg/L09-SEP-04EOCR216789 pH, Conductivity and Total Alkalinity pH8.90.1pH08-SEP-04PTTR216615 Conductivity (EC)6250.2uS/cm08-SEP-04PTTR216615 Bicarbonate (HCO3)3305mg/L08-SEP-04PTTR216615 Carbonate (CO3)345mg/L08-SEP-04PTTR216615 Hydroxide (OH)<55mg/L08-SEP-04PTTR216615 Alkalinity, Total (as CaCO3)3285mg/L08-SEP-04PTTR216615 Ion Balance Calculation Ion Balance102%10-SEP-04 TDS (Calculated)343mg/L10-SEP-04 Hardness (as CaCO3)197mg/L10-SEP-04 ICP metals and SO4 for routine water Calcium (Ca)17.10.5mg/L09-SEP-04EOCR216789 Potassium (K)7.80.1mg/L09-SEP-04EOCR216789 Magnesium (Mg)37.50.1mg/L09-SEP-04EOCR216789 Sodium (Na)671mg/L09-SEP-04EOCR216789 Sulfate (SO4)13.60.5mg/L09-SEP-04EOCR216789		RAMB						
L204046-11SLA-16M SYLVAN LAKE Sample Date: 06-SEP-04 Matrix: WATER Phosphorus, Dissolved0.0060.001mg/L15-SEP-04TLR218614 Phosphorus, Total0.0260.001mg/L15-SEP-04TLR218614 Ammonia-N0.0160.005mg/L09-SEP-04TL/SHCR216871								

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters		Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch	
L204046-11 SLA-16M SYLVAN LAKE Sample Date: 06-SEP-04 Matrix: WATER										
Total Kjeldahl Nitrogen		0.67	RAMB	0.05	mg/L		14-SEP-04	TL	R218231	
Routine Water: Majors,F,Fe,Mn (Dis)&SiO2										
Iron (Fe)-Dissolved		<0.06		0.06	mg/L		09-SEP-04	HAS	R216606	
Manganese(Mn)-Dissolved		<0.01		0.01	mg/L		09-SEP-04	HAS	R216606	
Chloride (Cl)		4		1	mg/L		09-SEP-04	JTV	R216810	
Fluoride (F)		0.16		0.05	mg/L		08-SEP-04	PTT	R216615	
Nitrate+Nitrite-N		<0.006		0.006	mg/L		07-SEP-04	TL	R216462	
Silica (as SiO2)		5.8		0.1	mg/L		09-SEP-04	EOC	R216789	
pH, Conductivity and Total Alkalinity										
pH		8.9		0.1	pH		08-SEP-04	PTT	R216615	
Conductivity (EC)		626		0.2	uS/cm		08-SEP-04	PTT	R216615	
Bicarbonate (HCO3)		333		5	mg/L		08-SEP-04	PTT	R216615	
Carbonate (CO3)		33		5	mg/L		08-SEP-04	PTT	R216615	
Hydroxide (OH)		<5		5	mg/L		08-SEP-04	PTT	R216615	
Alkalinity, Total (as CaCO3)		328		5	mg/L		08-SEP-04	PTT	R216615	
Ion Balance Calculation										
Ion Balance		101			%		10-SEP-04			
TDS (Calculated)		343			mg/L		10-SEP-04			
Hardness (as CaCO3)		195			mg/L		10-SEP-04			
ICP metals and SO4 for routine water										
Calcium (Ca)		17.0	0.5	mg/L		09-SEP-04	EOC	R216789		
Potassium (K)		7.7	0.1	mg/L		09-SEP-04	EOC	R216789		
Magnesium (Mg)		37.0	0.1	mg/L		09-SEP-04	EOC	R216789		
Sodium (Na)		67	1	mg/L		09-SEP-04	EOC	R216789		
Sulfate (SO4)		13.3	0.5	mg/L		09-SEP-04	EOC	R216789		
L204046-13 SLD SYLVAN LAKE Sample Date: 06-SEP-04 Matrix: WATER										
Phosphorus, Dissolved		0.004	RAMB	0.001	mg/L		15-SEP-04	TL	R218614	
Phosphorus, Total		0.016		0.001	mg/L		15-SEP-04	TL	R218614	
Ammonia-N		0.008		0.005	mg/L		09-SEP-04	TL/SHC	R216871	
Dissolved Organic Carbon		5		1	mg/L		09-SEP-04	RJK	R217022	
Phytoplankton Biovolumes		See Attached		0			20-SEP-04	BMG	R220067	
Total Kjeldahl Nitrogen		0.46		0.05	mg/L		14-SEP-04	TL	R218231	
Total Suspended Solids		2		1	mg/L		17-SEP-04	ZOW	R219314	
Routine Water: Majors,F,Fe,Mn (Dis)&SiO2										
Iron (Fe)-Dissolved		<0.06		0.06	mg/L		09-SEP-04	HAS	R216606	
Manganese(Mn)-Dissolved		<0.01		0.01	mg/L		09-SEP-04	HAS	R216606	
Chloride (Cl)		4		1	mg/L		09-SEP-04	JTV	R216810	
Fluoride (F)		0.16		0.05	mg/L		08-SEP-04	PTT	R216615	
Nitrate+Nitrite-N		<0.006		0.006	mg/L		07-SEP-04	TL	R216462	
Silica (as SiO2)		5.5		0.1	mg/L		09-SEP-04	EOC	R216789	
pH, Conductivity and Total Alkalinity										
pH		8.9		0.1	pH		08-SEP-04	PTT	R216615	
Conductivity (EC)		626		0.2	uS/cm		08-SEP-04	PTT	R216615	
Bicarbonate (HCO3)		329		5	mg/L		08-SEP-04	PTT	R216615	
Carbonate (CO3)		34		5	mg/L		08-SEP-04	PTT	R216615	
Hydroxide (OH)		<5	5	mg/L		08-SEP-04	PTT	R216615		

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L204046-13 SLD SYLVAN LAKE Sample Date: 06-SEP-04 Matrix: WATER Routine Water: Majors,F,Fe,Mn (Dis)&SiO2 pH, Conductivity and Total Alkalinity Alkalinity, Total (as CaCO3) Ion Balance Calculation Ion Balance TDS (Calculated) Hardness (as CaCO3) ICP metals and SO4 for routine water Calcium (Ca) Potassium (K) Magnesium (Mg) Sodium (Na) Sulfate (SO4)	326 102 342 196 17.0 7.7 37.3 67 13.3		5	mg/L % mg/L mg/L mg/L mg/L mg/L mg/L mg/L		08-SEP-04 10-SEP-04 10-SEP-04 10-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04	PTT EOC EOC EOC EOC EOC	R216615 R216789 R216789 R216789 R216789 R216789
L204046-14 JARVIS BAY SYLVAN LAKE Sample Date: 06-SEP-04 Matrix: WATER Phosphorus, Dissolved Phosphorus, Total Ammonia-N MF - E. Coli MF - Fecal Coliforms Total Kjeldahl Nitrogen Routine Water: Majors,F,Fe,Mn (Dis)&SiO2 Iron (Fe)-Dissolved Manganese(Mn)-Dissolved Chloride (Cl) Fluoride (F) Nitrate+Nitrite-N Silica (as SiO2) pH, Conductivity and Total Alkalinity pH Conductivity (EC) Bicarbonate (HCO3) Carbonate (CO3) Hydroxide (OH) Alkalinity, Total (as CaCO3) Ion Balance Calculation Ion Balance TDS (Calculated) Hardness (as CaCO3) ICP metals and SO4 for routine water Calcium (Ca) Potassium (K) Magnesium (Mg) Sodium (Na) Sulfate (SO4)	0.004 0.015 0.007 <1 1 0.73 <0.06 <0.01 4 0.16 <0.006 5.5 8.9 627 327 35 <5 327 102 343 196 17.0 7.6 37.4 67 13.3			0.001 0.001 0.005 1 1 0.05 0.06 0.01 1 0.05 0.006 0.1 0.1 0.2 5 5 5 5 % mg/L mg/L mg/L mg/L mg/L mg/L mg/L		15-SEP-04 15-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04 14-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04 08-SEP-04 07-SEP-04 09-SEP-04 08-SEP-04 08-SEP-04 08-SEP-04 08-SEP-04 08-SEP-04 08-SEP-04 10-SEP-04 10-SEP-04 10-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04	TL TL TL/SHC DEL DEL TL HAS HAS JTV PTT TL EOC PTT PTT PTT PTT PTT PTT EOC EOC EOC EOC EOC	R218614 R218614 R216871 R216775 R216775 R218231 R216606 R216606 R216810 R216615 R216462 R216789 R216615 R216615 R216615 R216615 R216615 R216615 R216789 R216789 R216789 R216789 R216789
L204046-15 BC-SITE #1 SYLVAN LAKE Sample Date: 06-SEP-04 Matrix: WATER								

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters		Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L204046-15 BC-SITE #1 SYLVAN LAKE Sample Date: 06-SEP-04 Matrix: WATER									
	Phosphorus, Dissolved	0.004		0.001	mg/L		15-SEP-04	TL	R218614
	Phosphorus, Total	0.016		0.001	mg/L		15-SEP-04	TL	R218614
	Ammonia-N	0.008		0.005	mg/L		09-SEP-04	TL/SHC	R216871
	Dissolved Organic Carbon	6		1	mg/L		09-SEP-04	RJK	R217022
	MF - E. Coli	1		1	CFU/100mL		09-SEP-04	DEL	R216775
	MF - Fecal Coliforms	1		1	CFU/100mL		09-SEP-04	DEL	R216775
	Total Kjeldahl Nitrogen	0.70	RAMB	0.05	mg/L		14-SEP-04	TL	R218231
	Total Suspended Solids	3		1	mg/L		17-SEP-04	ZOW	R219314
Routine Water: Majors,F,Fe,Mn (Dis)&SiO2									
	Iron (Fe)-Dissolved	<0.06		0.06	mg/L		09-SEP-04	HAS	R216606
	Manganese(Mn)-Dissolved	<0.01		0.01	mg/L		09-SEP-04	HAS	R216606
	Chloride (Cl)	4		1	mg/L		09-SEP-04	JTV	R216810
	Fluoride (F)	0.16		0.05	mg/L		08-SEP-04	PTT	R216615
	Nitrate+Nitrite-N	<0.006		0.006	mg/L		07-SEP-04	TL	R216462
	Silica (as SiO2)	5.6		0.1	mg/L		09-SEP-04	EOC	R216789
pH, Conductivity and Total Alkalinity									
	pH	8.9		0.1	pH		08-SEP-04	PTT	R216615
	Conductivity (EC)	628		0.2	uS/cm		08-SEP-04	PTT	R216615
	Bicarbonate (HCO3)	327		5	mg/L		08-SEP-04	PTT	R216615
	Carbonate (CO3)	36		5	mg/L		08-SEP-04	PTT	R216615
	Hydroxide (OH)	<5		5	mg/L		08-SEP-04	PTT	R216615
	Alkalinity, Total (as CaCO3)	327		5	mg/L		08-SEP-04	PTT	R216615
Ion Balance Calculation									
	Ion Balance	102			%		10-SEP-04		
	TDS (Calculated)	344			mg/L		10-SEP-04		
	Hardness (as CaCO3)	198			mg/L		10-SEP-04		
ICP metals and SO4 for routine water									
	Calcium (Ca)	17.1		0.5	mg/L		09-SEP-04	EOC	R216789
	Potassium (K)	7.7		0.1	mg/L		09-SEP-04	EOC	R216789
	Magnesium (Mg)	37.6		0.1	mg/L		09-SEP-04	EOC	R216789
	Sodium (Na)	68		1	mg/L		09-SEP-04	EOC	R216789
	Sulfate (SO4)	13.2		0.5	mg/L		09-SEP-04	EOC	R216789
L204046-16 BC-SITE #1-REP #2 SYLVAN LAKE Sample Date: 06-SEP-04 Matrix: WATER									
	Phosphorus, Dissolved	0.004		0.001	mg/L		15-SEP-04	TL	R218615
	Phosphorus, Total	0.015		0.001	mg/L		15-SEP-04	TL	R218615
	Ammonia-N	0.018		0.005	mg/L		09-SEP-04	TL/SHC	R216871
	MF - E. Coli	<1		1	CFU/100mL		09-SEP-04	DEL	R216775
	MF - Fecal Coliforms	<1		1	CFU/100mL		09-SEP-04	DEL	R216775
	Total Kjeldahl Nitrogen	0.51	RAMB	0.05	mg/L		14-SEP-04	TL	R218231
	Total Suspended Solids	2		1	mg/L		17-SEP-04	ZOW	R219314
Routine Water: Majors,F,Fe,Mn (Dis)&SiO2									
	Iron (Fe)-Dissolved	<0.06		0.06	mg/L		09-SEP-04	HAS	R216606
	Manganese(Mn)-Dissolved	<0.01		0.01	mg/L		09-SEP-04	HAS	R216606
	Chloride (Cl)	3		1	mg/L		09-SEP-04	JTV	R216810
	Fluoride (F)	0.17		0.05	mg/L		09-SEP-04	PTT	R216615

[illegible]

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L204046-17 BC-SITE #1-REP #3 SYLVAN LAKE Sample Date: 06-SEP-04 Matrix: WATER Routine Water: Majors,F,Fe,Mn (Dis)&SiO2 ICP metals and SO4 for routine water Potassium (K) Magnesium (Mg) Sodium (Na) Sulfate (SO4)	7.8 37.5 68 13.1		0.1 0.1 1 0.5	mg/L mg/L mg/L mg/L		09-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04	EOC EOC EOC EOC	R216789 R216789 R216789 R216789
L204046-18 2 SYLVAN LAKE Sample Date: 06-SEP-04 Matrix: WATER Phosphorus, Dissolved Phosphorus, Total Ammonia-N MF - E. Coli MF - Fecal Coliforms Total Kjeldahl Nitrogen Routine Water: Majors,F,Fe,Mn (Dis)&SiO2 Iron (Fe)-Dissolved Manganese(Mn)-Dissolved Chloride (Cl) Fluoride (F) Nitrate+Nitrite-N Silica (as SiO2) pH, Conductivity and Total Alkalinity pH Conductivity (EC) Bicarbonate (HCO3) Carbonate (CO3) Hydroxide (OH) Alkalinity, Total (as CaCO3) Ion Balance Calculation Ion Balance TDS (Calculated) Hardness (as CaCO3) ICP metals and SO4 for routine water Calcium (Ca) Potassium (K) Magnesium (Mg) Sodium (Na) Sulfate (SO4)	0.004 0.015 0.006 <1 <1 0.71 <0.06 <0.01 3 0.17 <0.006 5.5 8.9 627 327 35 <5 327 103 343 198 17.1 7.7 37.6 68 13.5		0.001 0.001 0.005 1 1 0.05 0.06 0.01 1 0.05 0.006 0.1 0.1 0.2 5 5 5 5 0.5 0.1 0.1 1 0.5	mg/L mg/L mg/L CFU/100mL CFU/100mL mg/L mg/L mg/L mg/L mg/L mg/L pH uS/cm mg/L mg/L mg/L mg/L mg/L mg/L mg/L mg/L mg/L mg/L mg/L		15-SEP-04 15-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04 14-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04 07-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04 10-SEP-04 10-SEP-04 10-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04	TL TL TL/SHC DEL DEL TL HAS HAS JTV PTT TL EOC PTT PTT PTT PTT PTT PTT PTT EOC EOC EOC EOC EOC	R218615 R218615 R216871 R216775 R216775 R218231 R216606 R216606 R216810 R216615 R216462 R216789 R216615 R216615 R216615 R216615 R216615 R216615 R216615 R216789 R216789 R216789 R216789 R216789
L204046-19 3 SYLVAN LAKE Sample Date: 06-SEP-04 Matrix: WATER Phosphorus, Dissolved Phosphorus, Total Ammonia-N MF - E. Coli MF - Fecal Coliforms Total Kjeldahl Nitrogen	0.004 0.016 0.005 <1 2 0.66		0.001 0.001 0.005 1 1 0.05	mg/L mg/L mg/L CFU/100mL CFU/100mL mg/L		15-SEP-04 15-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04 14-SEP-04	TL TL TL/SHC DEL DEL TL	R218615 R218615 R216871 R216775 R216775 R218231

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L204046-193 SYLVAN LAKE Sample Date: 06-SEP-04 Matrix: WATER								
Routine Water: Majors,F,Fe,Mn (Dis)&SiO2								
Iron (Fe)-Dissolved	<0.06		0.06	mg/L		09-SEP-04	HAS	R216606
Manganese(Mn)-Dissolved	<0.01		0.01	mg/L		09-SEP-04	HAS	R216606
Chloride (Cl)	4		1	mg/L		09-SEP-04	JTV	R216810
Fluoride (F)	0.17		0.05	mg/L		09-SEP-04	PTT	R216615
Nitrate+Nitrite-N	<0.006		0.006	mg/L		07-SEP-04	TL	R216462
Silica (as SiO2)	5.7		0.1	mg/L		09-SEP-04	EOC	R216789
pH, Conductivity and Total Alkalinity								
pH	8.9		0.1	pH		09-SEP-04	PTT	R216615
Conductivity (EC)	628		0.2	uS/cm		09-SEP-04	PTT	R216615
Bicarbonate (HCO3)	329		5	mg/L		09-SEP-04	PTT	R216615
Carbonate (CO3)	35		5	mg/L		09-SEP-04	PTT	R216615
Hydroxide (OH)	<5		5	mg/L		09-SEP-04	PTT	R216615
Alkalinity, Total (as CaCO3)	327		5	mg/L		09-SEP-04	PTT	R216615
Ion Balance Calculation								
Ion Balance	105			%		10-SEP-04		
TDS (Calculated)	349			mg/L		10-SEP-04		
Hardness (as CaCO3)	204			mg/L		10-SEP-04		
ICP metals and SO4 for routine water								
Calcium (Ca)	17.6		0.5	mg/L		09-SEP-04	EOC	R216789
Potassium (K)	8.1		0.1	mg/L		09-SEP-04	EOC	R216789
Magnesium (Mg)	38.8		0.1	mg/L		09-SEP-04	EOC	R216789
Sodium (Na)	70		1	mg/L		09-SEP-04	EOC	R216789
Sulfate (SO4)	13.9		0.5	mg/L		09-SEP-04	EOC	R216789
L204046-204 SYLVAN LAKE Sample Date: 06-SEP-04 Matrix: WATER								
Phosphorus, Dissolved	0.004		0.001	mg/L		15-SEP-04	TL	R218615
Phosphorus, Total	0.015		0.001	mg/L		15-SEP-04	TL	R218615
Ammonia-N	0.008		0.005	mg/L		09-SEP-04	TL/SHC	R216871
Total Kjeldahl Nitrogen	0.62	RAMB	0.05	mg/L		14-SEP-04	TL	R218231
Routine Water: Majors,F,Fe,Mn (Dis)&SiO2								
Iron (Fe)-Dissolved	<0.06		0.06	mg/L		09-SEP-04	HAS	R216606
Manganese(Mn)-Dissolved	<0.01		0.01	mg/L		09-SEP-04	HAS	R216606
Chloride (Cl)	4		1	mg/L		09-SEP-04	JTV	R216810
Fluoride (F)	0.17		0.05	mg/L		09-SEP-04	PTT	R216615
Nitrate+Nitrite-N	<0.006		0.006	mg/L		07-SEP-04	TL	R216462
Silica (as SiO2)	5.5		0.1	mg/L		09-SEP-04	EOC	R216789
pH, Conductivity and Total Alkalinity								
pH	8.9		0.1	pH		09-SEP-04	PTT	R216615
Conductivity (EC)	626		0.2	uS/cm		09-SEP-04	PTT	R216615
Bicarbonate (HCO3)	325		5	mg/L		09-SEP-04	PTT	R216615
Carbonate (CO3)	36		5	mg/L		09-SEP-04	PTT	R216615
Hydroxide (OH)	<5		5	mg/L		09-SEP-04	PTT	R216615
Alkalinity, Total (as CaCO3)	327		5	mg/L		09-SEP-04	PTT	R216615
Ion Balance Calculation								
Ion Balance	103			%		10-SEP-04		
TDS (Calculated)	345			mg/L		10-SEP-04		
Hardness (as CaCO3)	195			mg/L		10-SEP-04		

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L204046-204 SYLVAN LAKE Sample Date: 06-SEP-04 Matrix: WATER Routine Water: Majors,F,Fe,Mn (Dis)&SiO2 ICP metals and SO4 for routine water Calcium (Ca)16.90.5mg/L09-SEP-04EOCR216789 Potassium (K)8.00.1mg/L09-SEP-04EOCR216789 Magnesium (Mg)37.00.1mg/L09-SEP-04EOCR216789 Sodium (Na)691mg/L09-SEP-04EOCR216789 Sulfate (SO4)13.40.5mg/L09-SEP-04EOCR216789								
L204046-215 SYLVAN LAKE Sample Date: 06-SEP-04 Matrix: WATER Phosphorus, Dissolved0.0050.001mg/L15-SEP-04TLR218615 Phosphorus, Total0.0160.001mg/L15-SEP-04TLR218615 Ammonia-N0.0060.005mg/L09-SEP-04TL/SHCR216871 Total Kjeldahl Nitrogen0.690.05mg/L14-SEP-04TLR218231 Routine Water: Majors,F,Fe,Mn (Dis)&SiO2 Iron (Fe)-Dissolved<0.060.06mg/L09-SEP-04HASR216606 Manganese(Mn)-Dissolved<0.010.01mg/L09-SEP-04HASR216606 Chloride (Cl)41mg/L09-SEP-04JTVR216810 Fluoride (F)0.170.05mg/L09-SEP-04PTTR216615 Nitrate+Nitrite-N<0.0060.006mg/L07-SEP-04TLR216462 Silica (as SiO2)5.60.1mg/L09-SEP-04EOCR216789 pH, Conductivity and Total Alkalinity pH8.90.1pH09-SEP-04PTTR216615 Conductivity (EC)6260.2uS/cm09-SEP-04PTTR216615 Bicarbonate (HCO3)3245mg/L09-SEP-04PTTR216615 Carbonate (CO3)365mg/L09-SEP-04PTTR216615 Hydroxide (OH)<55mg/L09-SEP-04PTTR216615 Alkalinity, Total (as CaCO3)3265mg/L09-SEP-04PTTR216615 Ion Balance Calculation Ion Balance102%10-SEP-04 TDS (Calculated)342mg/L10-SEP-04 Hardness (as CaCO3)196mg/L10-SEP-04 ICP metals and SO4 for routine water Calcium (Ca)17.00.5mg/L09-SEP-04EOCR216789 Potassium (K)7.70.1mg/L09-SEP-04EOCR216789 Magnesium (Mg)37.40.1mg/L09-SEP-04EOCR216789 Sodium (Na)671mg/L09-SEP-04EOCR216789 Sulfate (SO4)13.30.5mg/L09-SEP-04EOCR216789		RAMB						
L204046-22SLB-SURFACE SYLVAN LAKE Sample Date: 06-SEP-04 Matrix: WATER Phosphorus, Dissolved0.0040.001mg/L15-SEP-04TLR218615 Phosphorus, Total0.0150.001mg/L15-SEP-04TLR218615 Ammonia-N0.0070.005mg/L09-SEP-04TL/SHCR216871 Total Kjeldahl Nitrogen0.670.05mg/L14-SEP-04TLR218231 Routine Water: Majors,F,Fe,Mn (Dis)&SiO2 Iron (Fe)-Dissolved<0.060.06mg/L09-SEP-04HASR216606 Manganese(Mn)-Dissolved<0.010.01mg/L09-SEP-04HASR216606		RAMB						

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters		Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L204046-22	SLB-SURFACE SYLVAN LAKE								
Sample Date: 06-SEP-04									
Matrix: WATER									
Routine Water: Majors,F,Fe,Mn (Dis)&SiO2									
Chloride (Cl)		4		1	mg/L		09-SEP-04	JTV	R216810
Fluoride (F)		0.17		0.05	mg/L		09-SEP-04	PTT	R216615
Nitrate+Nitrite-N		<0.006		0.006	mg/L		07-SEP-04	TL	R216462
Silica (as SiO2)		5.6		0.1	mg/L		09-SEP-04	EOC	R216789
pH, Conductivity and Total Alkalinity									
pH		8.9		0.1	pH		09-SEP-04	PTT	R216615
Conductivity (EC)		630		0.2	uS/cm		09-SEP-04	PTT	R216615
Bicarbonate (HCO3)		327		5	mg/L		09-SEP-04	PTT	R216615
Carbonate (CO3)		35		5	mg/L		09-SEP-04	PTT	R216615
Hydroxide (OH)		<5		5	mg/L		09-SEP-04	PTT	R216615
Alkalinity, Total (as CaCO3)		326		5	mg/L		09-SEP-04	PTT	R216615
Ion Balance Calculation									
Ion Balance		102			%		10-SEP-04		
TDS (Calculated)		342			mg/L		10-SEP-04		
Hardness (as CaCO3)		196			mg/L		10-SEP-04		
ICP metals and SO4 for routine water									
Calcium (Ca)		17.0		0.5	mg/L		09-SEP-04	EOC	R216789
Potassium (K)		7.6		0.1	mg/L		09-SEP-04	EOC	R216789
Magnesium (Mg)		37.2		0.1	mg/L		09-SEP-04	EOC	R216789
Sodium (Na)		67		1	mg/L		09-SEP-04	EOC	R216789
Sulfate (SO4)		13.2		0.5	mg/L		09-SEP-04	EOC	R216789
L204046-23	SLB-2M SYLVAN LAKE								
Sample Date: 06-SEP-04									
Matrix: WATER									
Phosphorus, Dissolved		0.005		0.001	mg/L		15-SEP-04	TL	R218615
Phosphorus, Total		0.035		0.001	mg/L		15-SEP-04	TL	R218615
Ammonia-N		0.009		0.005	mg/L		09-SEP-04	TL/SHC	R216871
Total Kjeldahl Nitrogen		0.80	RAMB	0.05	mg/L		14-SEP-04	TL	R218231
Routine Water: Majors,F,Fe,Mn (Dis)&SiO2									
Iron (Fe)-Dissolved		<0.06		0.06	mg/L		09-SEP-04	HAS	R216606
Manganese(Mn)-Dissolved		<0.01		0.01	mg/L		09-SEP-04	HAS	R216606
Chloride (Cl)		3		1	mg/L		09-SEP-04	JTV	R216810
Fluoride (F)		0.17		0.05	mg/L		09-SEP-04	PTT	R216615
Nitrate+Nitrite-N		<0.006		0.006	mg/L		07-SEP-04	TL	R216462
Silica (as SiO2)		5.6		0.1	mg/L		09-SEP-04	EOC	R216789
pH, Conductivity and Total Alkalinity									
pH		8.9		0.1	pH		09-SEP-04	PTT	R216615
Conductivity (EC)		628		0.2	uS/cm		09-SEP-04	PTT	R216615
Bicarbonate (HCO3)		329		5	mg/L		09-SEP-04	PTT	R216615
Carbonate (CO3)		34		5	mg/L		09-SEP-04	PTT	R216615
Hydroxide (OH)		<5		5	mg/L		09-SEP-04	PTT	R216615
Alkalinity, Total (as CaCO3)		326		5	mg/L		09-SEP-04	PTT	R216615
Ion Balance Calculation									
Ion Balance		103			%		10-SEP-04		
TDS (Calculated)		343			mg/L		10-SEP-04		
Hardness (as CaCO3)		198			mg/L		10-SEP-04		
ICP metals and SO4 for routine water									
Calcium (Ca)		17.2		0.5	mg/L		09-SEP-04	EOC	R216789
Potassium (K)		7.8		0.1	mg/L		09-SEP-04	EOC	R216789

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L204046-23SLB-2M SYLVAN LAKE Sample Date: 06-SEP-04 Matrix: WATER Routine Water: Majors,F,Fe,Mn (Dis)&SiO2 ICP metals and SO4 for routine water Magnesium (Mg) Sodium (Na) Sulfate (SO4)	37.7 68 13.4		0.1 1 0.5	mg/L mg/L mg/L		09-SEP-04 09-SEP-04 09-SEP-04	EOC EOC EOC	R216789 R216789 R216789
L204046-24SLB-4M SYLVAN LAKE Sample Date: 06-SEP-04 Matrix: WATER Phosphorus, Dissolved Phosphorus, Total Ammonia-N Total Kjeldahl Nitrogen Routine Water: Majors,F,Fe,Mn (Dis)&SiO2 Iron (Fe)-Dissolved Manganese(Mn)-Dissolved Chloride (Cl) Fluoride (F) Nitrate+Nitrite-N Silica (as SiO2) pH, Conductivity and Total Alkalinity pH Conductivity (EC) Bicarbonate (HCO3) Carbonate (CO3) Hydroxide (OH) Alkalinity, Total (as CaCO3) Ion Balance Calculation Ion Balance TDS (Calculated) Hardness (as CaCO3) ICP metals and SO4 for routine water Calcium (Ca) Potassium (K) Magnesium (Mg) Sodium (Na) Sulfate (SO4)	0.004 0.022 <0.005 0.70 <0.06 <0.01 3 0.17 <0.006 5.5 8.9 627 328 34 <5 325 103 341 198 17.1 7.7 37.7 67 13.2	RAMB	0.001 0.001 0.005 0.05 0.06 0.01 1 0.05 0.006 0.1 0.1 0.2 5 5 5 5 0.5 0.1 0.1 0.5	mg/L mg/L mg/L mg/L mg/L mg/L mg/L mg/L mg/L pH uS/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		15-SEP-04 15-SEP-04 09-SEP-04 14-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04 07-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04 10-SEP-04 10-SEP-04 10-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04	TL TL TL/SHC TL HAS HAS JTV PTT TL EOC PTT PTT PTT PTT PTT PTT PTT EOC EOC EOC EOC EOC	R218615 R218615 R216871 R218231 R216606 R216606 R216810 R216615 R216462 R216789 R216615 R216615 R216615 R216615 R216615 R216615 R216615 R216789 R216789 R216789 R216789 R216789
L204046-25SLB-6M SYLVAN LAKE Sample Date: 06-SEP-04 Matrix: WATER Phosphorus, Dissolved Phosphorus, Total Ammonia-N Total Kjeldahl Nitrogen Routine Water: Majors,F,Fe,Mn (Dis)&SiO2 Iron (Fe)-Dissolved Manganese(Mn)-Dissolved Chloride (Cl) Fluoride (F)	0.004 0.020 <0.005 0.52 <0.06 <0.01 3 0.17	RAMB	0.001 0.001 0.005 0.05 0.06 0.01 1 0.05	mg/L mg/L mg/L mg/L mg/L mg/L mg/L mg/L		15-SEP-04 15-SEP-04 13-SEP-04 14-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04	TL TL TL/S TL HAS HAS JTV PTT	R218615 R218615 R217770 R218231 R216606 R216606 R216810 R216615

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L204046-25SLB-6M SYLVAN LAKE Sample Date: 06-SEP-04 Matrix: WATER Routine Water: Majors,F,Fe,Mn (Dis)&SiO2 Nitrate+Nitrite-N Silica (as SiO2) pH, Conductivity and Total Alkalinity pH Conductivity (EC) Bicarbonate (HCO3) Carbonate (CO3) Hydroxide (OH) Alkalinity, Total (as CaCO3) Ion Balance Calculation Ion Balance TDS (Calculated) Hardness (as CaCO3) ICP metals and SO4 for routine water Calcium (Ca) Potassium (K) Magnesium (Mg) Sodium (Na) Sulfate (SO4)	<0.006 5.6 8.9 628 326 36 <5 327 103 343 196 17.0 7.9 37.3 68 13.2		0.006 0.1 0.1 0.2 5 5 5 0.5 0.1 0.1 1 0.5	mg/L mg/L pH uS/cm mg/L mg/L mg/L % mg/L mg/L mg/L mg/L mg/L mg/L mg/L		07-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04 10-SEP-04 10-SEP-04 10-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04	TL EOC PTT PTT PTT PTT PTT EOC EOC EOC EOC EOC	R216462 R216789 R216615 R216615 R216615 R216615 R216615 R216615 R216789 R216789 R216789 R216789 R216789
L204046-26SLB-8M SYLVAN LAKE Sample Date: 06-SEP-04 Matrix: WATER Phosphorus, Dissolved Phosphorus, Total Ammonia-N Total Kjeldahl Nitrogen Routine Water: Majors,F,Fe,Mn (Dis)&SiO2 Iron (Fe)-Dissolved Manganese(Mn)-Dissolved Chloride (Cl) Fluoride (F) Nitrate+Nitrite-N Silica (as SiO2) pH, Conductivity and Total Alkalinity pH Conductivity (EC) Bicarbonate (HCO3) Carbonate (CO3) Hydroxide (OH) Alkalinity, Total (as CaCO3) Ion Balance Calculation Ion Balance TDS (Calculated) Hardness (as CaCO3) ICP metals and SO4 for routine water Calcium (Ca) Potassium (K) Magnesium (Mg) Sodium (Na)	0.004 0.019 0.009 0.55 <0.06 <0.01 3 0.17 <0.006 5.7 8.9 628 324 37 <5 327 103 344 197 17.1 7.9 37.5 69		0.001 0.001 0.005 0.05 0.06 0.01 1 0.05 0.006 0.1 0.1 0.2 5 5 5 0.5 0.1 0.1 1	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		15-SEP-04 15-SEP-04 09-SEP-04 14-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04 07-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04 10-SEP-04 10-SEP-04 10-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04	TL TL TL/SHC TL HAS HAS JTV PTT TL EOC PTT PTT PTT PTT PTT PTT EOC EOC EOC EOC	R218615 R218615 R216871 R218231 R216606 R216606 R216810 R216615 R216462 R216789 R216615 R216615 R216615 R216615 R216615 R216615 R216789 R216789 R216789 R216789

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L204046-26 SLB-8M SYLVAN LAKE Sample Date: 06-SEP-04 Matrix: WATER Routine Water: Majors,F,Fe,Mn (Dis)&SiO2 ICP metals and SO4 for routine water Sulfate (SO4)	13.5		0.5	mg/L		09-SEP-04	EOC	R216789
L204046-27 SLB-10M SYLVAN LAKE Sample Date: 06-SEP-04 Matrix: WATER								
Phosphorus, Dissolved	0.003		0.001	mg/L		15-SEP-04	TL	R218615
Phosphorus, Total	0.017		0.001	mg/L		15-SEP-04	TL	R218615
Ammonia-N	0.006		0.005	mg/L		09-SEP-04	TL/SHC	R216871
Total Kjeldahl Nitrogen	0.51	RAMB	0.05	mg/L		14-SEP-04	TL	R218231
Routine Water: Majors,F,Fe,Mn (Dis)&SiO2								
Iron (Fe)-Dissolved	<0.06		0.06	mg/L		09-SEP-04	HAS	R216606
Manganese(Mn)-Dissolved	<0.01		0.01	mg/L		09-SEP-04	HAS	R216606
Chloride (Cl)	4		1	mg/L		09-SEP-04	JTV	R216810
Fluoride (F)	0.17		0.05	mg/L		09-SEP-04	PTT	R216615
Nitrate+Nitrite-N	<0.006		0.006	mg/L		07-SEP-04	TL	R216462
Silica (as SiO2)	5.6		0.1	mg/L		09-SEP-04	EOC	R216789
pH, Conductivity and Total Alkalinity								
pH	8.9		0.1	pH		09-SEP-04	PTT	R216615
Conductivity (EC)	627		0.2	uS/cm		09-SEP-04	PTT	R216615
Bicarbonate (HCO3)	325		5	mg/L		09-SEP-04	PTT	R216615
Carbonate (CO3)	36		5	mg/L		09-SEP-04	PTT	R216615
Hydroxide (OH)	<5		5	mg/L		09-SEP-04	PTT	R216615
Alkalinity, Total (as CaCO3)	327		5	mg/L		09-SEP-04	PTT	R216615
Ion Balance Calculation								
Ion Balance	102			%		10-SEP-04		
TDS (Calculated)	344			mg/L		10-SEP-04		
Hardness (as CaCO3)	194			mg/L		10-SEP-04		
ICP metals and SO4 for routine water								
Calcium (Ca)	17.1		0.5	mg/L		09-SEP-04	EOC	R216789
Potassium (K)	7.9		0.1	mg/L		09-SEP-04	EOC	R216789
Magnesium (Mg)	36.8		0.1	mg/L		09-SEP-04	EOC	R216789
Sodium (Na)	68		1	mg/L		09-SEP-04	EOC	R216789
Sulfate (SO4)	13.5		0.5	mg/L		09-SEP-04	EOC	R216789
L204046-28 SLB-12M SYLVAN LAKE Sample Date: 06-SEP-04 Matrix: WATER								
Phosphorus, Dissolved	0.004		0.001	mg/L		16-SEP-04	TL	R219051
Phosphorus, Total	0.017		0.001	mg/L		16-SEP-04	TL	R219051
Ammonia-N	0.006		0.005	mg/L		09-SEP-04	TL/SHC	R216871
Total Kjeldahl Nitrogen	0.56	RAMB	0.05	mg/L		14-SEP-04	TL	R218231
Routine Water: Majors,F,Fe,Mn (Dis)&SiO2								
Iron (Fe)-Dissolved	<0.06		0.06	mg/L		09-SEP-04	HAS	R216606
Manganese(Mn)-Dissolved	<0.01		0.01	mg/L		09-SEP-04	HAS	R216606
Chloride (Cl)	3		1	mg/L		09-SEP-04	JTV	R216810
Fluoride (F)	0.17		0.05	mg/L		09-SEP-04	PTT	R216615
Nitrate+Nitrite-N	<0.006		0.006	mg/L		07-SEP-04	TL	R216462
Silica (as SiO2)	5.6		0.1	mg/L		09-SEP-04	EOC	R216789

[illegible]

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L204046-30 SLC-2M SYLVAN LAKE Sample Date: 06-SEP-04 Matrix: WATER								
Phosphorus, Dissolved	0.004	RAMB	0.001	mg/L		16-SEP-04	TL	R219051
Phosphorus, Total	0.018		0.001	mg/L		16-SEP-04	TL	R219051
Ammonia-N	<0.005		0.005	mg/L		09-SEP-04	TL/SHC	R216871
Total Kjeldahl Nitrogen	0.65		0.05	mg/L		14-SEP-04	TL	R218231
Routine Water: Majors,F,Fe,Mn (Dis)&SiO2								
Iron (Fe)-Dissolved	<0.06		0.06	mg/L		09-SEP-04	HAS	R216606
Manganese(Mn)-Dissolved	<0.01		0.01	mg/L		09-SEP-04	HAS	R216606
Chloride (Cl)	3		1	mg/L		09-SEP-04	JTV	R216810
Fluoride (F)	0.17		0.05	mg/L		09-SEP-04	PTT	R216615
Nitrate+Nitrite-N	<0.006		0.006	mg/L		07-SEP-04	TL	R216462
Silica (as SiO2)	5.4		0.1	mg/L		09-SEP-04	EOC	R216789
pH, Conductivity and Total Alkalinity								
pH	8.9		0.1	pH		09-SEP-04	PTT	R216615
Conductivity (EC)	629		0.2	uS/cm		09-SEP-04	PTT	R216615
Bicarbonate (HCO3)	325		5	mg/L		09-SEP-04	PTT	R216615
Carbonate (CO3)	36		5	mg/L		09-SEP-04	PTT	R216615
Hydroxide (OH)	<5		5	mg/L		09-SEP-04	PTT	R216615
Alkalinity, Total (as CaCO3)	327		5	mg/L		09-SEP-04	PTT	R216615
Ion Balance Calculation								
Ion Balance	102			%		10-SEP-04		
TDS (Calculated)	341			mg/L		10-SEP-04		
Hardness (as CaCO3)	195			mg/L		10-SEP-04		
ICP metals and SO4 for routine water								
Calcium (Ca)	16.9		0.5	mg/L		09-SEP-04	EOC	R216789
Potassium (K)	7.8		0.1	mg/L		09-SEP-04	EOC	R216789
Magnesium (Mg)	37.0		0.1	mg/L		09-SEP-04	EOC	R216789
Sodium (Na)	67		1	mg/L		09-SEP-04	EOC	R216789
Sulfate (SO4)	13.4		0.5	mg/L		09-SEP-04	EOC	R216789
L204046-31 SLC-4M SYLVAN LAKE Sample Date: 06-SEP-04 Matrix: WATER								
Phosphorus, Dissolved	0.004	RAMB	0.001	mg/L		16-SEP-04	TL	R219051
Phosphorus, Total	0.018		0.001	mg/L		16-SEP-04	TL	R219051
Ammonia-N	0.005		0.005	mg/L		09-SEP-04	TL/SHC	R216871
Total Kjeldahl Nitrogen	0.59		0.05	mg/L		15-SEP-04	TL	R218606
Routine Water: Majors,F,Fe,Mn (Dis)&SiO2								
Iron (Fe)-Dissolved	<0.06		0.06	mg/L		09-SEP-04	HAS	R216606
Manganese(Mn)-Dissolved	<0.01		0.01	mg/L		09-SEP-04	HAS	R216606
Chloride (Cl)	4		1	mg/L		09-SEP-04	JTV	R216810
Fluoride (F)	0.17		0.05	mg/L		09-SEP-04	PTT	R216615
Nitrate+Nitrite-N	<0.006		0.006	mg/L		07-SEP-04	TL	R216462
Silica (as SiO2)	5.6		0.1	mg/L		09-SEP-04	EOC	R216789
pH, Conductivity and Total Alkalinity								
pH	8.9		0.1	pH		09-SEP-04	PTT	R216615
Conductivity (EC)	628		0.2	uS/cm		09-SEP-04	PTT	R216615
Bicarbonate (HCO3)	328		5	mg/L		09-SEP-04	PTT	R216615
Carbonate (CO3)	35		5	mg/L		09-SEP-04	PTT	R216615
Hydroxide (OH)	<5		5	mg/L		09-SEP-04	PTT	R216615

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters		Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L204046-31	SLC-4M SYLVAN LAKE Sample Date: 06-SEP-04 Matrix: WATER Routine Water: Majors,F,Fe,Mn (Dis)&SiO2 pH, Conductivity and Total Alkalinity Alkalinity, Total (as CaCO3) Ion Balance Calculation Ion Balance TDS (Calculated) Hardness (as CaCO3) ICP metals and SO4 for routine water Calcium (Ca) Potassium (K) Magnesium (Mg) Sodium (Na) Sulfate (SO4)	328 102 344 194 16.9 8.0 36.9 68 13.4		5 0.5 0.1 0.1 1 0.5	mg/L % mg/L mg/L	 09-SEP-04 10-SEP-04 10-SEP-04 10-SEP-04	09-SEP-04 10-SEP-04 10-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04	PTT EOC EOC EOC EOC EOC	R216615 R216789 R216789 R216789 R216789 R216789
L204046-32	SLC-6M SYLVAN LAKE Sample Date: 06-SEP-04 Matrix: WATER Phosphorus, Dissolved Phosphorus, Total Ammonia-N Total Kjeldahl Nitrogen Routine Water: Majors,F,Fe,Mn (Dis)&SiO2 Iron (Fe)-Dissolved Manganese(Mn)-Dissolved Chloride (Cl) Fluoride (F) Nitrate+Nitrite-N Silica (as SiO2) pH, Conductivity and Total Alkalinity pH Conductivity (EC) Bicarbonate (HCO3) Carbonate (CO3) Hydroxide (OH) Alkalinity, Total (as CaCO3) Ion Balance Calculation Ion Balance TDS (Calculated) Hardness (as CaCO3) ICP metals and SO4 for routine water Calcium (Ca) Potassium (K) Magnesium (Mg) Sodium (Na) Sulfate (SO4)	0.004 0.021 0.006 0.68 <0.06 <0.01 4 0.17 <0.006 5.6 8.9 628 328 35 <5 327 103 345 199 17.3 7.9 37.8 68 13.5	RAMB	0.001 0.001 0.005 0.05 0.06 0.01 1 0.05 0.006 0.1 0.1 0.2 5 5 5 5	mg/L mg/L mg/L mg/L	 09-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04 07-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04 10-SEP-04 10-SEP-04 10-SEP-04	16-SEP-04 16-SEP-04 09-SEP-04 15-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04 09-SEP-04	TL TL TL/SHC TL HAS HAS JTV PTT TL EOC PTT PTT PTT PTT PTT PTT EOC EOC EOC EOC EOC	R219052 R219052 R216871 R218606 R216606 R216606 R216810 R216615 R216462 R216789 R216615 R216615 R216615 R216615 R216615 R216615 R216789 R216789 R216789 R216789 R216789
L204046-33	SLC-8M SYLVAN LAKE Sample Date: 06-SEP-04 Matrix: WATER Phosphorus, Dissolved Phosphorus, Total	0.004 0.017		0.001 0.001	mg/L mg/L	 16-SEP-04 16-SEP-04	 16-SEP-04 16-SEP-04	TL TL	R219052 R219052

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L204046-33 SLC-8M SYLVAN LAKE Sample Date: 06-SEP-04 Matrix: WATER								
Ammonia-N	<0.005	RAMB	0.005	mg/L		09-SEP-04	TL/SHC	R216871
Total Kjeldahl Nitrogen	0.73		0.05	mg/L		15-SEP-04	TL	R218606
Routine Water: Majors,F,Fe,Mn (Dis)&SiO2								
Iron (Fe)-Dissolved	<0.06		0.06	mg/L		09-SEP-04	HAS	R216606
Manganese(Mn)-Dissolved	<0.01		0.01	mg/L		09-SEP-04	HAS	R216606
Chloride (Cl)	4		1	mg/L		09-SEP-04	JTV	R216810
Fluoride (F)	0.17		0.05	mg/L		09-SEP-04	PTT	R216615
Nitrate+Nitrite-N	<0.006		0.006	mg/L		07-SEP-04	TL	R216462
Silica (as SiO2)	5.4		0.1	mg/L		09-SEP-04	EOC	R216789
pH, Conductivity and Total Alkalinity								
pH	8.9		0.1	pH		09-SEP-04	PTT	R216615
Conductivity (EC)	629		0.2	uS/cm		09-SEP-04	PTT	R216615
Bicarbonate (HCO3)	330		5	mg/L		09-SEP-04	PTT	R216615
Carbonate (CO3)	34		5	mg/L		09-SEP-04	PTT	R216615
Hydroxide (OH)	<5		5	mg/L		09-SEP-04	PTT	R216615
Alkalinity, Total (as CaCO3)	327		5	mg/L		09-SEP-04	PTT	R216615
Ion Balance Calculation								
Ion Balance	102			%		10-SEP-04		
TDS (Calculated)	344			mg/L		10-SEP-04		
Hardness (as CaCO3)	197			mg/L		10-SEP-04		
ICP metals and SO4 for routine water								
Calcium (Ca)	17.1		0.5	mg/L		09-SEP-04	EOC	R216789
Potassium (K)	7.7		0.1	mg/L		09-SEP-04	EOC	R216789
Magnesium (Mg)	37.4		0.1	mg/L		09-SEP-04	EOC	R216789
Sodium (Na)	68		1	mg/L		09-SEP-04	EOC	R216789
Sulfate (SO4)	13.2		0.5	mg/L		09-SEP-04	EOC	R216789
L204046-34 SLC-10M SYLVAN LAKE Sample Date: 06-SEP-04 Matrix: WATER								
Phosphorus, Dissolved	0.004	RAMB	0.001	mg/L		16-SEP-04	TL	R219052
Phosphorus, Total	0.018		0.001	mg/L		16-SEP-04	TL	R219052
Ammonia-N	0.006		0.005	mg/L		09-SEP-04	TL/SHC	R216871
Total Kjeldahl Nitrogen	0.65		0.05	mg/L		15-SEP-04	TL	R218606
Routine Water: Majors,F,Fe,Mn (Dis)&SiO2								
Iron (Fe)-Dissolved	<0.06		0.06	mg/L		09-SEP-04	HAS	R216606
Manganese(Mn)-Dissolved	<0.01		0.01	mg/L		09-SEP-04	HAS	R216606
Chloride (Cl)	4		1	mg/L		09-SEP-04	JTV	R216810
Fluoride (F)	0.17		0.05	mg/L		09-SEP-04	PTT	R216615
Nitrate+Nitrite-N	<0.006		0.006	mg/L		07-SEP-04	TL	R216462
Silica (as SiO2)	5.5		0.1	mg/L		09-SEP-04	EOC	R216789
pH, Conductivity and Total Alkalinity								
pH	8.9		0.1	pH		09-SEP-04	PTT	R216615
Conductivity (EC)	629		0.2	uS/cm		09-SEP-04	PTT	R216615
Bicarbonate (HCO3)	329		5	mg/L		09-SEP-04	PTT	R216615
Carbonate (CO3)	35		5	mg/L		09-SEP-04	PTT	R216615
Hydroxide (OH)	<5		5	mg/L		09-SEP-04	PTT	R216615
Alkalinity, Total (as CaCO3)	328		5	mg/L		09-SEP-04	PTT	R216615
Ion Balance Calculation								

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L204046-34SLC-10M SYLVAN LAKE Sample Date: 06-SEP-04 Matrix: WATER Routine Water: Majors,F,Fe,Mn (Dis)&SiO2 Ion Balance Calculation Ion Balance101%10-SEP-04 TDS (Calculated)343mg/L10-SEP-04 Hardness (as CaCO3)195mg/L10-SEP-04 ICP metals and SO4 for routine water Calcium (Ca)16.90.5mg/L09-SEP-04EOC R216789 Potassium (K)7.80.1mg/L09-SEP-04EOC R216789 Magnesium (Mg)37.10.1mg/L09-SEP-04EOC R216789 Sodium (Na)671mg/L09-SEP-04EOC R216789 Sulfate (SO4)13.40.5mg/L09-SEP-04EOC R216789								
L204046-35SLC-12M SYLVAN LAKE Sample Date: 06-SEP-04 Matrix: WATER Phosphorus, Dissolved0.0040.001mg/L16-SEP-04TL R219052 Phosphorus, Total0.0180.001mg/L16-SEP-04TL R219052 Ammonia-N<0.0050.005mg/L13-SEP-04TL/S R217770 Total Kjeldahl Nitrogen0.690.05mg/L15-SEP-04TL R218606 Routine Water: Majors,F,Fe,Mn (Dis)&SiO2 Iron (Fe)-Dissolved<0.060.06mg/L09-SEP-04HAS R216606 Manganese(Mn)-Dissolved<0.010.01mg/L09-SEP-04HAS R216606 Chloride (Cl)41mg/L09-SEP-04JTV R216810 Fluoride (F)0.170.05mg/L09-SEP-04PTT R216615 Nitrate+Nitrite-N<0.0060.006mg/L07-SEP-04TL R216462 Silica (as SiO2)5.60.1mg/L09-SEP-04EOC R216789 pH, Conductivity and Total Alkalinity pH8.90.1pH09-SEP-04PTT R216615 Conductivity (EC)6300.2uS/cm09-SEP-04PTT R216615 Bicarbonate (HCO3)3245mg/L09-SEP-04PTT R216615 Carbonate (CO3)365mg/L09-SEP-04PTT R216615 Hydroxide (OH)<55mg/L09-SEP-04PTT R216615 Alkalinity, Total (as CaCO3)3255mg/L09-SEP-04PTT R216615 Ion Balance Calculation Ion Balance102%10-SEP-04 TDS (Calculated)341mg/L10-SEP-04 Hardness (as CaCO3)193mg/L10-SEP-04 ICP metals and SO4 for routine water Calcium (Ca)16.80.5mg/L09-SEP-04EOC R216789 Potassium (K)7.70.1mg/L09-SEP-04EOC R216789 Magnesium (Mg)36.60.1mg/L09-SEP-04EOC R216789 Sodium (Na)681mg/L09-SEP-04EOC R216789 Sulfate (SO4)13.20.5mg/L09-SEP-04EOC R216789		RAMB						
L204046-36DISCRETE SAMPLER SYLVAN LAKE Sample Date: 06-SEP-04 Matrix: WATER Phosphorus, Dissolved<0.0010.001mg/L16-SEP-04TL R219052 Phosphorus, Total<0.0010.001mg/L20-SEP-04TL R220118 Ammonia-N<0.0050.005mg/L09-SEP-04TL/SHC R216871								

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L204046-36 DISCRETE SAMPLER SYLVAN LAKE								
Sample Date: 06-SEP-04								
Matrix: WATER								
Total Kjeldahl Nitrogen	0.09	RAMB	0.05	mg/L		15-SEP-04	TL	R218606
Total Suspended Solids	<1		1	mg/L		17-SEP-04	ZOW	R219314
Routine Water: Majors,F,Fe,Mn (Dis)&SiO2								
Iron (Fe)-Dissolved	<0.06		0.06	mg/L		09-SEP-04	HAS	R216606
Manganese(Mn)-Dissolved	<0.01		0.01	mg/L		09-SEP-04	HAS	R216606
Chloride (Cl)	1		1	mg/L		09-SEP-04	JTV	R216810
Fluoride (F)	<0.05		0.05	mg/L		09-SEP-04	PTT	R216615
Nitrate+Nitrite-N	<0.006		0.006	mg/L		07-SEP-04	TL	R216462
Silica (as SiO2)	<0.1		0.1	mg/L		09-SEP-04	EOC	R216789
pH, Conductivity and Total Alkalinity								
pH	6.1		0.1	pH		09-SEP-04	PTT	R216615
Conductivity (EC)	1.2		0.2	uS/cm		09-SEP-04	PTT	R216615
Bicarbonate (HCO3)	<5		5	mg/L		09-SEP-04	PTT	R216615
Carbonate (CO3)	<5		5	mg/L		09-SEP-04	PTT	R216615
Hydroxide (OH)	<5		5	mg/L		09-SEP-04	PTT	R216615
Alkalinity, Total (as CaCO3)	<5		5	mg/L		09-SEP-04	PTT	R216615
Ion Balance Calculation								
Ion Balance	Low EC			%		10-SEP-04		
TDS (Calculated)	1			mg/L		10-SEP-04		
Hardness (as CaCO3)	<1			mg/L		10-SEP-04		
ICP metals and SO4 for routine water								
Calcium (Ca)	<0.5		0.5	mg/L		09-SEP-04	EOC	R216789
Potassium (K)	<0.1		0.1	mg/L		09-SEP-04	EOC	R216789
Magnesium (Mg)	<0.1		0.1	mg/L		09-SEP-04	EOC	R216789
Sodium (Na)	<1		1	mg/L		09-SEP-04	EOC	R216789
Sulfate (SO4)	<0.5		0.5	mg/L		09-SEP-04	EOC	R216789
Refer to Referenced Information for Qualifiers (if any) and Methodology.								

Reference Information

Sample Parameter Qualifier key listed:

Qualifier	Description
RAMB	Result Adjusted For Method Blank

Methods Listed (if applicable):

ETL Test Code	Matrix	Test Description	Preparation Method Reference(Based On)	Analytical Method Reference(Based On)
C-DIS-ORG-CL	Water	Dissolved Organic Carbon		APHA 5310 C-Instrumental
CL-ED	Water	Chloride (Cl)		APHA 4500 Cl E-Colorimetry
ECC-MF-RAW-ED	Water	Escherchia coli Count (E.coli)-MF		APHA 9221F MF
ETL-ROUTINE-ICP-ED	Water	ICP metals and SO4 for routine water		APHA 3120 B-ICP-OES
F-ED	Water	Fluoride (F)		APHA 4500 F-C-Electrode
FCC-MF-RAW-ED	Water	Fecal Coliform Count-MF		APHA 9222D MF
FE-DIS-HIGH-ED	Water	Iron (Fe)-Dissolved		EPA 200.7
IONBALANCE-ED	Water	Ion Balance Calculation		APHA 1030E
MN-DIS-HIGH-ED	Water	Manganese(Mn)-Dissolved		EPA 200.7
N-TOTKJ-LOW-ED	Water	Total Kjeldahl Nitrogen	TECHNICON	APHA 4500Norg C-Dig.-Auto-Colorimetry
N2N3-LOW-ED	Water	Nitrate+Nitrite-N		APHA 4500 NO3E-Colorimetry
NH4-LOW-ED	Water	Ammonia-N		APHA 4500 NH3F-Colorimetry
P-TOTAL-LOW-ED	Water	Phosphorus, Total		APHA 4500 P B,E-Auto-Colorimetry
P-TOTALDIS-LOW-ED	Water	Phosphorus, Dissolved		APHA 4500 P B,E-Auto-Colorimetry
PH/EC/ALK-ED	Water	pH, Conductivity and Total Alkalinity		APHA 4500-H, 2510, 2320
PHYTO-BIO-WP	Water	Phytoplankton Biovolumes		Standard Methods 10200, 1998
This procedure is applicable to the identification and enumeration of microscopic organisms occurring within samples of fresh water. Samples are prepared using a sedimentation technique, and are then examined using a compound phase contrast inverted microscope. Both phytoplankton and zooplankton are identified to species where possible, enumerated and reported.				
SIO2-CALC-ED	Water	Silica (as SIO2)		ICP/CALCULATION- ICP/CALCULATION
SOLIDS-TOTSUS-LOW-ED	Water	Total Suspended Solids		APHA 2540 D-Gravimetric

** Laboratory Methods employed follow in-house procedures, which are generally based on nationally or internationally accepted methodologies.

Chain of Custody numbers:

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location	Laboratory Definition Code	Laboratory Location
CL	Enviro-Test Laboratories - Calgary, Alberta, Canada	ED	Enviro-Test Laboratories - Edmonton, Alberta, Canada
WP	Enviro-Test Laboratories - Winnipeg, Manitoba, Canada		

Reference Information

GLOSSARY OF REPORT TERMS

Surr - A surrogate is an organic compound that is similar to the target analyte(s) in chemical composition and behavior but not normally detected in environmental samples. Prior to sample processing, samples are fortified with one or more surrogate compounds.

The reported surrogate recovery value provides a measure of method efficiency. The Laboratory warning units are determined under column heading D.L.

mg/kg (units) - unit of concentration based on mass, parts per million

mg/L (units) - unit of concentration based on volume, parts per million

< - Less than

D.L. - Detection Limit

N/A - Result not available. Refer to qualifier code and definition for explanation

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

UNLESS OTHERWISE STATED, SAMPLES ARE NOT CORRECTED FOR CLIENT FIELD BLANKS.

Although test results are generated under strict QA/QC protocols, any unsigned test reports, faxes, or emails are considered preliminary.

Enviro-Test Laboratories has an extensive QA/QC program where all analytical data reported is analyzed using approved referenced procedures followed by checks and reviews by senior managers and quality assurance personnel. However, since the results are obtained from chemical measurements and thus cannot be guaranteed, Enviro-Test Laboratories assumes no liability for the use or interpretation of the results.

ANALYTICAL REPORT

NORTH/SOUTH CONSULTANTS

DATE: 09-MAR-05 04:46 PM

Revision: 1

ATTN: MEGAN COOLEY

83 SCURFIELD BLVD

WINNIPEG MB R3Y 1G4

Lab Work Order #: L210502

Sampled By:

Date Received: 25-SEP-04

Project P.O. #: SYLVAN LAKE

Project Reference: NS174

Comments:

APPROVED BY:



WARREN GREIG

Project Manager

THIS REPORT SHALL NOT BE REPRODUCED EXCEPT IN FULL WITHOUT THE WRITTEN AUTHORITY OF THE LABORATORY.
ANY REMAINING SAMPLES WILL BE DISPOSED OF AFTER 30 DAYS FOLLOWING ANALYSIS. PLEASE CONTACT THE LAB IF YOU
REQUIRE ADDITIONAL SAMPLE STORAGE TIME.

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L210502-1 NA-SITE#3 Sample Date: 23-SEP-04 Matrix: SEDIMENT Total Organic Carbon Total Carbon by Combustion Inorg/Org Carbon calc needs C-TOT-LECO Inorganic Carbon Total Organic Carbon % Moisture P Sorption Capacity Total Nitrogen Phosphorus, Total Particle size - Pipette removal OM & CO3 % Sand % Silt % Clay Texture	6.3 4.03 2.3 63.6 944 0.27 450 56 32 13 Sandy loam		0.1 0.01 0.1 0.5 1 0.01 90 1 1 1	% % % % mg/kg % mg/kg % % %	30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 29-SEP-04 02-OCT-04 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04	30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 02-OCT-04 01-OCT-04 01-OCT-04 01-OCT-04 01-OCT-04	HSL JRB JRB BD BEM APD BEM WW WW WW WW	R223779 R224048 R224048 R223717 R223876 R224063 R224368 R224323 R224323 R224323 R224323
L210502-2 NA-SITE#4 Sample Date: 23-SEP-04 Matrix: SEDIMENT Total Organic Carbon Total Carbon by Combustion Inorg/Org Carbon calc needs C-TOT-LECO Inorganic Carbon Total Organic Carbon % Moisture P Sorption Capacity Total Nitrogen Phosphorus, Total Particle size - Pipette removal OM & CO3 % Sand % Silt % Clay Texture	6.5 4.01 2.5 66.8 949 0.25 480 61 28 11 Sandy loam		0.1 0.01 0.1 0.5 1 0.01 90 1 1 1	% % % % mg/kg % mg/kg % % %	30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 29-SEP-04 02-OCT-04 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04	30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 02-OCT-04 01-OCT-04 01-OCT-04 01-OCT-04 01-OCT-04	HSL JRB JRB BD BEM APD BEM WW WW WW WW	R223779 R224048 R224048 R223717 R223876 R224063 R224368 R224323 R224323 R224323 R224323
L210502-3 NA-SITE#5 Sample Date: 23-SEP-04 Matrix: SEDIMENT Total Organic Carbon Total Carbon by Combustion Inorg/Org Carbon calc needs C-TOT-LECO Inorganic Carbon Total Organic Carbon % Moisture P Sorption Capacity Total Nitrogen Phosphorus, Total Particle size - Pipette removal OM & CO3 % Sand % Silt % Clay	1.8 0.95 0.8 44.7 329 0.11 440 90 7 3		0.1 0.01 0.1 0.5 1 0.01 90 1 1 1	% % % % mg/kg % mg/kg % % %	30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 29-SEP-04 02-OCT-04 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04	30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 02-OCT-04 01-OCT-04 01-OCT-04 01-OCT-04 01-OCT-04	HSL JRB JRB BD BEM APD BEM WW WW WW	R223779 R224048 R224048 R223717 R223876 R224063 R224368 R224323 R224323 R224323

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L210502-3 NA-SITE#5 Sample Date: 23-SEP-04 Matrix: SEDIMENT Particle size - Pipette removal OM & CO3 Texture	Sand				30-SEP-04	01-OCT-04	WW	R224323
L210502-4 SLB Sample Date: 23-SEP-04 Matrix: SEDIMENT Total Organic Carbon Total Carbon by Combustion Inorg/Org Carbon calc needs C-TOT-LECO Inorganic Carbon Total Organic Carbon % Moisture P Sorption Capacity Total Nitrogen Phosphorus, Total Particle size - Pipette removal OM & CO3 % Sand % Silt % Clay Texture	4.7 1.06 3.6 91.9 456 0.43 740 40 28 32 Clay loam		0.1 0.01 0.1 0.5 1 0.01 90 1 1 1	% % % % mg/kg % mg/kg % % %	30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 29-SEP-04 02-OCT-04 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04	30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 02-OCT-04 01-OCT-04 01-OCT-04 01-OCT-04 01-OCT-04	HSL JRB JRB BD BEM APD BEM WW WW WW WW	R223779 R224048 R224048 R223717 R223876 R224063 R224368 R224323 R224323 R224323 R224323
L210502-5 SLC Sample Date: 23-SEP-04 Matrix: SEDIMENT Total Organic Carbon Total Carbon by Combustion Inorg/Org Carbon calc needs C-TOT-LECO Inorganic Carbon Total Organic Carbon % Moisture P Sorption Capacity Total Nitrogen Phosphorus, Total Particle size - Pipette removal OM & CO3 % Sand % Silt % Clay Texture	12.1 2.47 9.6 92.2 650 1.25 1210 4 45 50 Silty clay		0.1 0.01 0.1 0.5 1 0.01 90 1 1 1	% % % % mg/kg % mg/kg % % %	30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 29-SEP-04 02-OCT-04 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04	30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 02-OCT-04 01-OCT-04 01-OCT-04 01-OCT-04 01-OCT-04	HSL JRB JRB BD BEM APD BEM WW WW WW WW	R223779 R224048 R224048 R223717 R223876 R224063 R224368 R224323 R224323 R224323 R224323
L210502-6 SEDIMENT CORE 0-5CM Sample Date: 23-SEP-04 Matrix: SEDIMENT Total Organic Carbon Total Carbon by Combustion Inorg/Org Carbon calc needs C-TOT-LECO Inorganic Carbon Total Organic Carbon % Moisture P Sorption Capacity	8.1 2.65 5.4 82.9 553		0.1 0.01 0.1 0.5 1	% % % % mg/kg	30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04	30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04	HSL JRB JRB BD BEM	R223779 R224048 R224048 R223717 R223876

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L210502-6 SEDIMENT CORE 0-5CM Sample Date: 23-SEP-04 Matrix: SEDIMENT Total Nitrogen Phosphorus, Total Particle size - Pipette removal OM & CO3 % Sand % Silt % Clay Texture	0.66 850 22 49 29 Clay loam		0.01 90 1 1 1	% mg/kg % % %	29-SEP-04 02-OCT-04 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04	30-SEP-04 02-OCT-04 01-OCT-04 01-OCT-04 01-OCT-04 01-OCT-04	APD BEM WW WW WW WW	R224063 R224368 R224323 R224323 R224323 R224323
L210502-7 SEDIMENT CORE 5-10CM Sample Date: 23-SEP-04 Matrix: SEDIMENT Total Organic Carbon Total Carbon by Combustion Inorg/Org Carbon calc needs C-TOT-LECO Inorganic Carbon Total Organic Carbon % Moisture P Sorption Capacity Total Nitrogen Phosphorus, Total Particle size - Pipette removal OM & CO3 % Sand % Silt % Clay Texture	7.8 2.89 4.9 80.2 569 0.57 790 19 50 30 Silty clay loam		0.1 0.01 0.1 0.5 1 0.01 90 1 1 1	% % % % mg/kg % mg/kg % % %	30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 29-SEP-04 02-OCT-04 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04	30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 02-OCT-04 01-OCT-04 01-OCT-04 01-OCT-04 01-OCT-04	HSL JRB JRB BD BEM APD BEM WW WW WW WW	R223779 R224048 R224048 R223717 R223876 R224063 R224368 R224323 R224323 R224323 R224323
L210502-8 SEDIMENT CORE 10-15CM Sample Date: 23-SEP-04 Matrix: SEDIMENT Total Organic Carbon Total Carbon by Combustion Inorg/Org Carbon calc needs C-TOT-LECO Inorganic Carbon Total Organic Carbon % Moisture P Sorption Capacity Total Nitrogen Phosphorus, Total Particle size - Pipette removal OM & CO3 % Sand % Silt % Clay Texture	8.2 3.04 5.2 83.0 561 0.52 730 16 52 32 Silty clay loam		0.1 0.01 0.1 0.5 1 0.01 90 1 1 1	% % % % mg/kg % mg/kg % % %	30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 29-SEP-04 02-OCT-04 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04	30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 02-OCT-04 01-OCT-04 01-OCT-04 01-OCT-04 01-OCT-04	HSL JRB JRB BD BEM APD BEM WW WW WW WW	R223779 R224048 R224048 R223717 R223876 R224063 R224368 R224323 R224323 R224323 R224323
L210502-9 SEDIMENT CORE 15-20CM Sample Date: 23-SEP-04 Matrix: SEDIMENT Total Organic Carbon Total Carbon by Combustion Inorg/Org Carbon calc needs C-TOT-LECO	7.7		0.1	%	30-SEP-04	30-SEP-04	HSL	R223779

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L210502-9 SEDIMENT CORE 15-20CM Sample Date: 23-SEP-04 Matrix: SEDIMENT Total Organic Carbon Inorg/Org Carbon calc needs C-TOT-LECO Inorganic Carbon Total Organic Carbon % Moisture P Sorption Capacity Total Nitrogen Phosphorus, Total Particle size - Pipette removal OM & CO3 % Sand % Silt % Clay Texture	3.14 4.5 77.6 571 0.46 740 11 52 37 Silty clay loam		0.01 0.1 0.5 1 0.01 90 1 1 1	% % % mg/kg % mg/kg % % %	30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 29-SEP-04 02-OCT-04 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04	30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 02-OCT-04 01-OCT-04 01-OCT-04 01-OCT-04 01-OCT-04	JRB JRB BD BEM APD BEM WW WW WW WW	R224048 R224048 R223717 R223876 R224063 R224368 R224323 R224323 R224323 R224323
L210502-10 SEDIMENT CORE 20-30CM Sample Date: 23-SEP-04 Matrix: SEDIMENT Total Organic Carbon Total Carbon by Combustion Inorg/Org Carbon calc needs C-TOT-LECO Inorganic Carbon Total Organic Carbon % Moisture P Sorption Capacity Total Nitrogen Phosphorus, Total Particle size - Pipette removal OM & CO3 % Sand % Silt % Clay Texture	6.5 2.21 4.3 73.6 620 0.43 710 6 55 39 Silty clay loam		0.1 0.01 0.1 0.5 1 0.01 90 1 1 1	% % % % mg/kg % mg/kg % % %	30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 29-SEP-04 02-OCT-04 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04	30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 02-OCT-04 01-OCT-04 01-OCT-04 01-OCT-04 01-OCT-04	HSL JRB JRB BD BEM APD BEM WW WW WW WW	R223779 R224048 R224048 R223717 R223876 R224063 R224368 R224323 R224323 R224323 R224323
L210502-11 TSL SITE #1 Sample Date: 23-SEP-04 Matrix: SEDIMENT Total Organic Carbon Total Carbon by Combustion Inorg/Org Carbon calc needs C-TOT-LECO Inorganic Carbon Total Organic Carbon % Moisture P Sorption Capacity Total Nitrogen Phosphorus, Total Particle size - Pipette removal OM & CO3 % Sand % Silt % Clay Texture	2.5 1.58 0.9 47.9 416 0.14 610 83 13 4 Loamy sand		0.1 0.01 0.1 0.5 1 0.01 90 1 1 1	% % % % mg/kg % mg/kg % % %	30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 29-SEP-04 02-OCT-04 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04	30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 02-OCT-04 01-OCT-04 01-OCT-04 01-OCT-04 01-OCT-04	HSL JRB JRB BD BEM APD BEM WW WW WW WW	R223779 R224048 R224048 R223717 R223876 R224063 R224368 R224323 R224323 R224323 R224323

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L210502-11 TSL SITE #1 Sample Date: 23-SEP-04 Matrix: SEDIMENT								
L210502-12 TSL SITE #3 Sample Date: 23-SEP-04 Matrix: SEDIMENT Total Organic Carbon Total Carbon by Combustion Inorg/Org Carbon calc needs C-TOT-LECO Inorganic Carbon Total Organic Carbon % Moisture P Sorption Capacity Total Nitrogen Phosphorus, Total Particle size - Pipette removal OM & CO3 % Sand % Silt % Clay Texture	2.1 1.48 0.6 35.6 388 0.08 480 91 6 3 Sand		0.1 0.01 0.1 0.5 1 0.01 90 1 1 1	% % % % mg/kg % mg/kg % % % 	30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 29-SEP-04 02-OCT-04 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04	30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 02-OCT-04 01-OCT-04 01-OCT-04 01-OCT-04 01-OCT-04	HSL JRB JRB BD BEM APD BEM WW WW WW WW	R223779 R224048 R224048 R223717 R223876 R224063 R224368 R224323 R224323 R224323 R224323
L210502-13 TSL SITE #4 Sample Date: 23-SEP-04 Matrix: SEDIMENT Total Organic Carbon Total Carbon by Combustion Inorg/Org Carbon calc needs C-TOT-LECO Inorganic Carbon Total Organic Carbon % Moisture P Sorption Capacity Total Nitrogen Phosphorus, Total Particle size - Pipette removal OM & CO3 % Sand % Silt % Clay Texture	2.9 1.84 1.0 49.0 446 0.14 480 85 9 5 Loamy sand		0.1 0.01 0.1 0.5 1 0.01 90 1 1 1	% % % % mg/kg % mg/kg % % % 	30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 29-SEP-04 02-OCT-04 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04	30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 02-OCT-04 01-OCT-04 01-OCT-04 01-OCT-04 01-OCT-04	HSL JRB JRB BD BEM APD BEM WW WW WW WW	R223779 R224048 R224048 R223717 R223876 R224063 R224368 R224323 R224323 R224323 R224323
L210502-14 HB SITE #3 Sample Date: 23-SEP-04 Matrix: SEDIMENT Total Organic Carbon Total Carbon by Combustion Inorg/Org Carbon calc needs C-TOT-LECO Inorganic Carbon Total Organic Carbon % Moisture P Sorption Capacity Total Nitrogen Phosphorus, Total	1.9 0.13 1.7 42.4 244 0.06 390		0.1 0.01 0.1 0.5 1 0.01 90	% % % % mg/kg % mg/kg	30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 29-SEP-04 02-OCT-04	30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 02-OCT-04	HSL JRB JRB BD BEM APD BEM	R223779 R224048 R224048 R223717 R223876 R224063 R224368

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L210502-14 HB SITE #3 Sample Date: 23-SEP-04 Matrix: SEDIMENT Particle size - Pipette removal OM & CO3 % Sand % Silt % Clay Texture	 94 3 2 Sand		 1 1 1	 % % %	 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04	 01-OCT-04 01-OCT-04 01-OCT-04 01-OCT-04	 WW WW WW WW	 R224323 R224323 R224323 R224323
L210502-15 HB SITE #4 Sample Date: 23-SEP-04 Matrix: SEDIMENT Total Organic Carbon Total Carbon by Combustion Inorg/Org Carbon calc needs C-TOT-LECO Inorganic Carbon Total Organic Carbon % Moisture P Sorption Capacity Total Nitrogen Phosphorus, Total Particle size - Pipette removal OM & CO3 % Sand % Silt % Clay Texture	 2.0 1.65 0.3 28.3 221 0.06 300 96 2 2 Sand		 0.1 0.01 0.1 0.5 1 0.01 90	 % % % % mg/kg % mg/kg	 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 29-SEP-04 02-OCT-04 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04	 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 02-OCT-04 01-OCT-04 01-OCT-04 01-OCT-04 01-OCT-04	 HSL JRB JRB BD BEM APD BEM WW WW WW WW	 R223779 R224048 R224048 R223717 R223876 R224063 R224368 R224323 R224323 R224323 R224323
L210502-16 HB SITE #5 Sample Date: 23-SEP-04 Matrix: SEDIMENT Total Organic Carbon Total Carbon by Combustion Inorg/Org Carbon calc needs C-TOT-LECO Inorganic Carbon Total Organic Carbon % Moisture P Sorption Capacity Total Nitrogen Phosphorus, Total Particle size - Pipette removal OM & CO3 % Sand % Silt % Clay Texture	 1.9 1.33 0.6 46.0 547 0.08 430 91 5 4 Sand		 0.1 0.01 0.1 0.5 1 0.01 90	 % % % % mg/kg % mg/kg	 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 29-SEP-04 02-OCT-04 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04	 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 02-OCT-04 01-OCT-04 01-OCT-04 01-OCT-04 01-OCT-04	 HSL JRB JRB BD BEM APD BEM WW WW WW WW	 R223779 R224048 R224048 R223717 R223876 R224063 R224368 R224323 R224323 R224323 R224323
L210502-17 BC SITE #3 Sample Date: 23-SEP-04 Matrix: SEDIMENT Total Organic Carbon Total Carbon by Combustion Inorg/Org Carbon calc needs C-TOT-LECO Inorganic Carbon Total Organic Carbon	 2.1 0.90 1.2		 0.1 0.01 0.1	 % % %	 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04	 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04	 HSL JRB JRB	 R223779 R224048 R224048

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L210502-17 BC SITE #3 Sample Date: 23-SEP-04 Matrix: SEDIMENT Total Organic Carbon % Moisture P Sorption Capacity Total Nitrogen Phosphorus, Total Particle size - Pipette removal OM & CO3 % Sand % Silt % Clay Texture	 56.2 469 0.16 580 84 8 8 Loamy sand		 0.5 1 0.01 90 1 1 1	 % mg/kg % mg/kg % % % 	 30-SEP-04 30-SEP-04 29-SEP-04 02-OCT-04 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04	 30-SEP-04 30-SEP-04 30-SEP-04 02-OCT-04 01-OCT-04 01-OCT-04 01-OCT-04 01-OCT-04	 BD BEM APD BEM WW WW WW WW	 R223717 R223876 R224063 R224368 R224323 R224323 R224323 R224323
L210502-18 BC SITE #4 Sample Date: 23-SEP-04 Matrix: SEDIMENT Total Organic Carbon Total Carbon by Combustion Inorg/Org Carbon calc needs C-TOT-LECO Inorganic Carbon Total Organic Carbon % Moisture P Sorption Capacity Total Nitrogen Phosphorus, Total Particle size - Pipette removal OM & CO3 % Sand % Silt % Clay Texture	 2.1 1.15 0.9 45.9 453 0.10 460 89 6 4 Sand		 0.1 0.01 0.1 0.5 1 0.01 90 1 1 1	 % % % % mg/kg % mg/kg % % % 	 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 29-SEP-04 02-OCT-04 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04	 30-SEP-04 30-SEP-04 30-SEP-04 02-OCT-04 01-OCT-04 01-OCT-04 01-OCT-04 01-OCT-04	 HSL JRB JRB BD BEM HSL BEM WW WW WW WW	 R223779 R224048 R224048 R223717 R223876 R224050 R224368 R224323 R224323 R224323 R224323
L210502-19 BC SITE #5 Sample Date: 23-SEP-04 Matrix: SEDIMENT Total Organic Carbon Total Carbon by Combustion Inorg/Org Carbon calc needs C-TOT-LECO Inorganic Carbon Total Organic Carbon % Moisture P Sorption Capacity Total Nitrogen Phosphorus, Total Particle size - Pipette removal OM & CO3 % Sand % Silt % Clay Texture	 1.7 1.53 0.2 41.7 236 0.04 340 94 5 1 Sand		 0.1 0.01 0.1 0.5 1 0.01 90 1 1 1	 % % % % mg/kg % mg/kg % % % 	 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04 29-SEP-04 02-OCT-04 30-SEP-04 30-SEP-04 30-SEP-04 30-SEP-04	 30-SEP-04 30-SEP-04 30-SEP-04 02-OCT-04 01-OCT-04 01-OCT-04 01-OCT-04 01-OCT-04	 HSL JRB JRB BD BEM HSL BEM WW WW WW WW	 R223779 R224048 R224048 R223717 R223876 R224050 R224368 R224323 R224323 R224323 R224323
Refer to Referenced Information for Qualifiers (if any) and Methodology.								

Reference Information

Methods Listed (if applicable):

ETL Test Code	Matrix	Test Description	Preparation Method Reference(Based On)	Analytical Method Reference(Based On)
C-TOT-LECO-SK	Soil	Total Carbon by combustion method		SSSA (1996) - Combustion Instrument
		Nelson, D.W. and Sommers, L.E. 1996. Total carbon and organic matter. p 961-1010. In: J.M. Bartels et al. (ed.). Methods of Soil Analysis: Part 3 Chemical Methods. (3rd ed.) ASA and SSSA, Madison, WI. Book series no. 5.		
N-TOT-DIG-SK	Soil	Total Nitrogen - TKN with pretreatment		Soil Sci Soc. Am. J. 45:822-855
		Total Nitrogen - Digestion method with pretreatment		
P-SORP-CAP-SK	Soil	Phosphorus Sorption Capacity		J. Soil Sci. 22:2089-301
P-TOT-SK	Soil	Total Phosphorus - HNO ₃ /HClO ₄ digestion		SSSA (1996) p. 870-872
		Kuo, S. 1996. Total Phosphorous, Digestion with Perchloric Acid. p. 870-872. In: J.M. Bartels et al. (ed.) Methods of Soil Analysis: Part 3 Chemical Methods. (3rd ed.) ASA and SSSA, Madison, WI. Book series no. 5		
PSA-3-SK	Soil	Particle size - Pipette removal OM & CO ₃		Forestry Canada (1991) p. 46-53
		Kalra, Y.P., Maynard, D.G. 1991. Methods manual for forest soil and plant analysis. Forestry Canada. 46-53.		

** Laboratory Methods employed follow in-house procedures, which are generally based on nationally or internationally accepted methodologies.

Chain of Custody numbers:

127931, 127930

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location	Laboratory Definition Code	Laboratory Location
SK	Enviro-Test Laboratories - Saskatoon, Saskatchewan, Canada		

GLOSSARY OF REPORT TERMS

Surr - A surrogate is an organic compound that is similar to the target analyte(s) in chemical composition and behavior but not normally detected in environmental samples. Prior to sample processing, samples are fortified with one or more surrogate compounds.

The reported surrogate recovery value provides a measure of method efficiency. The Laboratory warning units are determined under column heading D.L.

mg/kg (units) - unit of concentration based on mass, parts per million

mg/L (units) - unit of concentration based on volume, parts per million

< - Less than

D.L. - Detection Limit

N/A - Result not available. Refer to qualifier code and definition for explanation

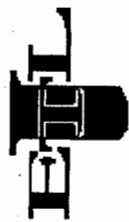
Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

UNLESS OTHERWISE STATED, SAMPLES ARE NOT CORRECTED FOR CLIENT FIELD BLANKS.

Although test results are generated under strict QA/QC protocols, any unsigned test reports, faxes, or emails are considered preliminary.

Enviro-Test Laboratories has an extensive QA/QC program where all analytical data reported is analyzed using approved referenced procedures followed by checks and reviews by senior managers and quality assurance personnel. However, since the results are obtained from chemical measurements and thus cannot be guaranteed, Enviro-Test Laboratories assumes no liability for the use or interpretation of the results.



Enviro-Test Laboratories
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745 Logan Ave
Winnipeg, Manitoba R3E 3L5
(204) 945-3705

Phytoplankton Sample Results

Lab Number: L204046-13 Work Order: L204046

Date Sampled: September 06, 2004

Submitter: CF/DK

Source:

WQNum SLD SYLVAN

Sample Type WATER

Class	Genus	Species	Number of Cells per litre	Unit Biovolume μ^3	Total Biovolume μ^3
Bacillariophyceae	<i>Asterionella</i>	sp.	11400	1280	14592000
Bacillariophyceae	<i>Cyclotella</i>	sp.	9800	4000	39200000
Bacillariophyceae	<i>Cymatopleura</i>	sp.	1600	45000	72000000
Bacillariophyceae	<i>Fragilaria</i>	<i>crotonensis</i>	148000	4320	639360000
Bacillariophyceae	<i>Melosira</i>	sp.	3300	2500	8250000
Bacillariophyceae	<i>Stephanodiscus</i>	sp.	8200	50000	410000000
Bacillariophyceae	<i>Synedra</i>	<i>acus</i>	1600	280	448000
Bacillariophyceae	<i>Synedra</i>	<i>ulna</i>	1600	6400	10240000
Chlorophyceae	<i>Closterium</i>	sp.	6500	3600	23400000
Chlorophyceae	<i>Oedogonium</i>	sp.	14700	2500	36750000
Chlorophyceae	<i>Pediastrum</i>	<i>Boryanum</i>	1600	81000	129600000
Cryptophyceae	<i>Cryptomonas</i>	sp.	6500	3000	19500000
Cryptophyceae	<i>Rhodomonas</i>	sp.	1600	1500	2400000
Myxophyceae	<i>Anabaena</i>	sp.	6500	10000	65000000
Myxophyceae	<i>Aphanizomenon</i>	<i>flos-aquae</i>	233000	1920	447360000
Myxophyceae	<i>Aphanocapsa</i>	sp.	45600	216000	9849600000
Myxophyceae	<i>Chroococcus</i>	sp.	17900	8000	143200000
Myxophyceae	<i>Gomphosphaeria</i>	sp.	116000	27000	3132000000
Peridineeae	<i>Ceratium</i>	sp.	14700	256000	3763200000

Date Printed: September 20, 2004

Lab Number: L204046-13

Work Order: L204046

Date Sampled: September 06, 2004

Submitter: CF/DK

Source:

WQNum

SLD SYLVAN

Sample Type WATER

Class

Genus

Species

Number of Cells per litre

Unit Biovolume μ 3

Total Biovolume μ 3

Peridineae

Peridinium

sp.

3300

64000

211200000

Approved By:

H. Chouaie

Date Approved:

Sept 20/04

Date Printed: September 20, 2004



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Phytoplankton Sample Results

Lab Number: L204046-13		Work Order: L204046			
Date Sampled:	September 06, 2004	Submitter:	CF/DK		
Source:		WQNum	SLD SYLVAN	Sample Type	WATER
Class	Genus	Species	Number of Cells per litre	Unit Biovolume μ^3	Total Biovolume μ^3
Bacillariophyceae	<i>Asterionella</i>	sp.	11400	1280	14592000
Bacillariophyceae	<i>Cyclotella</i>	sp.	9800	4000	39200000
Bacillariophyceae	<i>Cymatopleura</i>	sp.	1600	45000	72000000
Bacillariophyceae	<i>Fragilaria</i>	<i>crottonensis</i>	148000	4320	639360000
Bacillariophyceae	<i>Melosira</i>	sp.	3300	2500	8250000
Bacillariophyceae	<i>Stephanodiscus</i>	sp.	8200	50000	410000000
Bacillariophyceae	<i>Synedra</i>	<i>acus</i>	1600	280	448000
Bacillariophyceae	<i>Synedra</i>	<i>ulna</i>	1600	6400	10240000
Chlorophyceae	<i>Closterium</i>	sp.	6500	3600	23400000
Chlorophyceae	<i>Oedogonium</i>	sp.	14700	2500	36750000
Chlorophyceae	<i>Pediastrum</i>	<i>Boryanum</i>	1600	81000	129600000
Cryptophyceae	<i>Cryptomonas</i>	sp.	6500	3000	19500000
Cryptophyceae	<i>Rhodomonas</i>	sp.	1600	1500	2400000
Myxophyceae	<i>Anabaena</i>	sp.	6500	10000	65000000
Myxophyceae	<i>Aphanizomenon</i>	<i>flos-aquae</i>	233000	1920	447360000
Myxophyceae	<i>Aphanocapsa</i>	sp.	45600	216000	9849600000
Myxophyceae	<i>Chroococcus</i>	sp.	17900	8000	143200000
Myxophyceae	<i>Gomphosphaeria</i>	sp.	116000	27000	3132000000
Peridineeae	<i>Ceratium</i>	sp.	14700	256000	3763200000

Date Printed: September 20, 2004

Lab Number:	L204046-13	Work Order:	L204046
Date Sampled:	September 06, 2004	Submitter:	CF/DK
Source:		WQNum	SLD SYLVAN
Class	Genus	Species	Number of Cells per litre
Peridineae	Peridinium	sp.	3300
Approved By:	<u>[Signature]</u>		Unit Biovolume μ 3
			64000
		Date Approved:	211200000
			<u>sent 20/24</u>
			Sample Type WATER
			Total Biovolume μ 3

Appendix D. Detailed water balance for Sylvan Lake.

Table D-1. Detailed water balance for Sylvan Lake.

Date	Total Precipitation		Evaporation		Computed Inflow		Sylvan Lake Level	Outflow		Storage		Computed Monthly Groundwater Inflow	
	(mm)	(m ³)	(mm)	(m ³)	(mm)	(m ³)		(mm)	(m ³)	(mm)	(m ³)	(mm)	(m ³)
Jan-56	16.1	672175	0.0	0	0.0	0	936.97	26.8	1118617	-	-	-	-
Feb-56	16.4	684700	0.0	0	0.0	0	936.97	26.0	1085379	6.9	286520	16.5	687198
Mar-56	46.2	1928850	0.0	0	0.0	0	936.98	28.8	1202019	6.9	286520	-10.5	-440312
Apr-56	19.7	822475	41.3	1724275	82.0	3422071	936.99	28.9	1204626	7.0	291295	-24.5	-1024350
May-56	11.0	459250	134.0	5594500	8.0	334730	936.99	30.8	1287954	7.0	291295	152.8	6379769
Jun-56	149.0	6220750	151.8	6337650	51.7	2159081	937.00	30.9	1288922	7.0	291295	-11.1	-461964
Jul-56	46.6	1945550	135.0	5636250	32.3	1350512	937.01	33.0	1376716	7.0	291295	96.0	4008199
Aug-56	61.9	2584325	118.9	4964075	17.2	717568	936.99	30.3	1266562	-17.4	-726781	52.7	2201963
Sep-56	26.4	1102200	84.1	3511175	4.9	206576	936.93	20.2	842585	-65.3	-2727074	7.6	317910
Oct-56	18.6	776550	52.2	2179350	6.5	269523	936.83	9.9	414274	-96.4	-4025550	-59.4	-2477999
Nov-56	3.6	150300	0.0	0	0.0	0	936.80	7.8	327725	-23.9	-996178	-19.6	-818754
Dec-56	42.4	1770200	0.0	0	0.0	0	936.82	9.1	379708	13.5	562510	-19.8	-827982
Jan-57	20.4	851700	0.0	0	0.0	0	936.83	10.2	425279	13.7	571732	3.5	145310
Feb-57	21.6	901800	0.0	0	0.0	0	936.84	10.2	427059	13.0	544067	1.7	69327
Mar-57	27.8	1160650	0.0	0	0.0	0	936.86	12.6	524585	13.0	544067	-2.2	-91997
Apr-57	33.7	1406975	39.0	1628250	124.5	5199183	936.87	13.5	564364	13.5	562510	-92.2	-3851034
May-57	50.8	2120900	134.3	5607025	37.0	1545844	936.88	15.2	636394	11.2	467212	72.9	3043888
Jun-57	80.1	3344175	136.2	5686350	27.8	1160687	936.87	13.8	576049	-8.6	-357749	33.5	1399788
Jul-57	37.6	1569800	177.3	7402275	26.1	1089684	936.85	11.5	478961	-27.5	-1146213	97.6	4075539
Aug-57	79.6	3323300	136.4	5694700	22.1	922754	936.80	7.8	325591	-46.2	-1928994	-3.7	-154757
Sep-57	25.3	1056275	121.5	5072625	4.7	197969	936.75	4.7	195588	-47.7	-1990029	48.5	2023939
Oct-57	60.3	2517525	48.2	2012350	20.9	873776	936.71	2.4	98984	-47.1	-1967880	-77.8	-3247847
Nov-57	15.5	647125	0.0	0	0.0	0	936.67	0.5	20453	-39.6	-1651594	-54.6	-2278267
Dec-57	4.7	196225	0.0	0	0.0	0	936.68	1.0	42725	11.3	470833	7.6	317332
Jan-58	32.8	1369400	0.0	0	0.0	0	936.70	2.2	93230	25.4	1061124	-5.2	-215046
Feb-58	23.2	968600	0.0	0	0.0	0	936.73	3.1	130075	24.2	1009780	4.1	171255

Table D-1. - continued -

Date	Total Precipitation		Evaporation		Computed Inflow		Sylvan Lake Level	Outflow		Storage		Computed Monthly Groundwater Inflow	
	(mm)	(m ³)	(mm)	(m ³)	(mm)	(m ³)		(mm)	(m ³)	(mm)	(m ³)	(mm)	(m ³)
Mar-58	41.1	1715925	0.0	0	0.0	0	936.75	4.8	198363	24.2	1009780	-12.2	-507782
Apr-58	10.0	417500	45.7	1907975	106.0	4427131	936.78	6.0	251129	25.0	1044009	-39.3	-1641517
May-58	47.4	1978950	148.2	6187350	34.5	1442382	936.78	6.3	264494	2.0	83387	74.6	3113899
Jun-58	89.2	3724100	138.5	5782375	31.0	1292551	936.76	5.1	213179	-17.7	-738216	5.8	240688
Jul-58	85.7	3577975	140.0	5845000	59.5	2483668	936.78	6.3	261411	16.4	686730	17.5	731498
Aug-58	29.6	1235800	165.4	6905450	8.2	343134	936.74	4.1	170790	-37.8	-1576407	93.9	3920899
Sep-58	49.8	2079150	121.2	5060100	9.3	389678	936.61	0.0	0	133.8	-5584335	-71.7	-2993063
Oct-58	3.3	137775	77.2	3223100	1.1	47819	936.54	0.0	0	-63.1	-2633195	9.7	404311
Nov-58	32.3	1348525	0.0	0	0.0	0	936.54	0.0	0	-3.5	-144118	-35.8	-1492643
Dec-58	17.8	743150	0.0	0	0.0	0	936.55	0.0	0	7.1	295191	-10.7	-447959
Jan-59	39.5	1649125	0.0	0	0.0	0	936.55	0.0	0	7.2	300031	-32.3	-1349094
Feb-59	13.9	580325	0.0	0	0.0	0	936.56	0.0	0	6.8	285513	-7.1	-294812
Mar-59	19.3	805775	0.0	0	0.0	0	936.57	0.0	0	6.8	285513	-12.5	-520262
Apr-59	31.5	1315125	70.8	2955900	128.5	5366113	936.57	0.0	0	7.1	295191	-82.2	-3430147
May-59	30.1	1256675	134.5	5615375	21.9	915943	936.58	0.0	0	7.3	303955	89.7	3746712
Jun-59	83.3	3477775	154.9	6467075	28.9	1207057	936.59	0.0	0	12.1	505758	54.8	2288001
Jul-59	116.6	4868050	182.6	7623550	80.9	3379179	936.60	0.0	0	3.7	154549	-11.2	-469130
Aug-59	54.5	2275375	146.7	6124725	15.1	631785	936.61	0.0	0	9.5	396335	86.6	3613900
Sep-59	22.8	951900	111.7	4663475	4.3	178407	936.55	0.0	0	-58.6	-2447130	26.0	1086038
Oct-59	27.0	1127250	52.1	2175175	9.4	391243	936.50	0.0	0	-48.2	-2011525	-32.5	-1354843
Nov-59	18.1	755675	0.0	0	0.0	0	936.49	0.0	0	-11.6	-485895	-29.7	-1241570
Dec-59	24.1	1006175	0.0	0	0.0	0	936.50	0.0	0	8.7	363821	-15.4	-642354
Jan-60	20.1	839175	0.0	0	0.0	0	936.51	0.0	0	8.9	369786	-11.2	-469389
Feb-60	49.5	2066625	0.0	0	0.0	0	936.51	0.0	0	8.6	357857	-40.9	-1708768
Mar-60	15.8	659650	0.0	0	0.0	0	936.52	0.0	0	10.5	439907	-5.3	-219743
Apr-60	18.5	772375	69.4	2897450	121.7	5080941	936.58	0.0	0	54.5	2275847	-16.3	-680019

Table D-1. - continued -

Date	Total Precipitation		Evaporation		Computed Inflow		Sylvan Lake Level	Outflow		Storage		Computed Monthly Groundwater Inflow	
	(mm)	(m ³)	(mm)	(m ³)	(mm)	(m ³)		(mm)	(m ³)	(mm)	(m ³)	(mm)	(m ³)
May-60	67.9	2834825	154.0	6429500	49.5	2066197	936.64	0.0	0	60.8	2537736	97.4	4066214
Jun-60	83.5	3486125	175.6	7331300	29.0	1209955	936.66	0.4	16536	24.0	999936	87.5	3651693
Jul-60	65.8	2747150	177.4	7406450	45.7	1906947	936.67	0.6	23508	3.4	140005	69.8	2915866
Aug-60	44.3	1849525	172.2	7189350	12.3	513543	936.64	0.0	0	-31.1	-1297546	84.5	3528736
Sep-60	22.7	947725	129.7	5414975	4.3	177624	936.54	0.0	0	-91.7	-3828207	11.1	461419
Oct-60	21.7	905975	67.3	2809775	7.5	314443	936.49	0.0	0	-49.5	-2067062	-11.4	-477706
Nov-60	24.1	1006175	0.0	0	0.0	0	936.51	0.0	0	17.9	746975	-6.2	-259200
Dec-60	21.2	885100	0.0	0	0.0	0	936.54	0.0	0	23.1	964450	1.9	79350
Jan-61	7.3	304775	0.0	0	0.0	0	936.56	0.0	0	23.5	980260	16.2	675485
Feb-61	24.0	1002000	0.0	0	0.0	0	936.58	0.0	0	22.3	932828	-1.7	-69172
Mar-61	11.6	484300	0.0	0	0.0	0	936.60	0.0	0	22.1	923034	10.5	438734
Apr-61	17.3	722275	68.4	2855700	87.9	3668989	936.58	0.0	0	-19.1	-796837	-55.9	-2332401
May-61	60.3	2517525	137.7	5748975	44.0	1834929	936.53	0.0	0	-50.8	-2122292	-17.4	-725771
Jun-61	42.9	1791075	207.2	8650600	14.9	621641	936.48	0.0	0	-51.0	-2131039	98.4	4106844
Jul-61	81.8	3415150	177.5	7410625	56.8	2370642	936.41	0.0	0	-68.3	-2852449	-29.4	-1227616
Aug-61	38.8	1619900	172.5	7201875	10.8	449784	936.40	0.0	0	-14.8	-617114	108.1	4515076
Sep-61	28.8	1202400	118.5	4947375	5.4	225356	936.40	0.0	0	0.6	22963	84.9	3542582
Oct-61	34.8	1452900	59.0	2463250	12.1	504269	936.39	0.0	0	-11.5	-479964	0.6	26117
Nov-61	3.9	162825	0.0	0	0.0	0	936.38	0.0	0	-11.5	-479964	-15.4	-642789
Dec-61	18.5	772375	0.0	0	0.0	0	936.37	0.0	0	-11.5	-479964	-30.0	-1252339
Jan-62	11.6	484300	0.0	0	0.0	0	936.35	0.0	0	-11.7	-487833	-23.3	-972133
Feb-62	34.2	1427850	0.0	0	0.0	0	936.34	0.0	0	-11.1	-464228	-45.3	-1892078
Mar-62	17.0	709750	0.0	0	0.0	0	936.33	0.0	0	-11.1	-464228	-28.1	-1173978
Apr-62	21.8	910150	59.2	2471600	89.1	3721155	936.32	0.0	0	-11.5	-479964	-63.2	-2639669
May-62	52.0	2171000	120.5	5030875	37.9	1582360	936.31	0.0	0	-7.5	-312621	23.1	964894
Jun-62	69.7	2909975	159.8	6671650	24.2	1009986	936.33	0.0	0	16.1	670339	82.0	3422028

Table D-1. - continued -

Date	Total Precipitation		Evaporation		Computed Inflow		Sylvan Lake Level	Outflow		Storage		Computed Monthly Groundwater Inflow	
	(mm)	(m ³)	(mm)	(m ³)	(mm)	(m ³)		(mm)	(m ³)	(mm)	(m ³)	(mm)	(m ³)
Jul-62	125.4	5235450	153.0	6387750	87.0	3634212	936.35	0.0	0	18.8	786591	-40.6	-1695321
Aug-62	70.1	2926675	159.3	6650775	19.5	812626	936.34	0.0	0	-11.3	-470569	58.5	2440905
Sep-62	42.7	1782725	128.2	5352350	8.0	334121	936.27	0.0	0	-67.1	-2802867	10.4	432637
Oct-62	10.7	446725	66.5	2776375	3.7	155048	936.26	0.0	0	-13.9	-580045	38.2	1594557
Nov-62	6.7	279725	0.0	0	0.0	0	936.25	0.0	0	-1.5	-63405	-8.2	-343130
Dec-62	27.3	1139775	0.0	0	0.0	0	936.25	0.0	0	-1.5	-63405	-28.8	-1203180
Jan-63	55.3	2308775	0.0	0	0.0	0	936.25	0.0	0	-1.5	-64444	-56.8	-2373219
Feb-63	25.7	1072975	0.0	0	0.0	0	936.25	0.0	0	-1.5	-61326	-27.2	-1134301
Mar-63	24.3	1014525	0.0	0	0.0	0	936.25	0.0	0	-1.5	-61326	-25.8	-1075851
Apr-63	59.1	2467425	51.3	2141775	165.3	6899786	936.25	0.0	0	-1.5	-63405	-174.6	-7288840
May-63	15.7	655475	129.2	5394100	11.4	477751	936.24	0.0	0	-6.3	-262588	95.8	3998286
Jun-63	56.5	2358875	158.6	6621550	19.6	818712	936.20	0.0	0	-38.3	-1599015	44.2	1844948
Jul-63	107.8	4500650	164.4	6863700	74.8	3124147	936.15	0.0	0	-54.1	-2256923	-72.3	-3018020
Aug-63	50.0	2087500	139.5	5824125	13.9	579619	936.09	0.0	0	-55.7	-2326700	19.9	830306
Sep-63	34.0	1419500	114.6	4784550	6.4	266045	936.10	0.0	0	8.9	372213	83.1	3471217
Oct-63	6.1	254675	70.2	2930850	2.1	88392	936.11	0.0	0	12.7	529675	74.7	3117458
Nov-63	19.6	818300	0.0	0	0.0	0	936.11	0.0	0	-2.4	-100988	-22.0	-919288
Dec-63	15.3	638775	0.0	0	0.0	0	936.11	0.0	0	3.3	136433	-12.0	-502342
Jan-64	18.1	755675	0.0	0	0.0	0	936.12	0.0	0	3.3	138670	-14.8	-617005
Feb-64	7.3	304775	0.0	0	0.0	0	936.12	0.0	0	3.2	134196	-4.1	-170579
Mar-64	14.5	605375	0.0	0	0.0	0	936.12	0.0	0	3.2	134196	-11.3	-471179
Apr-64	33.8	1411150	63.2	2638600	90.5	3776798	936.13	0.0	0	3.2	134847	-57.8	-2414501
May-64	79.5	3319125	138.3	5774025	57.9	2419185	936.16	0.0	0	34.1	1423054	34.9	1458768
Jun-64	59.2	2471600	156.1	6517175	20.5	857836	936.19	0.0	0	31.2	1304313	107.6	4492051
Jul-64	45.9	1916325	173.8	7256150	31.9	1330226	936.18	0.0	0	-8.8	-366426	87.3	3643173
Aug-64	54.4	2271200	177.6	7414800	15.1	630626	936.16	0.0	0	-22.6	-945073	85.5	3567902

Table D-1. - continued -

Date	Total Precipitation		Evaporation		Computed Inflow		Sylvan Lake Level	Outflow		Storage		Computed Monthly Groundwater Inflow	
	(mm)	(m ³)	(mm)	(m ³)	(mm)	(m ³)		(mm)	(m ³)	(mm)	(m ³)	(mm)	(m ³)
Sep-64	71.6	2989300	106.5	4446375	13.4	560260	936.12	0.0	0	-46.5	-1940596	-25.0	-1043781
Oct-64	11.5	480125	63.6	2655300	4.0	166640	936.07	0.0	0	-47.8	-1997252	0.3	11283
Nov-64	23.7	989475	0.0	0	0.0	0	936.07	0.0	0	5.9	246282	-17.8	-743193
Dec-64	25.7	1072975	0.0	0	0.0	0	936.11	0.0	0	40.3	1681945	14.6	608970
Jan-65	28.3	1181525	0.0	0	0.0	0	936.15	0.0	0	40.9	1709517	12.6	527992
Feb-65	27.4	1143950	0.0	0	0.0	0	936.19	0.0	0	39.0	1626799	11.6	482849
Mar-65	19.2	801600	0.0	0	0.0	0	936.23	0.0	0	39.0	1626799	19.8	825199
Apr-65	13.0	542750	42.0	1753500	114.4	4774902	936.27	0.0	0	40.3	1681945	-45.1	-1882207
May-65	68.6	2864050	139.5	5824125	50.0	2087498	936.32	0.0	0	48.1	2009502	69.0	2882079
Jun-65	108.4	4525700	155.9	6508825	37.6	1570768	936.40	0.0	0	83.8	3497824	93.7	3910182
Jul-65	68.0	2839000	157.4	6571450	47.2	1970705	936.50	0.0	0	96.5	4030831	138.7	5792576
Aug-65	70.5	2943375	154.2	6437850	19.6	817263	936.53	0.0	0	30.2	1260601	94.3	3937814
Sep-65	70.7	2951725	88.5	3694875	13.3	553217	936.47	0.0	0	-58.0	-2421528	-53.5	-2231595
Oct-65	3.3	137775	70.7	2951725	1.1	47819	936.41	0.0	0	-67.7	-2825723	-1.4	-59592
Nov-65	24.3	1014525	0.0	0	0.0	0	936.41	0.0	0	3.7	154276	-20.6	-860249
Dec-65	14.8	617900	0.0	0	0.0	0	936.43	0.0	0	25.4	1060130	10.6	442230
Jan-66	36.6	1528050	0.0	0	0.0	0	936.46	0.0	0	25.8	1077510	-10.8	-450540
Feb-66	25.4	1060450	0.0	0	0.0	0	936.48	0.0	0	24.6	1025372	-0.8	-35078
Mar-66	4.2	175350	0.0	0	0.0	0	936.51	0.0	0	24.6	1025372	20.4	850022
Apr-66	27.9	1164825	50.9	2125075	111.0	4632316	936.53	0.0	0	25.4	1060130	-62.6	-2611935
May-66	34.9	1457075	155.4	6487950	25.4	1062007	936.56	0.0	0	26.7	1115670	121.8	5084538
Jun-66	53.1	2216925	142.3	5941025	18.4	769444	936.58	0.0	0	20.1	840114	90.9	3794770
Jul-66	106.5	4446375	129.2	5394100	73.9	3086472	936.57	0.0	0	-14.1	-586624	-65.3	-2725371
Aug-66	65.1	2717925	122.1	5097675	18.1	754664	936.56	0.0	0	-11.9	-498155	27.0	1126931
Sep-66	15.5	647125	99.2	4141600	2.9	121285	936.53	0.0	0	-26.9	-1124647	53.9	2248543
Oct-66	18.4	768200	52.9	2208575	6.4	266625	936.50	0.0	0	-29.0	-1208919	-0.8	-35168

Table D-1. - continued -

Date	Total Precipitation		Evaporation		Computed Inflow		Sylvan Lake Level	Outflow		Storage		Computed Monthly Groundwater Inflow	
	(mm)	(m ³)	(mm)	(m ³)	(mm)	(m ³)		(mm)	(m ³)	(mm)	(m ³)	(mm)	(m ³)
Nov-66	28.8	1202400	0.0	0	0.0	0	936.49	0.0	0	-7.5	-311290	-36.3	-1513690
Dec-66	2.3	96025	0.0	0	0.0	0	936.49	0.0	0	-5.0	-210766	-7.3	-306791
Jan-67	23.1	964425	0.0	0	0.0	0	936.48	0.0	0	-5.1	-214221	-28.2	-1178646
Feb-67	24.5	1022875	0.0	0	0.0	0	936.48	0.0	0	-4.9	-203855	-29.4	-1226730
Mar-67	25.5	1064625	0.0	0	0.0	0	936.49	0.0	0	8.5	353630	-17.0	-710995
Apr-67	9.7	404975	36.9	1540575	94.9	3961117	936.52	0.0	0	38.0	1587572	-29.7	-1237944
May-67	23.8	993650	111.8	4667650	17.3	724234	936.58	0.0	0	56.2	2344508	126.8	5294274
Jun-67	89.3	3728275	128.9	5381575	31.0	1294000	936.63	0.0	0	49.9	2083045	58.5	2442346
Jul-67	58.4	2438200	154.2	6437850	40.5	1692488	936.63	0.0	0	-4.0	-167083	51.3	2140080
Aug-67	27.2	1135600	159.8	6671650	7.6	315313	936.59	0.0	0	-38.7	-1614477	86.4	3606260
Sep-67	3.7	154475	136.9	5715575	0.7	28952	936.52	0.0	0	-70.9	-2959090	61.6	2573058
Oct-67	33.3	1390275	56.5	2358875	11.6	482533	936.38	0.0	0	-140.7	-5875489	-129.1	-5389422
Nov-67	12.0	501000	0.0	0	0.0	0	936.32	0.0	0	-55.9	-2332538	-67.9	-2833538
Dec-67	32.4	1352700	0.0	0	0.0	0	936.35	0.0	0	26.6	1110476	-5.8	-242224
Jan-68	20.2	843350	0.0	0	0.0	0	936.38	0.0	0	29.7	1240769	9.5	397419
Feb-68	6.4	267200	0.0	0	0.0	0	936.40	0.0	0	28.8	1200744	22.4	933544
Mar-68	7.4	308950	0.0	0	0.0	0	936.42	0.0	0	11.6	483447	4.2	174497
Apr-68	15.8	659650	62.1	2592675	78.5	3276007	936.39	0.0	0	-23.7	-989712	-55.9	-2332694
May-68	21.4	893450	154.9	6467075	15.6	651202	936.37	0.0	0	-18.1	-755417	99.8	4167006
Jun-68	71.4	2980950	144.3	6024525	24.8	1034620	936.37	0.0	0	-8.8	-366382	39.3	1642572
Jul-68	134.1	5598675	162.1	6767675	93.1	3886346	936.36	0.0	0	-4.1	-169697	-69.2	-2887043
Aug-68	63.9	2667825	129.1	5389925	17.7	740753	936.41	0.0	0	46.5	1942853	94.0	3924200
Sep-68	77.1	3218925	100.9	4212575	14.5	603297	936.43	0.0	0	23.7	990224	33.1	1380577
Oct-68	41.9	1749325	57.4	2396450	14.5	607151	936.39	0.0	0	-40.6	-1694649	-39.6	-1654675
Nov-68	11.7	488475	0.0	0	0.0	0	936.34	0.0	0	-49.0	-2044914	-60.7	-2533389
Dec-68	23.9	997825	0.0	0	0.0	0	936.37	0.0	0	30.0	1253532	6.1	255707

Table D-1. - continued -

Date	Total Precipitation		Evaporation		Computed Inflow		Sylvan Lake Level	Outflow		Storage		Computed Monthly Groundwater Inflow	
	(mm)	(m ³)	(mm)	(m ³)	(mm)	(m ³)		(mm)	(m ³)	(mm)	(m ³)	(mm)	(m ³)
Jan-69	26.3	1098025	0.0	0	0.0	0	936.40	0.0	0	31.4	1310130	5.1	212105
Feb-69	15.5	647125	0.0	0	0.0	0	936.43	0.0	0	29.9	1246737	14.4	599612
Mar-69	8.2	342350	0.0	0	0.0	0	936.46	0.0	0	29.9	1246737	21.7	904387
Apr-69	13.0	542750	55.6	2321300	82.1	3429026	936.47	0.0	0	9.0	375665	-30.5	-1274812
May-69	13.8	576150	136.4	5694700	10.1	419934	936.50	0.0	0	22.8	951300	135.3	5649916
Jun-69	45.8	1912150	153.3	6400275	15.9	663664	936.47	0.0	0	-21.0	-875896	70.6	2948565
Jul-69	139.8	5836650	148.6	6204050	97.0	4051537	936.48	0.0	0	5.2	217430	-83.0	-3466708
Aug-69	57.2	2388100	156.5	6533875	15.9	663084	936.49	0.0	0	15.1	629858	98.5	4112549
Sep-69	139.2	5811600	102.4	4275200	26.1	1089220	936.44	0.0	0	-53.4	-2229659	-116.3	-4855279
Oct-69	37.1	1548925	51.6	2154300	12.9	537597	936.40	0.0	0	-45.1	-1884913	-43.5	-1817135
Nov-69	11.6	484300	0.0	0	0.0	0	936.39	0.0	0	-7.8	-325707	-19.4	-810007
Dec-69	12.5	521875	0.0	0	0.0	0	936.40	0.0	0	10.5	438041	-2.0	-83834
Jan-70	11.3	471775	0.0	0	0.0	0	936.41	0.0	0	10.7	445222	-0.6	-26553
Feb-70	13.2	551100	0.0	0	0.0	0	936.42	0.0	0	10.1	423679	-3.1	-127421
Mar-70	19.8	826650	0.0	0	0.0	0	936.41	0.0	0	-10.9	-456242	-30.7	-1282892
Apr-70	17.4	726450	53.5	2233625	71.5	2983879	936.41	0.0	0	1.6	66314	-33.8	-1410390
May-70	32.1	1340175	140.5	5865875	23.4	976803	936.43	0.0	0	15.5	646978	100.5	4195875
Jun-70	243.9	10182825	166.7	6959725	84.7	3534227	936.52	0.0	0	90.2	3765308	-71.7	-2992019
Jul-70	40.4	1686700	161.4	6738450	28.0	1170831	936.57	0.0	0	53.2	2222193	146.2	6103113
Aug-70	14.2	592850	171.9	7176825	3.9	164612	936.51	0.0	0	-58.5	-2441381	95.3	3977982
Sep-70	29.6	1235800	122.1	5097675	5.5	231616	936.42	0.0	0	-92.0	-3840006	-5.0	-209747
Oct-70	50.7	2116725	66.9	2793075	17.6	734667	936.35	0.0	0	-68.5	-2861094	-69.9	-2919411
Nov-70	31.1	1298425	0.0	0	0.0	0	936.34	0.0	0	-15.0	-625915	-46.1	-1924340
Dec-70	16.6	693050	0.0	0	0.0	0	936.36	0.0	0	21.9	913164	5.3	220114
Jan-71	63.8	2663650	0.0	0	0.0	0	936.38	0.0	0	22.8	951329	-41.0	-1712321
Feb-71	7.9	329825	0.0	0	0.0	0	936.40	0.0	0	21.7	905297	13.8	575472

Table D-1. - continued -

Date	Total Precipitation		Evaporation		Computed Inflow		Sylvan Lake Level	Outflow		Storage		Computed Monthly Groundwater Inflow	
	(mm)	(m ³)	(mm)	(m ³)	(mm)	(m ³)		(mm)	(m ³)	(mm)	(m ³)	(mm)	(m ³)
Mar-71	19.1	797425	0.0	0	0.0	0	936.43	0.0	0	30.9	1290405	11.8	492980
Apr-71	6.1	254675	48.4	2020700	120.4	5028775	936.51	0.0	0	77.7	3245714	-0.4	-17036
May-71	6.4	267200	146.8	6128900	4.7	194752	936.57	0.0	0	61.7	2573910	197.4	8240858
Jun-71	85.6	3573800	126.2	5268850	29.7	1240385	936.59	0.0	0	19.8	828447	30.7	1283113
Jul-71	107.4	4483950	159.4	6654950	74.6	3112554	936.65	0.0	0	57.5	2398614	34.9	1457060
Aug-71	12.4	517700	181.3	7569275	3.4	143746	936.59	0.0	0	-58.9	-2458556	106.6	4449274
Sep-71	43.9	1832825	120.2	5018350	8.2	343511	936.49	0.0	0	-97.2	-4056311	-29.1	-1214297
Oct-71	7.1	296425	64.9	2709575	2.5	102882	936.41	0.0	0	-81.7	-3411975	-26.4	-1101708
Nov-71	11.9	496825	0.0	0	0.0	0	936.38	0.0	0	-33.5	-1398381	-45.4	-1895206
Dec-71	24.4	1018700	0.0	0	0.0	0	936.40	0.0	0	18.4	767132	-6.0	-251568
Jan-72	21.6	901800	0.0	0	0.0	0	936.42	0.0	0	19.0	792004	-2.6	-109796
Feb-72	31.5	1315125	0.0	0	0.0	0	936.43	0.0	0	18.4	766455	-13.1	-548670
Mar-72	8.6	359050	0.0	0	0.0	0	936.46	0.0	0	22.6	941915	14.0	582865
Apr-72	27.4	1143950	67.3	2809775	104.5	4361054	936.52	0.0	0	59.7	2493147	-4.8	-202082
May-72	54.4	2271200	128.8	5377400	39.7	1655392	936.57	0.0	0	54.4	2272336	89.2	3723144
Jun-72	116.3	4855525	151.9	6341825	40.4	1685242	936.60	0.0	0	32.2	1345870	27.5	1146928
Jul-72	65.5	2734625	143.6	5995300	45.5	1898252	936.66	0.0	280	52.6	2194537	85.2	3557239
Aug-72	44.7	1866225	142.5	5949375	12.4	518179	936.62	0.0	0	-39.3	-1640807	46.1	1924164
Sep-72	75.4	3147950	88.6	3699050	14.1	589994	936.56	0.0	0	-60.1	-2507644	-61.0	-2546538
Oct-72	9.7	404975	57.4	2396450	3.4	140558	936.52	0.0	0	-40.7	-1700652	3.6	150265
Nov-72	13.7	571975	0.0	0	0.0	0	936.50	0.0	0	-19.3	-804989	-33.0	-1376964
Dec-72	22.4	935200	0.0	0	0.0	0	936.50	0.0	0	8.3	347917	-14.1	-587283
Jan-73	5.1	212925	0.0	0	0.0	0	936.51	0.0	0	8.5	355919	3.4	142994
Feb-73	14.2	592850	0.0	0	0.0	0	936.52	0.0	0	8.1	338697	-6.1	-254153
Mar-73	16.3	680525	0.0	0	0.0	0	936.55	0.0	0	30.0	1254513	13.7	573988
Apr-73	47.0	1962250	49.7	2074975	98.9	4128047	936.61	0.0	0	56.0	2338658	-40.2	-1676665

Table D-1. - continued -

Date	Total Precipitation		Evaporation		Computed Inflow		Sylvan Lake Level	Outflow		Storage		Computed Monthly Groundwater Inflow	
	(mm)	(m ³)	(mm)	(m ³)	(mm)	(m ³)		(mm)	(m ³)	(mm)	(m ³)	(mm)	(m ³)
May-73	26.7	1114725	154.9	6467075	19.5	812481	936.65	0.0	0	47.8	1994543	156.5	6534412
Jun-73	94.5	3945375	165.9	6926325	32.8	1369350	936.66	0.0	1575	1.3	53233	39.9	1666408
Jul-73	65.0	2713750	167.7	7001475	45.1	1883762	936.67	0.8	34646	17.2	720053	75.7	3158661
Aug-73	137.2	5728100	145.2	6062100	38.1	1590475	936.65	0.0	0	-19.0	-792577	-49.1	-2049051
Sep-73	19.8	826650	109.7	4579975	3.7	154932	936.59	0.0	0	-63.0	-2631763	23.2	966630
Oct-73	4.8	200400	61.1	2550925	1.7	69554	936.52	0.0	0	-75.3	-3143946	-20.7	-862975
Nov-73	31.5	1315125	0.0	0	0.0	0	936.49	0.0	0	-26.0	-1087188	-57.5	-2402313
Dec-73	18.5	772375	0.0	0	0.0	0	936.51	0.0	0	16.7	697076	-1.8	-75299
Jan-74	44.7	1866225	0.0	0	0.0	0	936.52	0.0	0	17.7	739571	-27.0	-1126654
Feb-74	5.8	242150	0.0	0	0.0	0	936.54	0.0	0	17.1	715799	11.3	473649
Mar-74	36.1	1507175	0.0	0	0.0	0	936.58	0.0	0	42.1	1756993	6.0	249818
Apr-74	38.4	1603200	48.1	2008175	145.8	6086000	936.64	0.0	0	58.4	2437604	-77.7	-3243422
May-74	88.6	3699050	114.7	4788725	64.6	2696098	936.73	3.7	154128	89.9	3753210	55.1	2300914
Jun-74	47.5	1983125	180.6	7540050	16.5	688298	936.76	5.3	220493	31.8	1327467	153.7	6416588
Jul-74	67.1	2801425	172.2	7189350	46.6	1944622	936.77	6.0	248413	8.2	343495	72.7	3035211
Aug-74	93.2	3891100	149.2	6229100	25.9	1080410	936.71	2.8	115033	-58.3	-2434968	-25.4	-1062345
Sep-74	42.9	1791075	106.6	4450550	8.0	335686	936.66	0.4	15686	-49.9	-2082831	6.1	256644
Oct-74	29.7	1239975	65.3	2726275	10.3	430367	936.61	0.0	0	-48.7	-2032911	-23.4	-976978
Nov-74	2.8	116900	0.0	0	0.0	0	936.59	0.0	0	-28.7	-1198446	-31.5	-1315346
Dec-74	17.0	709750	0.0	0	0.0	0	936.59	0.0	0	3.2	131846	-13.8	-577904
Jan-75	9.9	413325	0.0	0	0.0	0	936.59	0.0	0	4.9	206645	-5.0	-206680
Feb-75	19.6	818300	0.0	0	0.0	0	936.60	0.0	0	4.7	196646	-14.9	-621654
Mar-75	13.5	563625	0.0	0	0.0	0	936.62	0.0	0	19.3	805645	5.8	242020
Apr-75	37.6	1569800	40.7	1699225	83.6	3491625	936.67	0.5	20125	47.7	1990598	-32.4	-1351478
May-75	73.9	3085325	125.0	5218750	53.9	2248777	936.74	4.1	171302	73.5	3067696	74.8	3123646
Jun-75	87.6	3657300	143.8	6003650	30.4	1269366	936.74	4.3	177484	5.3	219598	35.3	1474066

Table D-1. - continued -

Date	Total Precipitation		Evaporation		Computed Inflow		Sylvan Lake Level	Outflow		Storage		Computed Monthly Groundwater Inflow	
	(mm)	(m ³)	(mm)	(m ³)	(mm)	(m ³)		(mm)	(m ³)	(mm)	(m ³)	(mm)	(m ³)
Jul-75	51.3	2141775	149.4	6237450	35.6	1486723	936.74	4.4	182057	-0.6	-24377	66.3	2766633
Aug-75	50.3	2100025	135.3	5648775	14.0	583097	936.66	0.1	2933	-87.5	-3652452	-16.4	-683865
Sep-75	15.7	655475	114.0	4759500	2.9	122850	936.59	0.0	0	-71.2	-2973251	24.1	1007924
Oct-75	15.7	655475	60.3	2517525	5.4	227500	936.50	0.0	0	-89.4	-3730991	-50.2	-2096441
Nov-75	9.4	392450	0.0	0	0.0	0	936.50	0.0	0	3.9	163175	-5.5	-229275
Dec-75	59.7	2492475	0.0	0	0.0	0	936.50	0.0	0	3.7	152805	-56.0	-2339670
Jan-76	5.1	212925	0.0	0	0.0	0	936.51	0.0	0	3.7	155310	-1.4	-57615
Feb-76	15.0	626250	0.0	0	0.0	0	936.51	0.0	0	3.6	150300	-11.4	-475950
Mar-76	20.8	868400	0.0	0	0.0	0	936.53	0.0	0	20.8	868740	0.0	340
Apr-76	14.7	613725	62.4	2605200	103.9	4336710	936.55	0.0	0	23.0	958754	-33.2	-1386481
May-76	56.1	2342175	156.3	6525525	40.9	1707123	936.55	0.0	0	-1.8	-73619	57.5	2402608
Jun-76	90.4	3774200	141.1	5890925	31.4	1309939	936.56	0.0	0	7.7	320265	27.0	1127051
Jul-76	22.4	935200	161.6	6746800	15.5	649173	936.74	4.4	182057	183.5	7660963	311.5	13005447
Aug-76	101.9	4254325	144.5	6032875	28.3	1181264	936.66	0.1	2933	-87.5	-3652452	-73.1	-3052232
Sep-76	21.3	889275	109.7	4579975	4.0	166669	936.59	0.0	0	-71.2	-2973251	13.2	550780
Oct-76	10.2	425850	65.7	2742975	3.5	147803	936.50	0.0	0	-89.4	-3730991	-37.4	-1561669
Nov-76	20.3	847525	0.0	0	0.0	0	936.50	0.0	0	3.9	163175	-16.4	-684350
Dec-76	26.2	1093850	0.0	0	0.0	0	936.50	0.0	0	3.7	152805	-22.5	-941045
Jan-77	29.8	1244150	0.0	0	0.0	0	936.51	0.0	0	3.7	155310	-26.1	-1088840
Feb-77	0.8	33400	0.0	0	0.0	0	936.51	0.0	0	3.6	150300	2.8	116900
Mar-77	4.1	171175	0.0	0	0.0	0	936.53	0.0	0	20.8	868740	16.7	697565
Apr-77	5.1	212925	81.4	3398450	71.9	3001268	936.55	0.0	0	23.0	958754	27.4	1143011
May-77	106.8	4458900	129.7	5414975	77.8	3249924	936.55	0.0	0	-1.8	-73619	-56.7	-2367469
Jun-77	34.7	1448725	167.0	6972250	12.0	502820	936.56	0.0	0	7.7	320265	127.9	5340971
Jul-77	114.6	4784550	172.6	7206050	79.6	3321217	936.53	0.0	0	-28.3	-1181754	-49.9	-2081471
Aug-77	99.0	4133250	131.6	5494300	27.5	1147646	936.51	0.0	0	-22.7	-948668	-17.6	-735264

Table D-1. - continued -

Date	Total Precipitation		Evaporation		Computed Inflow		Sylvan Lake Level	Outflow		Storage		Computed Monthly Groundwater Inflow	
	(mm)	(m ³)	(mm)	(m ³)	(mm)	(m ³)		(mm)	(m ³)	(mm)	(m ³)	(mm)	(m ³)
Sep-77	85.2	3557100	85.9	3586325	16.0	666678	936.45	0.0	0	-56.9	-2375934	-72.2	-3013387
Oct-77	8.2	342350	70.0	2922500	2.8	118822	936.35	0.0	0	-105.3	-4395573	-46.3	-1934245
Nov-77	16.0	668000	0.0	0	0.0	0	936.31	0.0	0	-37.8	-1577371	-53.8	-2245371
Dec-77	12.7	530225	0.0	0	0.0	0	936.32	0.0	0	5.5	229782	-7.2	-300443
Jan-78	26.9	1123075	0.0	0	0.0	0	936.32	0.0	0	5.6	233549	-21.3	-889526
Feb-78	5.4	225450	0.0	0	0.0	0	936.33	0.0	0	5.3	222248	-0.1	-3202
Mar-78	3.1	129425	0.0	0	0.0	0	936.34	0.0	0	10.9	455032	7.8	325607
Apr-78	35.5	1482125	47.5	1983125	83.0	3463804	936.36	0.0	0	20.1	840801	-50.8	-2122003
May-78	71.8	2997650	125.9	5256325	52.3	2184874	936.43	0.0	0	75.5	3150584	77.2	3224385
Jun-78	112.6	4701050	128.3	5356525	39.1	1631628	936.44	0.0	0	3.6	148594	-19.8	-827559
Jul-78	36.3	1515525	138.6	5786550	25.2	1052009	936.40	0.0	0	-34.6	-1445594	42.5	1773423
Aug-78	127.5	5323125	130.0	5427500	35.4	1478029	936.40	0.0	0	-2.8	-118468	-35.7	-1492122
Sep-78	103.4	4316950	90.2	3765850	19.4	809090	936.38	0.0	0	-20.4	-850878	-53.0	-2211068
Oct-78	25.7	1072975	63.1	2634425	8.9	372405	936.34	0.0	0	-43.0	-1797321	-14.6	-608277
Nov-78	18.4	768200	0.0	0	0.0	0	936.32	0.0	0	-16.0	-669507	-34.4	-1437707
Dec-78	9.9	413325	0.0	0	0.0	0	936.32	0.0	0	1.5	60637	-8.4	-352688
Jan-79	6.0	250500	0.0	0	0.0	0	936.32	0.0	0	1.5	61631	-4.5	-188869
Feb-79	12.3	513525	0.0	0	0.0	0	936.32	0.0	0	1.4	59820	-10.9	-453705
Mar-79	3.2	133600	0.0	0	0.0	0	936.34	0.0	0	14.7	615138	11.5	481538
Apr-79	32.7	1365225	45.6	1903800	68.7	2869114	936.36	0.0	0	25.4	1061146	-30.4	-1269394
May-79	29.3	1223275	118.9	4964075	21.4	891599	936.40	0.0	0	35.7	1492114	104.0	4341315
Jun-79	22.4	935200	160.9	6717575	7.8	324587	936.44	0.0	0	36.4	1519453	167.1	6977241
Jul-79	63.6	2655300	170.6	7122550	44.1	1843189	936.42	0.0	0	-19.4	-809030	43.5	1815032
Aug-79	33.2	1386100	150.1	6266675	9.2	384867	936.38	0.0	0	-40.5	-1689528	67.2	2806180
Sep-79	25.2	1052100	118.0	4926500	4.7	197186	936.39	0.0	0	12.8	532829	100.8	4210042
Oct-79	20.5	855875	50.3	2100025	7.1	297055	936.31	0.0	0	-80.8	-3371425	-58.1	-2424330

Table D-1. - continued -

Date	Total Precipitation		Evaporation		Computed Inflow		Sylvan Lake Level	Outflow		Storage		Computed Monthly Groundwater Inflow	
	(mm)	(m ³)	(mm)	(m ³)	(mm)	(m ³)		(mm)	(m ³)	(mm)	(m ³)	(mm)	(m ³)
Nov-79	19.6	818300	0.0	0	0.0	0	936.31	0.0	0	6.1	256347	-13.5	-561953
Dec-79	30.5	1273375	0.0	0	0.0	0	936.32	0.0	0	4.3	180419	-26.2	-1092956
Jan-80	32.2	1344350	0.0	0	0.0	0	936.21	0.0	0	-106.0	-4426315	-138.2	-5770665
Feb-80	10.5	438375	0.0	0	0.0	0	936.22	0.0	0	4.3	178784	-6.2	-259591
Mar-80	13.1	546925	0.0	0	0.0	0	936.23	0.0	0	11.0	457653	-2.1	-89272
Apr-80	6.7	279725	60.6	2530050	93.8	3915907	936.22	0.0	0	-6.2	-260239	-46.1	-1925820
May-80	73.6	3072800	152.6	6371050	53.6	2239648	936.32	0.0	0	101.2	4224382	126.5	5282984
Jun-80	160.7	6709225	120.6	5035050	55.8	2328620	936.34	0.0	0	15.5	645756	-80.4	-3357039
Jul-80	84.9	3544575	128.4	5360700	58.9	2460483	936.35	0.0	0	16.6	694958	1.2	50600
Aug-80	48.6	2029050	127.7	5331475	13.5	563390	936.46	0.0	0	105.0	4382403	170.6	7121438
Sep-80	56.5	2358875	94.9	3962075	10.6	442104	936.39	0.0	0	-65.4	-2731707	-37.6	-1570611
Oct-80	15.4	642950	57.1	2383925	5.3	223153	936.34	0.0	0	-52.3	-2184019	-16.0	-666197
Nov-80	16.1	672175	0.0	0	0.0	0	936.29	0.0	0	-54.8	-2286515	-70.9	-2958690
Dec-80	23.8	993650	0.0	0	0.0	0	936.28	0.0	0	-8.8	-367683	-32.6	-1361333
Jan-81	4.8	200400	0.0	0	0.0	0	936.27	0.0	0	-9.0	-374119	-13.8	-574519
Feb-81	7.9	329825	0.0	0	0.0	0	936.26	0.0	0	-8.5	-356017	-16.4	-685842
Mar-81	18.9	789075	0.0	0	0.0	0	936.28	0.0	0	21.6	900555	2.7	111480
Apr-81	8.1	338175	68.2	2847350	66.3	2768261	936.39	0.0	0	108.5	4530370	102.3	4271284
May-81	101.5	4237625	110.8	4625900	74.0	3088645	936.46	0.0	0	66.0	2755332	1.3	54961
Jun-81	77.5	3235625	122.3	5106025	26.9	1123012	936.51	0.0	0	57.3	2393487	75.2	3140875
Jul-81	172.1	7185175	127.7	5331475	119.5	4987622	936.64	0.0	0	121.9	5090268	-41.9	-1751054
Aug-81	52.6	2196050	139.3	5815775	14.6	609759	936.62	0.0	0	-11.5	-481484	60.6	2528482
Sep-81	74.8	3122900	100.1	4179175	14.0	585299	936.58	0.0	0	-48.1	-2008006	-36.8	-1537031
Oct-81	43.3	1807775	42.5	1774375	15.0	627438	936.53	0.0	0	-43.2	-1804986	-59.1	-2465824
Nov-81	4.9	204575	0.0	0	0.0	0	936.51	0.0	0	-27.4	-1142761	-32.3	-1347336
Dec-81	6.7	279725	0.0	0	0.0	0	936.50	0.0	0	-10.8	-448813	-17.5	-728538

Table D-1. - continued -

Date	Total Precipitation		Evaporation		Computed Inflow		Sylvan Lake Level	Outflow		Storage		Computed Monthly Groundwater Inflow	
	(mm)	(m ³)	(mm)	(m ³)	(mm)	(m ³)		(mm)	(m ³)	(mm)	(m ³)	(mm)	(m ³)
Jan-82	28.9	1206575	0.0	0	0.0	0	936.48	0.0	0	-10.9	-456170	-39.8	-1662745
Feb-82	12.3	513525	0.0	0	0.0	0	936.47	0.0	0	-10.4	-434097	-22.7	-947622
Mar-82	32.1	1340175	0.0	0	0.0	0	936.49	0.0	0	11.3	472145	-20.8	-868030
Apr-82	9.4	392450	56.3	2350525	78.6	3279485	936.61	0.0	0	120.7	5038483	89.0	3717074
May-82	52.7	2200225	135.9	5673825	38.4	1603661	936.67	0.6	24703	62.1	2592531	107.5	4487173
Jun-82	87.9	3669825	128.4	5360700	30.5	1273713	936.65	0.0	0	-21.8	-911166	-11.8	-494004
Jul-82	139.3	5815775	123.9	5172825	96.7	4037047	936.70	1.9	78282	49.2	2054518	-61.0	-2547197
Aug-82	61.8	2580150	115.1	4805425	17.2	716409	936.73	3.6	151146	35.0	1459978	74.7	3119990
Sep-82	59.1	2467425	93.7	3911975	11.1	462449	936.62	0.0	0	-110.2	-4600970	-86.7	-3618869
Oct-82	16.5	688875	56.4	2354700	5.7	239093	936.54	0.0	0	-81.0	-3380837	-46.8	-1954105
Nov-82	9.7	404975	0.0	0	0.0	0	936.53	0.0	0	-10.8	-452348	-20.5	-857323
Dec-82	4.8	200400	0.0	0	0.0	0	936.52	0.0	0	-6.0	-252094	-10.8	-452494
Jan-83	13.2	551100	0.0	0	0.0	0	936.52	0.0	0	-6.3	-264733	-19.5	-815833
Feb-83	14.6	609550	0.0	0	0.0	0	936.51	0.0	0	-6.1	-256193	-20.7	-865743
Mar-83	16.9	705575	0.0	0	0.0	0	936.52	0.0	0	7.8	325626	-9.1	-379949
Apr-83	42.8	1786900	47.6	1987300	85.0	3547269	936.58	0.0	0	59.3	2477841	-20.8	-869028
May-83	20.2	843350	133.1	5556925	14.7	614686	936.61	0.0	0	33.5	1397060	131.6	5495949
Jun-83	106.3	4438025	135.1	5640425	36.9	1540338	936.65	0.0	0	35.6	1486771	27.5	1148834
Jul-83	83.1	3469425	126.5	5281375	57.7	2408317	936.60	0.0	0	-43.7	-1825485	-58.0	-2421852
Aug-83	9.5	396625	137.4	5736450	2.6	110128	936.53	0.0	0	-74.3	-3102294	51.0	2127403
Sep-83	25.5	1064625	106.4	4442200	4.8	199534	936.46	0.0	0	-70.0	-2921221	6.2	256821
Oct-83	7.3	304775	52.2	2179350	2.5	105780	936.44	0.0	0	-20.7	-863888	21.7	904906
Nov-83	8.0	334000	0.0	0	0.0	0	936.41	0.0	0	-22.7	-947010	-30.7	-1281010
Dec-83	14.4	601200	0.0	0	0.0	0	936.44	0.0	0	22.2	928702	7.8	327502
Jan-84	24.4	1018700	0.0	0	0.0	0	936.46	0.0	0	22.6	943927	-1.8	-74773
Feb-84	0.5	20875	0.0	0	0.0	0	936.48	0.0	0	21.5	898253	21.0	877378

Table D-1. - continued -

Date	Total Precipitation		Evaporation		Computed Inflow		Sylvan Lake Level	Outflow		Storage		Computed Monthly Groundwater Inflow	
	(mm)	(m ³)	(mm)	(m ³)	(mm)	(m ³)		(mm)	(m ³)	(mm)	(m ³)	(mm)	(m ³)
Mar-84	22.7	947725	0.0	0	0.0	0	936.50	0.0	0	18.7	781028	-4.0	-166697
Apr-84	16.3	680525	63.5	2651125	71.9	3001268	936.57	0.0	0	71.6	2988306	46.9	1957638
May-84	66.0	2755500	127.9	5339825	48.1	2008380	936.60	0.0	0	24.6	1026045	38.4	1601990
Jun-84	57.1	2383925	135.7	5665475	19.8	827406	936.57	0.0	0	-30.7	-1281502	28.1	1172642
Jul-84	73.5	3068625	151.6	6329300	51.0	2130100	936.50	0.0	0	-68.9	-2874499	-41.8	-1743924
Aug-84	21.9	914325	157.5	6575625	6.1	253873	936.46	0.0	0	-33.2	-1385831	96.3	4021596
Sep-84	107.3	4479775	89.7	3744975	20.1	839607	936.46	0.0	0	-5.8	-242060	-43.5	-1816467
Oct-84	25.7	1072975	55.2	2304600	8.9	372405	936.42	0.0	0	-33.9	-1415145	-13.3	-555926
Nov-84	6.8	283900	0.0	0	0.0	0	936.39	0.0	0	-28.5	-1190181	-35.3	-1474081
Dec-84	24.8	1035400	0.0	0	0.0	0	936.42	0.0	0	24.6	1026670	-0.2	-8730
Jan-85	12.6	526050	0.0	0	0.0	0	936.45	0.0	0	28.2	1176591	15.6	650541
Feb-85	11.5	480125	0.0	0	0.0	0	936.47	0.0	0	26.8	1119659	15.3	639534
Mar-85	6.4	267200	0.0	0	0.0	0	936.45	0.0	0	-24.5	-1021589	-30.9	-1288789
Apr-85	22.6	943550	55.6	2321300	70.6	2945624	936.47	0.0	0	17.5	729846	-20.1	-838029
May-85	24.2	1010350	141.6	5911800	17.6	736406	936.56	0.0	0	93.6	3908047	193.4	8073091
Jun-85	29.5	1231625	168.3	7026525	10.2	427469	936.57	0.0	0	9.3	386984	137.8	5754415
Jul-85	43.6	1820300	169.3	7068275	30.3	1263570	936.62	0.0	0	51.3	2143268	146.8	6127673
Aug-85	123.0	5135250	127.4	5318950	34.2	1425863	936.67	0.6	25722	46.8	1952149	17.6	735708
Sep-85	85.8	3582150	90.6	3782550	16.1	671373	936.62	0.0	0	-50.3	-2099419	-61.6	-2570392
Oct-85	20.0	835000	53.5	2233625	6.9	289810	936.64	0.0	0	17.6	735810	44.2	1844626
Nov-85	13.4	559450	0.0	0	0.0	0	936.62	0.0	0	-13.4	-558028	-26.8	-1117478
Dec-85	7.9	329825	0.0	0	0.0	0	936.62	0.0	0	0.3	12629	-7.6	-317196
Jan-86	0.6	25050	0.0	0	0.0	0	936.62	0.0	0	0.5	21393	-0.1	-3657
Feb-86	18.3	764025	0.0	0	0.0	0	936.62	0.0	0	0.5	20357	-17.8	-743668
Mar-86	25.0	1043750	0.0	0	0.0	0	936.64	0.0	0	19.7	824048	-5.3	-219702
Apr-86	15.5	647125	55.5	2317125	67.2	2806516	936.72	3.0	123855	76.0	3171675	51.7	2159014

Table D-1. - continued -

Date	Total Precipitation		Evaporation		Computed Inflow		Sylvan Lake Level	Outflow		Storage		Computed Monthly Groundwater Inflow	
	(mm)	(m ³)	(mm)	(m ³)	(mm)	(m ³)		(mm)	(m ³)	(mm)	(m ³)	(mm)	(m ³)
May-86	72.0	3006000	123.0	5135250	52.5	2190960	936.73	3.5	147837	9.3	387983	11.4	474110
Jun-86	90.9	3795075	139.0	5803250	31.5	1317184	936.68	1.3	53043	-45.1	-1883329	-27.3	-1139295
Jul-86	189.5	7911625	128.3	5356525	131.5	5491891	936.67	0.5	21368	-17.4	-728066	-209.7	-8753689
Aug-86	31.1	1298425	122.6	5118550	8.6	360523	936.64	0.0	0	-25.0	-1041730	57.9	2417872
Sep-86	119.1	4972425	76.6	3198050	22.3	931941	936.61	0.0	0	-33.7	-1407031	-98.5	-4113347
Oct-86	21.5	897625	50.5	2108375	7.5	311545	936.54	0.0	0	-64.3	-2684806	-42.8	-1785601
Nov-86	11.9	496825	0.0	0	0.0	0	936.47	0.0	0	-71.1	-2969739	-83.0	-3466564
Dec-86	1.7	70975	0.0	0	0.0	0	936.47	0.0	0	-4.0	-168839	-5.7	-239814
Jan-87	8.9	371575	0.0	0	0.0	0	936.62	0.0	0	155.2	6479477	146.3	6107902
Feb-87	8.9	371575	0.0	0	0.0	0	936.62	0.0	0	0.5	20357	-8.4	-351218
Mar-87	29.4	1227450	0.0	0	0.0	0	936.64	0.0	0	19.7	824048	-9.7	-403402
Apr-87	17.7	738975	57.9	2417325	65.4	2730006	936.72	3.0	123855	76.0	3171675	53.7	2243874
May-87	27.9	1164825	132.5	5531875	20.3	848997	936.73	3.5	147837	9.3	387983	97.1	4053873
Jun-87	48.8	2037400	160.8	6713400	16.9	707135	936.68	1.3	53043	-45.1	-1883329	51.2	2138579
Jul-87	86.4	3607200	123.8	5168650	60.0	2503954	936.67	0.5	21368	-17.4	-728066	-39.5	-1649203
Aug-87	115.4	4817950	117.0	4884750	32.0	1337761	936.64	0.0	0	-25.0	-1041730	-55.4	-2312691
Sep-87	33.8	1411150	101.5	4237625	6.3	264480	936.61	0.0	0	-33.7	-1407031	27.7	1154964
Oct-87	7.4	308950	64.9	2709575	2.6	107230	936.54	0.0	0	-64.3	-2684806	-9.4	-391410
Nov-87	14.2	592850	0.0	0	0.0	0	936.47	0.0	0	-71.1	-2969739	-85.3	-3562589
Dec-87	5.6	233800	0.0	0	0.0	0	936.47	0.0	0	-4.0	-168839	-9.6	-402639
Jan-88	6.6	275550	0.0	0	0.0	0	936.46	0.0	0	-3.5	-146307	-10.1	-421857
Feb-88	8.2	342350	0.0	0	0.0	0	936.46	0.0	0	-3.3	-137293	-11.5	-479643
Mar-88	32.1	1340175	0.0	0	0.0	0	936.47	0.0	0	5.3	221432	-26.8	-1118743
Apr-88	5.0	208750	74.1	3093675	59.7	2493521	936.50	0.0	0	36.0	1503889	45.4	1895293
May-88	9.9	413325	161.7	6750975	7.2	301257	936.48	0.0	0	-24.2	-1010159	120.4	5026234
Jun-88	118.8	4959900	150.1	6266675	41.2	1721469	936.48	0.0	0	0.3	10595	-9.7	-404099

Table D-1. - continued -

Date	Total Precipitation		Evaporation		Computed Inflow		Sylvan Lake Level	Outflow		Storage		Computed Monthly Groundwater Inflow	
	(mm)	(m ³)	(mm)	(m ³)	(mm)	(m ³)		(mm)	(m ³)	(mm)	(m ³)	(mm)	(m ³)
Jul-88	98.0	4091500	147.3	6149775	68.0	2840134	936.49	0.0	0	8.4	350678	-10.3	-431181
Aug-88	124.8	5210400	143.8	6003650	34.7	1446729	936.47	0.0	0	-19.9	-830286	-35.5	-1483766
Sep-88	82.1	3427675	98.4	4108200	15.4	642421	936.44	0.0	0	-31.9	-1332341	-31.0	-1294237
Oct-88	7.4	308950	55.5	2317125	2.6	107230	936.39	0.0	0	-44.2	-1844026	1.4	56920
Nov-88	4.7	196225	0.0	0	0.0	0	936.35	0.0	0	-39.0	-1627154	-43.7	-1823379
Dec-88	17.2	718100	0.0	0	0.0	0	936.37	0.0	0	13.8	575473	-3.4	-142627
Jan-89	25.9	1081325	0.0	0	0.0	0	936.38	0.0	0	14.0	584131	-11.9	-497194
Feb-89	21.5	897625	0.0	0	0.0	0	936.39	0.0	0	12.7	529204	-8.8	-368421
Mar-89	3.6	150300	0.0	0	0.0	0	936.38	0.0	0	-10.2	-426383	-13.8	-576683
Apr-89	22.1	922675	42.8	1786900	79.1	3303829	936.41	0.0	0	23.7	988960	-34.7	-1450644
May-89	54.2	2262850	118.7	4955725	39.5	1649306	936.46	0.0	0	58.1	2427015	83.1	3470584
Jun-89	76.9	3210575	146.4	6112200	26.7	1114318	936.47	0.0	0	9.1	381832	52.0	2169139
Jul-89	61.2	2555100	143.2	5978600	42.5	1773634	936.48	0.0	0	8.4	349002	47.9	1998867
Aug-89	94.2	3932850	111.0	4634250	26.2	1092002	936.48	0.0	0	-5.9	-244440	-15.2	-635042
Sep-89	33.2	1386100	99.3	4145775	6.2	259785	936.43	0.0	0	-43.0	-1796945	16.8	702945
Oct-89	41.1	1715925	53.7	2241975	14.3	595559	936.37	0.0	0	-63.0	-2629229	-64.6	-2698737
Nov-89	22.7	947725	0.0	0	0.0	0	936.36	0.0	0	-7.9	-330147	-30.6	-1277872
Dec-89	14.7	613725	0.0	0	0.0	0	936.33	0.0	0	-31.8	-1329719	-46.5	-1943444
Jan-90	10.6	442550	0.0	0	0.0	0	936.30	0.0	0	-32.4	-1351518	-43.0	-1794068
Feb-90	10.1	421675	0.0	0	0.0	0	936.27	0.0	0	-29.7	-1240899	-39.8	-1662574
Mar-90	16.3	680525	0.0	0	0.0	0	936.29	0.0	0	20.9	871209	4.6	190684
Apr-90	48.2	2012350	45.4	1895450	102.1	4263678	936.47	0.0	0	178.5	7451161	73.5	3070583
May-90	80.7	3369225	105.3	4396275	58.8	2455701	936.52	0.0	0	50.6	2112953	16.4	684301
Jun-90	178.0	7431500	137.4	5736450	61.8	2579305	936.72	2.9	121684	200.5	8371032	101.0	4218361
Jul-90	108.3	4521525	143.3	5982775	75.2	3138637	936.88	14.9	623712	161.6	6747518	136.4	5693843
Aug-90	50.6	2112550	125.2	5227100	14.0	586575	936.85	11.8	494203	-29.5	-1233068	42.9	1789110

Table D-1. - continued -

Date	Total Precipitation		Evaporation		Computed Inflow		Sylvan Lake Level	Outflow		Storage		Computed Monthly Groundwater Inflow	
	(mm)	(m ³)	(mm)	(m ³)	(mm)	(m ³)		(mm)	(m ³)	(mm)	(m ³)	(mm)	(m ³)
Sep-90	4.1	171175	110.0	4592500	0.8	32082	936.76	5.2	216950	-88.5	-3693355	21.9	912838
Oct-90	20.6	860050	60.4	2521700	7.1	298504	936.66	0.4	16860	-98.2	-4098984	-65.1	-2718978
Nov-90	18.8	784900	0.0	0	0.0	0	936.63	0.0	0	-29.3	-1224429	-48.1	-2009329
Dec-90	31.3	1306775	0.0	0	0.0	0	936.65	0.0	0	17.8	744601	-13.5	-562174
Jan-91	8.7	363225	0.0	0	0.0	0	936.67	0.7	29561	18.1	756807	10.1	423143
Feb-91	22.9	956075	0.0	0	0.0	0	936.69	1.4	56888	17.2	719316	-4.3	-179871
Mar-91	14.8	617900	0.0	0	0.0	0	936.70	1.9	78723	7.8	327248	-5.1	-211930
Apr-91	17.4	726450	60.8	2538400	94.9	3961117	936.74	4.0	168599	45.1	1882936	-2.3	-97632
May-91	99.3	4145775	111.9	4671825	72.4	3021699	936.84	10.5	437165	94.6	3950280	45.3	1891795
Jun-91	143.8	6003650	114.1	4763675	49.9	2083731	936.92	19.4	810687	84.2	3515664	24.0	1002646
Jul-91	77.3	3227275	139.3	5815775	53.7	2240228	937.00	31.9	1332576	81.4	3400021	121.7	5080869
Aug-91	122.7	5122725	126.1	5264675	34.1	1422385	937.03	36.6	1527124	29.1	1216810	35.1	1463500
Sep-91	27.5	1148125	99.9	4170825	5.2	215184	936.98	27.5	1149910	-52.4	-2189467	42.3	1767960
Oct-91	46.9	1958075	52.7	2200225	16.3	679603	936.91	19.1	796090	-65.3	-2725262	-56.7	-2366625
Nov-91	12.0	501000	0.0	0	0.0	0	936.91	18.2	758488	-2.2	-90366	4.0	167121
Dec-91	6.9	288075	0.0	0	0.0	0	936.92	19.6	818350	6.0	250442	18.7	780717
Jan-92	13.1	546925	0.0	0	0.0	0	936.92	20.5	854410	6.1	256711	13.5	564196
Feb-92	14.1	588675	0.0	0	0.0	0	936.93	19.9	832493	6.0	248430	11.8	492248
Mar-92	1.0	41750	0.0	0	0.0	0	936.95	23.8	994469	17.4	724642	40.2	1677361
Apr-92	16.1	672175	61.9	2584325	52.6	2197916	936.99	28.7	1198358	40.2	1677157	62.0	2589750
May-92	63.2	2638600	125.5	5239625	46.1	1923176	937.01	34.1	1422521	29.0	1208669	79.3	3309039
Jun-92	80.2	3348350	139.1	5807425	27.8	1162136	937.08	42.5	1774495	62.7	2617321	136.3	5688755
Jul-92	57.0	2379750	135.7	5665475	39.6	1651914	937.07	42.9	1791895	-7.6	-317031	74.5	3108675
Aug-92	24.8	1035400	142.4	5945200	6.9	287491	936.99	30.1	1255345	-81.3	-3393871	59.5	2483783
Sep-92	55.2	2304600	108.4	4525700	10.3	431932	936.90	16.3	679908	-93.0	-3883423	-33.9	-1414347
Oct-92	22.6	943550	58.7	2450725	7.8	327485	936.87	13.7	571686	-26.7	-1113109	15.3	638267

Table D-1. - continued -

Date	Total Precipitation		Evaporation		Computed Inflow		Sylvan Lake Level	Outflow		Storage		Computed Monthly Groundwater Inflow	
	(mm)	(m ³)	(mm)	(m ³)	(mm)	(m ³)		(mm)	(m ³)	(mm)	(m ³)	(mm)	(m ³)
Nov-92	25.8	1077150	0.0	0	0.0	0	936.82	9.2	382381	-46.0	-1920561	-62.6	-2615330
Dec-92	25.3	1056275	0.0	0	0.0	0	936.82	9.3	387055	-2.4	-101264	-18.5	-770484
Jan-93	5.5	229625	0.0	0	0.0	0	936.82	9.1	380987	-1.8	-76132	1.8	75230
Feb-93	10.6	442550	0.0	0	0.0	0	936.82	8.1	338902	-1.7	-72449	-4.2	-176097
Mar-93	25.4	1060450	0.0	0	0.0	0	936.84	10.6	440720	19.3	807470	4.5	187740
Apr-93	30.4	1269200	48.1	2008175	102.5	4277589	936.93	20.3	849263	90.0	3756378	25.6	1067027
May-93	45.2	1887100	140.3	5857525	32.9	1375436	937.00	31.6	1320186	72.7	3036751	166.5	6951926
Jun-93	104.4	4358700	151.1	6308425	36.2	1512806	936.99	30.0	1253104	-4.0	-167831	36.5	1522193
Jul-93	98.4	4108200	140.1	5849175	68.3	2851726	937.04	37.8	1578231	42.4	1769145	53.6	2236625
Aug-93	46.1	1924675	126.4	5277200	12.8	534409	937.02	34.9	1456429	-17.5	-729952	84.9	3544594
Sep-93	27.8	1160650	106.5	4446375	5.2	217531	936.94	22.8	950750	-76.2	-3180273	20.1	838672
Oct-93	12.7	530225	58.2	2429850	4.4	184029	936.85	11.5	480896	-96.5	-4027663	-43.9	-1831171
Nov-93	24.6	1027050	0.0	0	0.0	0	936.81	8.2	343220	-37.1	-1548359	-53.5	-2232188
Dec-93	9.9	413325	0.0	0	0.0	0	936.82	9.0	376441	7.2	299750	6.3	262866
Jan-94	46.7	1949725	0.0	0	0.0	0	936.82	9.6	401276	7.5	311579	-29.6	-1236870
Feb-94	9.5	396625	0.0	0	0.0	0	936.83	9.2	383789	7.1	296502	6.8	283666
Mar-94	13.0	542750	0.0	0	0.0	0	936.86	12.4	517867	24.5	1023424	23.9	998541
Apr-94	2.4	100200	66.3	2768025	88.4	3689855	936.87	13.6	569535	16.3	682257	5.5	229762
May-94	74.0	3089500	133.1	5556925	53.9	2251820	936.87	13.8	576398	-2.7	-114330	16.2	677673
Jun-94	96.5	4028875	148.8	6212400	33.5	1398331	936.89	15.3	638546	17.4	724924	51.5	2148664
Jul-94	77.0	3214750	157.0	6554750	53.4	2231533	936.85	11.7	488863	-38.1	-1592246	0.1	5083
Aug-94	116.9	4880575	139.7	5832475	32.5	1355149	936.79	7.3	303359	-56.7	-2367629	-59.1	-2467520
Sep-94	78.3	3269025	102.3	4271025	14.7	612686	936.75	4.8	199520	-37.9	-1583133	-23.8	-994299
Oct-94	25.1	1047925	54.6	2279550	8.7	363711	936.67	0.6	23776	-87.1	-3635617	-65.7	-2743927
Nov-94	8.0	334000	0.0	0	0.0	0	936.64	0.0	0	-29.7	-1241625	-37.7	-1575625
Dec-94	10.8	450900	0.0	0	0.0	0	936.64	0.0	0	1.3	55850	-9.5	-395050

Table D-1. - continued -

Date	Total Precipitation		Evaporation		Computed Inflow		Sylvan Lake Level	Outflow		Storage		Computed Monthly Groundwater Inflow	
	(mm)	(m ³)	(mm)	(m ³)	(mm)	(m ³)		(mm)	(m ³)	(mm)	(m ³)	(mm)	(m ³)
Jan-95	7.3	304775	0.0	0	0.0	0	936.64	0.0	0	1.4	56765	-5.9	-248010
Feb-95	5.0	208750	0.0	0	0.0	0	936.64	0.0	0	1.5	63953	-3.5	-144797
Mar-95	11.4	475950	0.0	0	0.0	0	936.65	0.0	0	8.1	336703	-3.3	-139247
Apr-95	26.4	1102200	51.9	2166825	57.4	2396145	936.68	0.9	38036	25.6	1066970	-5.4	-226514
May-95	50.4	2104200	123.7	5164475	36.7	1533672	936.70	1.9	79991	20.6	860462	59.1	2467056
Jun-95	83.0	3465250	136.2	5686350	28.8	1202710	936.73	3.7	152627	37.2	1552831	65.2	2723848
Jul-95	88.8	3707400	126.5	5281375	61.6	2573509	936.77	6.1	254140	40.6	1696487	22.8	951092
Aug-95	106.5	4446375	117.7	4913975	29.6	1234589	936.78	6.4	266883	5.1	212790	-6.9	-287316
Sep-95	13.2	551100	98.9	4129075	2.5	103288	936.74	4.1	172513	-36.7	-1532135	50.7	2115065
Oct-95	18.5	772375	53.7	2241975	6.4	268074	936.67	0.8	33102	-70.1	-2925687	-40.5	-1691059
Nov-95	35.2	1469600	0.0	0	0.0	0	936.63	0.0	0	-38.9	-1625919	-74.1	-3095519
Dec-95	16.1	672175	0.0	0	0.0	0	936.64	0.0	0	7.0	293856	-9.1	-378319
Jan-96	28.0	1169000	0.0	0	0.0	0	936.65	0.0	0	7.2	298673	-20.8	-870327
Feb-96	1.8	75150	0.0	0	0.0	0	936.65	0.0	0	7.3	303104	5.5	227954
Mar-96	26.2	1093850	0.0	0	0.0	0	936.69	1.7	72329	37.5	1566690	13.1	545169
Apr-96	10.0	417500	48.5	2024875	97.7	4079359	936.75	4.5	187341	56.7	2367401	2.0	82758
May-96	42.4	1770200	97.3	4062275	30.9	1290232	936.79	7.3	305210	44.1	1839807	75.4	3146860
Jun-96	81.1	3385925	139.4	5819950	28.1	1175178	936.81	7.9	330844	12.7	530417	50.8	2120108
Jul-96	100.9	4212575	138.9	5799075	70.0	2924178	936.85	11.7	486971	42.9	1789459	22.5	938752
Aug-96	37.4	1561450	142.6	5953550	10.4	433555	936.82	9.5	397708	-25.0	-1045770	79.3	3310483
Sep-96	64.0	2672000	94.2	3932850	12.0	500791	936.72	3.1	130230	-101.1	-4221464	-79.8	-3331175
Oct-96	23.2	968600	49.3	2058275	8.1	336179	936.68	1.1	46626	-43.1	-1801310	-24.0	-1001188
Nov-96	52.6	2196050	0.0	0	0.0	0	936.67	0.5	22162	-12.4	-517407	-64.5	-2691295
Dec-96	27.2	1135600	0.0	0	0.0	0	936.68	1.2	49127	13.7	571940	-12.3	-514533
Jan-97	14.3	597025	0.0	0	0.0	0	936.69	1.8	76869	13.9	581316	1.5	61159
Feb-97	9.0	375750	0.0	0	0.0	0	936.71	2.2	93898	13.5	563263	6.7	281411

Table D-1. - continued -

Date	Total Precipitation		Evaporation		Computed Inflow		Sylvan Lake Level	Outflow		Storage		Computed Monthly Groundwater Inflow	
	(mm)	(m ³)	(mm)	(m ³)	(mm)	(m ³)		(mm)	(m ³)	(mm)	(m ³)	(mm)	(m ³)
Mar-97	38.2	1594850	0.0	0	0.0	0	936.76	5.3	223285	53.6	2235746	20.7	864180
Apr-97	18.1	755675	51.4	2145950	132.8	5543477	936.84	10.9	454338	82.4	3440013	-6.2	-258851
May-97	44.8	1870400	125.8	5252150	32.7	1363264	936.89	16.1	672211	45.6	1905816	110.1	4596513
Jun-97	111.3	4646775	128.8	5377400	38.6	1612790	936.93	20.3	845512	35.8	1496611	35.0	1459957
Jul-97	63.6	2655300	146.6	6120550	44.1	1843189	936.92	19.9	831758	-7.1	-296393	51.7	2157426
Aug-97	71.6	2989300	126.8	5293900	19.9	830015	936.88	15.2	633625	-36.4	-1518448	14.1	589762
Sep-97	42.2	1761850	99.6	4158300	7.9	330209	936.85	11.8	492550	-27.9	-1166845	33.3	1391946
Oct-97	21.2	885100	43.6	1820300	7.4	307198	936.74	4.1	170149	-115.3	-4812159	-96.1	-4014008
Nov-97	5.4	225450	0.0	0	0.0	0	936.68	1.3	55418	-54.0	-2255192	-58.1	-2425224
Dec-97	1.4	58450	0.0	0	0.0	0	936.68	1.3	54855	-1.2	-50112	-1.3	-53706
Jan-98	18.8	784900	0.0	0	0.0	0	936.68	1.1	46816	-4.2	-174017	-21.8	-912101
Feb-98	0.0	0	0.0	0	0.0	0	936.68	0.8	35427	-4.0	-165597	-3.1	-130170
Mar-98	19.7	822475	0.0	0	0.0	0	936.69	1.5	62355	11.9	495549	-6.3	-264571
Apr-98	27.6	1152300	53.2	2221100	60.7	2535254	936.72	3.2	135004	37.5	1563646	5.6	232197
May-98	58.0	2421500	137.4	5736450	42.3	1764940	936.74	4.0	166662	12.5	522424	53.6	2239095
Jun-98	121.2	5060100	120.9	5047575	42.1	1756246	936.74	4.1	170806	4.3	178582	-34.0	-1419382
Jul-98	58.8	2454900	125.9	5256325	40.8	1704080	936.79	7.3	303359	50.8	2121708	84.4	3522412
Aug-98	59.8	2496650	143.7	5999475	16.6	693224	936.77	5.6	233089	-26.9	-1121863	46.0	1920827
Sep-98	26.2	1093850	106.4	4442200	4.9	205011	936.66	0.4	15439	-102.2	-4267478	-26.6	-1108701
Oct-98	52.8	2204400	43.4	1811950	18.3	765097	936.60	0.0	0	-59.9	-2502755	-87.7	-3660303
Nov-98	20.2	843350	0.0	0	0.0	0	936.59	0.0	0	-16.6	-694537	-36.8	-1537887
Dec-98	23.1	964425	0.0	0	0.0	0	936.59	0.0	0	7.4	308962	-15.7	-655463
Jan-99	32.6	1361050	0.0	0	0.0	0	936.60	0.0	0	6.9	288895	-25.7	-1072155
Feb-99	0.6	25050	0.0	0	0.0	0	936.61	0.0	0	7.2	301447	6.6	276397
Mar-99	19.5	814125	0.0	0	0.0	0	936.67	0.7	29837	62.3	2600741	43.5	1816453
Apr-99	38.4	1603200	62.8	2621900	112.0	4674048	936.74	4.1	171751	71.4	2982604	-12.0	-500993

Table D-1. - continued -

Date	Total Precipitation		Evaporation		Computed Inflow		Sylvan Lake Level	Outflow		Storage		Computed Monthly Groundwater Inflow	
	(mm)	(m ³)	(mm)	(m ³)	(mm)	(m ³)		(mm)	(m ³)	(mm)	(m ³)	(mm)	(m ³)
May-99	77.4	3231450	128.1	5348175	56.4	2355282	936.71	2.3	98041	-36.9	-1540387	-40.3	-1680903
Jun-99	86.4	3607200	133.8	5586150	30.0	1251977	936.71	2.3	96409	0.8	32884	20.5	856266
Jul-99	274.4	11456200	158.2	6604850	190.5	7952374	936.90	18.0	751156	198.5	8286814	-90.2	-3765754
Aug-99	69.2	2889100	148.3	6191525	19.2	802193	936.94	22.6	944141	32.9	1371690	115.4	4816063
Sep-99	10.2	425850	120.8	5043400	1.9	79814	936.87	13.8	577336	-62.9	-2627108	59.6	2487965
Oct-99	6.8	283900	65.4	2730450	2.4	98535	936.77	5.9	245063	-104.0	-4341827	-41.9	-1748749
Nov-99	11.7	488475	0.0	0	0.0	0	936.75	4.4	184211	-22.7	-948360	-30.0	-1252623
Dec-99	5.0	208750	0.0	0	0.0	0	936.76	5.4	223497	14.1	588244	14.4	602991
Jan-00	14.0	584500	0.0	0	0.0	0	936.78	6.2	259302	14.3	597887	6.5	272689
Feb-00	11.8	492650	0.0	0	0.0	0	936.79	6.6	277312	13.9	578601	8.7	363262
Mar-00	17.8	743150	0.0	0	0.0	0	936.80	8.0	335693	13.9	578601	4.1	171143
Apr-00	25.9	1081325	51.1	2133425	71.8	2997790	936.82	8.8	366286	14.1	588244	-23.7	-991160
May-00	43.7	1824475	111.8	4667650	31.9	1329791	936.84	10.9	454705	22.2	925194	69.3	2893282
Jun-00	118.1	4930675	129.8	5419150	41.0	1711325	936.87	13.6	568071	32.3	1348525	16.6	693746
Jul-00	164.4	6863700	126.8	5293900	114.1	4764469	936.92	20.4	853519	49.8	2080362	-81.4	-3400388
Aug-00	49.8	2079150	121.7	5080975	13.8	577301	936.90	17.7	737829	-20.2	-841734	55.6	2320619
Sep-00	25.3	1056275	86.2	3598850	4.7	197969	936.81	8.5	356223	-87.5	-3651778	-22.8	-950949
Oct-00	6.4	267200	51.4	2145950	2.2	92739	936.74	4.1	170371	-75.6	-3154819	-28.7	-1198436
Nov-00	8.6	359050	0.0	0	0.0	0	936.72	2.8	118859	-21.9	-915806	-27.7	-1155998
Dec-00	21.6	901800	0.0	0	0.0	0	936.72	2.9	122821	0.0	0	-18.7	-778979