FRASER RIVER
ACTION PLAN

Bridge Creek Watershed Volunteer Lake Secchi Disk Monitoring Program 1996

DOE FRAP 1996-13

BC Environment

Environment Canada / Environnement Canada

Bridge Creek Watershed Volunteer Lake Secchi Disk Monitoring Program 1996

DOE FRAP 1996-13

Ryan Liebe
Norm Zirnhelt

Environmental Protection
Ministry of Environment, Lands and Parks
Williams Lake, B.C.

December 1996

ABSTRACT

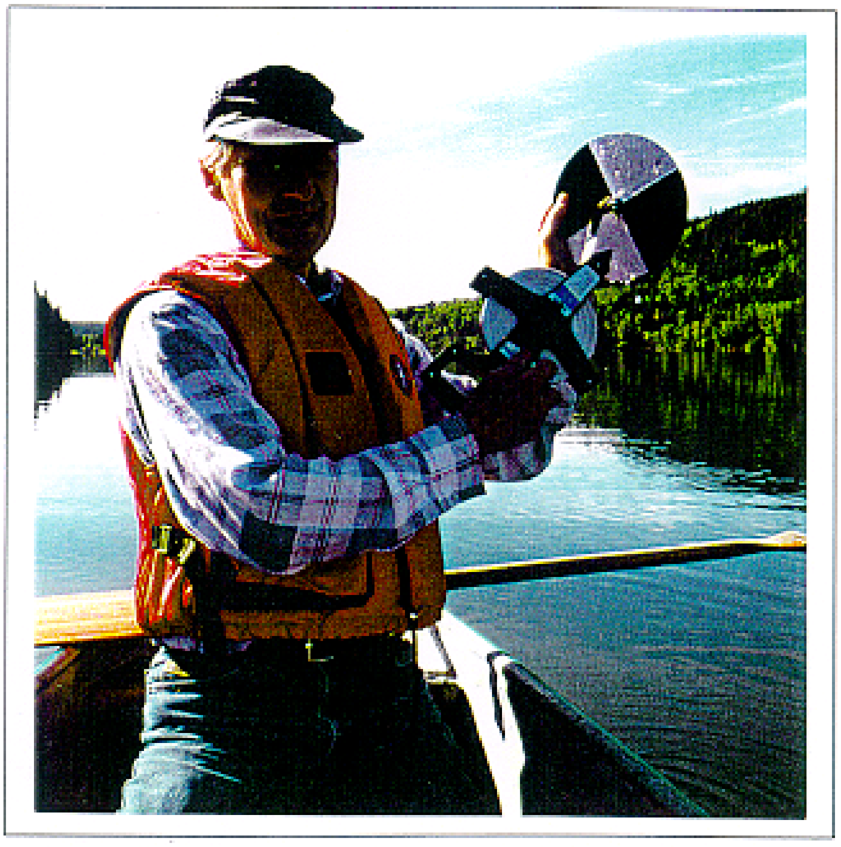
This document summarizes data collected during the first year of the Bridge Creek Watershed Volunteer Lake Monitoring Program. Using a Secchi disk, volunteers collected water transparency data from 22 lakes in the Bridge Creek watershed. Secchi depth readings were collected between May 15 and October 25, and the average number of readings per lake was approximately 13. For 1996 an audit was conducted by BC Ministry of Environment, Lands and Parks (MELP) with 16 volunteers. Results of the audit showed a mean difference of 3.39% between MELP and volunteer values. The audit revealed minor procedural errors and the need to improve field notes. Recommendations for next year's program are provided and the possibility of expanding the program to measure more parameters is discussed. The estimated cost of expanding the program to include the measurement of pH, specific conductance, total phosphorus, orthophosphorus, total dissolved phosphorus, ammonia, Kjeldahl nitrogen, nitrate, nitrite, nitrite + nitrate, total nitrogen, total organic nitrogen and chlorophyll *a* is $11,505.00 per lake. The estimate is based on a biweekly sampling schedule for one season and includes the cost of lab analyses, equipment, courier service and miscellaneous travel costs. In addition, 10 MELP person days would be needed per lake for training and auditing volunteers, processing samples, and compiling data. Based on this estimate, a Co-op student could monitor an expanded program on eight lakes during a four month work term.

ACKNOWLEDGMENTS

The authors would like to acknowledge all the volunteers who gave time to sample during the 1996 season. This program would not have been possible without the efforts of Art and Carol Andrews, John Bianchi, Steve Budd, Erich and Irene Borter, Nick and Margaret Culic, Henny and Tjerk DeGruiter, Paul Desaulniers, Morley Far-well, Mike and Maureen (Mozie) Glueck, Mel Grahn, John and Nel Hanemaayer, Jim Luton, Dennis McCoy, Dolores Miller, Eric Paddison, Scott Salter and Joanne Perrier, Neal and Cathy Sampson, Pat Silver-ton, Bruno and Dora Sprecher, Gerry Swope and Roy Tomlinson. A special thank you to Sheila Michener, Chair of the Upper Bridge Creek Watershed Protection Society, who was instrumental in organizing the volunteers and acted as the liaison between the Ministry of Environment, Lands and Parks, and the volunteers.

RÉSUMÉ

Le document résume les données recueillies pendant la première année du programme volontaire de surveillance des lacs du bassin du crique Bridge. À l'aide du disque de Secchi, les volontaires ont recueilli des données sur la transparence de l'eau dans 22 lacs du bassin. Les mesures on tété faites entre le 15 mai et le 25 octobre, avec un nombre moyen de 13 lectures environ par lac. En 1996, une vérification a été effectuée par le ministère de l'Environnement, des Terres et des Parcs (MELP) de Colombie-Britannique, avec 16 volontaires. Les résultats de la vérification montrent une différence moyenne de 3,39 % entre les deux séries de mesures. La vérification a aussi révélé des erreurs mineures de procédure, et fait ressortir la nécessité d'améliorer la prise de notes sur le terrain. Nous présentons des recommandations pour le programme de l'an prochain, et envisageons la possibilité d'en élargir la portée en mesurant d'autres paramètres. Nous estimons à 11 505,OO $ le coût supplémentaire par lac si on élargit le programme pour mesurer le pH, la conductance spécifique, le phosphore total, l'orthophosphore, le phosphore dissous total, l'ammoniac, l'azote kjeldahl, le nitrate, le nitrite, le nitrite + nitrate, l'azote total, l'azote organique total et la chlorophylle ***a*.** Cette estimation est fondée sur un calendrier d'échantillonnage à la quinzaine pour une saison, et inclut le coût des analyses de laboratoire, du matériel, du service de courrier et des frais divers de déplacement. De plus, il faudrait dix jours-personnes du MELP par lac pour former les volontaires, traiter les échantillons et compiler les données. Selon cette estimation, un étudiant pourrait s'occuper d'un programme élargi de surveillance sur huit lacs pendant une session de travail de quatre mois.



ROY TOMLINSON DISPLAYING HIS SECCHI DISK ON HATHAWAY LAKE.

NEL HANEMAAYER TAKING A SECCHI READING ON WHITLEY LAKE.

TABLE OF CONTENTS

Page

ABSTRACT .... **i**

ACKNOWLEDGMENTS .... **ii**

LIST OF FIGURES .... **iv**

LIST OF TABLES .... **v**

LIST OF APPENDICES .... **v**

1.0 INTRODUCTION **1**

2.0 METHODS **2**

3.0 RESULTS AND DISCUSSION **4**

3.1 SECCHI READINGS, 1996 4
3.1.1 Big Rutherford 5
3.1.2 Bridge Lake 5
3.1.3 Burn Lake 6
3.1.4 Deka Lake - Northern Basin 6
3.1.5 Deka Lake - Southern Basin 6
3.1.6 Eugene Lake 7
3.1.7 Fawn Lake 7
3.1.8 Hansen Lake 7
3.1.9 Hathaway Lake 8
3.1.10 Henley Lake 8
3.1.11 Higgins Lake 8
3.1.12 Horse Lake 9
3.1.13 Knight Lake 9
3.1.14 Lower Stack Lake 9
3.1.15 Middle Stack Lake 10
3.1.16 Otter Lake 10
3.1.17 Roe Lake 10
3.1.18 Sheridan Lake 11
3.1.19 Sulphurous Lake 11
3.1.20 Wavey Lake 12
3.1.21 Webb Lake 12
3.1.22 West Twin Lake 12
3.1.23 Whitley Lake 12
3.2 1996 AUDIT 13
3.3 THE GREAT 1996 SECCHI DIPIN 14
3.4 PROGRAM EXPANSION 14

4.0 CONCLUSIONS **17**

5.0 RECOMMENDATIONS **18**

6.0 REFERENCES **20**

LIST OF FIGURES

Figure 1. Bridge Creek basin lakes volunteer Secchi disk monitoring program - 1996.

Figure 2. Comparison of the minimum, mean and maximum Secchi depths for all lakes in the Bridge Creek Watershed VLMP.

Figure 3. Bridge Lake Secchi disk readings, 1996.

Figure 4. Burn Lake Secchi disk readings, 1996.

Figure 5. Deka Lake (northern basin) Secchi disk readings, 1996.

Figure 6. Deka Lake (southern basin) Secchi disk readings, 1996.

Figure 7. Eugene Lake Secchi disk readings, 1996.

Figure 8. Fawn Lake Secchi disk readings, 1996.

Figure 9. Hansen Lake Secchi disk readings, 1996.

Figure 10. Hathaway Lake Secchi disk readings, 1996.

Figure 11. Henley Lake Secchi disk readings, 1996.

Figure 12. Higgins Lake Secchi disk readings, 1996.

Figure 13. Horse Lake Secchi disk readings, 1996.

Figure 14. Knight Lake Secchi disk readings, 1996.

Figure 15. Middle Stack Lake Secchi disk readings, 1996.

Figure 16. Otter Lake Secchi disk readings, 1996.

Figure 17. Roe Lake Secchi disk readings, 1996.

Figure 18. Sheridan Lake Secchi disk readings, 1996.

Figure 19. Sulphurous Lake Secchi disk readings, 1996.

Figure 20. Webb Lake Secchi disk readings, 1996.

Figure 21. West Twin Lake Secchi disk readings, 1996.

Figure 22. Whitley Lake Secchi disk readings, 1996.

Figure 23. Secchi data collected from Horse Lake (1979, 1994 and 1996).

Figure 24. Secchi data collected from Sheridan Lake (1993 - 1996).

Figure 25. Secchi data collected during 1995 and 1996 by the Friends of Sheridan Lake and Pat Silverton.

Figure 26. Frequency histogram of the percent difference between readings taken by BC Environment and the volunteers.

LIST OF TABLES

Table 1. Volunteer information.

Table 2. Audit data.

Table 3. Lake parameters measured by various volunteer monitoring programs.

Table 4. Estimation of cost to monitor one lake biweekly at one site for one sampling season (May - October).

LIST OF APPENDICES

Appendix 1. Lake maps.

Appendix 2. 1996 and proposed 1997 Secchi disk field form.

1.0 INTRODUCTION

Bridge Creek drains a 1550 km^2 area and is the principal water source for the District of 100 Mile House (Figure 1). Water quality in the Bridge Creek basin has been a concern for residents and has led to the commissioning of several studies by the BC Ministry of Environment, Lands and Parks (MELP) and Environment Canada. A study of the Bridge Creek Basin was conducted between the fall of 1993 and the fall of 1994 by J.S. Hart and Associates (Hart, 1995). Impacts of land use in the basin were documented and recommendations were made for water quality management. Recommendations included evaluating water quality change at the basin scale by establishing a long-term monitoring program. With the large number of lakes in the basin it was recognized that there would have to be some prioritization. It was recommended that water quality be monitored to evaluate trophic status and sensitivity of the more developed lakes to control land use impacts on lake and stream water quality.

To start implementing recommendations, lakes were prioritized for monitoring (Petch and Zirnhelt, 1996). Of 67 lakes reviewed, six lakes were deemed high priority for monitoring (Bridge, Deka, Horse, Otter, Sheridan, and Sulphurous), and monitoring at spring overturn was carried out in 1996 by MELP. This data is being summarized in another report (Zirnhelt *et al.*, in prep.). The Bridge Creek Watershed Volunteer Lake Monitoring Program (VLMP) discussed in this report includes these high priority lakes (provides data in addition to MELP collected spring overturn data) and 15 others selected on the basis of the availability of volunteers.

Volunteer Lake Monitoring Programs can play a fundamental role in water quality management. There are many lakes which would benefit from monitoring, however, shortages in staff time do not allow government agencies to perform the work. Volunteer programs are a viable solution, bridging the gap between need and capability (Rex and Carmichael, 1995).

As of 1995, in North America, VLMPs were in place in seventeen states and two provinces. Many states have had VLMPs in place for numerous years. For example, Minnesota has had a Citizen Lake Monitoring Program in place for over twenty years, and in 1992, 580 lakes were being monitored (Ripley, 1993). The Alberta VLMP programs have been in place since 1988 and currently monitor 13 lakes (Rex and Carmichael, 1995). British Columbia presently has four regions with VLMPs: the Omineca Peace Region monitoring five lakes, the Southern Interior Region monitoring seven lakes, the Skeena Region monitoring two lakes, and the other reported here.

The Bridge Creek Watershed VLMP was initiated by MELP and the Upper Bridge Creek Watershed Protection Society (UBCWPS) in 1996. A total of 22 lakes were monitored during the initial year of the program. Several other lakes were considered for the program, but proved to be too shallow for taking Secchi depths. Data will be collected over a three year period to provide adequate background information. A complete list of the volunteers and the lakes included in the program can be seen in Table 1. Data collected during the initial year was limited to Secchi disk values, and visual weather and water conditions taken at the time of the Secchi reading. The monitoring of additional parameters was not included in the program due to a shortage of available staff time and budget constraints.

The Secchi disk has been described as the cornerstone instrument for most volunteer lake monitoring programs (Ripley, 1993). The disk is inexpensive, low maintenance, easy to use, and yet provides very useful information. The Secchi disk measures lake transparency, and is a more precise measure than the often substituted test of water turbidity. Transparency data can be used as a long term indicator of lake water quality and is a good relative measure between lakes. In most lakes Secchi depth relates to the concentration of algae chlorophyll pigments, another water quality parameter often measured (Carlson, 1995). It has been suggested that every one meter drop in Secchi disk transparency could translate to a 10 to 15 per cent drop in waterfront property values (Davey, 1996). A complete background on the Secchi disk and its uses can be found in "The Secchi Disk and the Volunteer Monitor" (Carlson, 1995).

This paper has three objectives:

1) To summarize information collected by the volunteers, which will be used as background data by MELP.

2) To produce a document to be given to volunteers which will show the usefulness of their data, and review the background and scope of the program.

3) To produce a document useful to new volunteers monitoring Cariboo lakes, as well as being useful for comparative purposes for other VLMPs.

2.0 METHODS

The Bridge Creek watershed was selected due to its value as a water source for the community of 100 Mile House, its recreational value and the potential impact that urban development, lakeshore residents, agriculture and forestry may have on the area. Rider Petch, MELP staff member, solicited volunteers for the six lakes determined to be of high monitoring priority by Petch and Zirnhelt (1996). High priority lakes included Bridge, Deka, Horse, Otter, Sheridan, and Sulphurous. These volunteers were individually trained by Rider following ice-off.

The selection of the other lakes in the program was largely dependent on the availability of volunteers. Sheila Michener, Chair of the UBCWPS, accepted the task of obtaining volunteers. In addition to having a willing volunteer, each lake in the program needed to be deep enough to take a Secchi reading and have relatively easy access.

Initial training of volunteers was conducted on June 23, 1996. The training session on Bridge Lake at the Nature Hills Resort was led by Rider Petch. Volunteers were given a copy of "The Secchi Disk and the Volunteer Monitor" (Carlson, 1995) as background on the Secchi disk and the water quality information it provides. Each volunteer also received field forms describing proper Secchi disk procedures. The correct use of a Secchi disk was demonstrated and then each of the volunteers took a practice reading.

The Secchi disk procedure, using the standard 20 cm disk with alternating black and white quadrants, was as follows: the disk was lowered into the water, and the depth at which it disappeared was noted to the nearest 0.10 meters. The disk was then raised until it reappeared, again noting the depth to the nearest 0.10 meters. The average of the two readings was recorded as the Secchi depth. Standard conditions for the use of the Secchi disk were considered to be clear sky, sun directly overhead (between 10:00 a.m. and 2:00 p.m.); shaded, protected side of the boat; under a sunshade; and minimal waves or ripples. Each week, sampling occurred as close to the same time and day as possible (weather/water conditions permitting). Water (eg. rough, calm, ripples) and weather conditions (eg. overcast, sunny, partly cloudy) were carefully noted as were any departures from the standard conditions.

Secchi readings should be taken from spring overturn[1] until fall overturn. For the majority of lakes, monitoring was initiated in late June after volunteers had received training and were given their Secchi disks. Monitoring on the six high

---

[1] Overturn occurs when water temperature, and therefore water density, is the same throughout a lake. Water has different densities at different temperatures, and waters of different densities do not mix. During winter months water near the surface becomes cooler then the underlying water, resulting in the development of a temperature gradient from top to bottom. In spring, when the surface water increases in temperature there comes a point when surface temperature will equal the temperature of the underlying water. At this time the densities are equal and mixing occurs throughout the lake with the aid of wind and convection currents. During summer most lakes in the Cariboo region stratify into three layers. The surface layer contains warmer waters that mix thoroughly, then there is a layer of rapid temperature change (the thermocline), and lastly a lower layer of colder water which does not mix and can become devoid of oxygen. During fall overturn the warm surface waters are cooled until they become the same temperature as underlying waters, resulting in complete mixing of lake waters.

priority lakes started earlier (around mid-May). It was suggested to volunteers that readings be taken from ice-off until middle to late October. This time period was determined to be sufficient to span the time between spring and fall overturn for the Bridge Creek watershed.

An audit of the volunteers was conducted by one of the authors, Ryan Liebe, MELP Co-op student. The audit took place on seven different days during late September and October. Volunteers took two side by side Secchi readings with Liebe at the lakes they normally monitored. Audit results are given in Table 2. Technique was observed to ensure everyone was using the same procedure. In situations where a volunteer was monitoring more than one lake, only one lake was visited. If two volunteers were monitoring one lake, both volunteers were audited. Of the twenty volunteers taking readings, sixteen were audited. Of the four remaining volunteers (sampling Bridge, West Twin, Wavey and Otter Lakes), two had a work schedule which would not allow time for an audit, one moved to his winter home before an audit was scheduled, and the lake the final volunteer was monitoring started freezing over before an audit could be completed.

3.0 RESULTS AND DISCUSSION

3.1 Secchi Readings, 1996

Volunteer participation was exceptional during this initial year of the program. It is encouraging that there is such interest in the long term water quality of the Bridge Creek basin. This year a total of 22 lakes were involved in the volunteer program (Appendix 1). The average number of readings taken during the sampling period was approximately 13. The dates readings were taken ranged from May 15 (Sheridan Lake) to October 25 (Deka Lake and Eugene Lake). A graphical comparison of all lake Secchi readings is shown in Figure 2.

There was variability in water transparency between the different lakes monitored, from the lowest mean Secchi depth of 1.85 m to the highest mean Secchi depth of 10.41 m (Figure 2). Lake variability is a natural occurrence and is the result of lakes being in different stages of successional development. Lakes are generally classified as being eutrophic, mesotrophic, or oligotrophic[2] depending on lake productivity. Lakes tend to change from lower to higher productivity through a process called eutrophication, which can be accelerated by human factors (Wetzel, 1983). The background data being collected by volunteers will be

---

[2] Eutrophic lakes are considered nutrient enriched and are characterized by reduced water transparency, large blooms of macrophytes and/or blue green algae. Oligotrophic lakes are nutrient deficient with low algal densities, low fish production, and high water transparency. Mesotrophic lakes are midway between (Rex and Carmichael, 1995).

essential in determining if individual lakes are changing, and will provide information about the impacts humans are having on the Bridge Creek watershed.

The number of readings taken per lake varied. The average number of readings taken was approximately 13, with a range of 1 to 24. One explanation for this variation is the different times volunteers received Secchi disks. Volunteers on the high priority lakes received disks in early spring, while some volunteers did not receive disks until summer. Another explanation is differences in sampling consistency.

Consistent sampling is important when collecting information which will be used for background levels. As mentioned on the Secchi disk field form (Appendix 2), sampling should be made as close to the same time and day as possible, each week (weather/water conditions permitting). It was often not possible to take weekly readings due to bad weather, sickness or vacations. Where possible, it would be beneficial to have alternate samplers to fill in during such times.

The description of weather and water conditions is a part of the field notes which generally needs to be improved. It is important to note both weather and water conditions at the time of sampling, as changes in these conditions may explain abnormally low or high readings.

3.1.1 Big Rutherford

One reading of 4.78 m was taken at 12:20 pm on October 4, 1996. The station depth was six meters, and conditions were noted as being dull gray light and still water.

3.1.2 Bridge Lake

A total of 13 readings were taken between May 24 and September 20, 1996. The maximum recorded depth was 9.40 m, the minimum recorded depth was 5.90 m, and the mean depth for 1996 was 7.17 m (Figure 3). Station depth, determined from a bathymetric map, was approximately 30 m.

Bridge Lake is one of the larger lakes sampled, and has significant development and recreation pressures due to many shoreline residences. The shoreline is 95% privately owned and has 195 residences (Petch and Zirnhelt, 1996). Sampling on Bridge Lake was fairly consistent, with an average of one reading taken approximately every 9 days. Water transparency increased steadily to a high of 9.40 m on July 21, and then decreased during the remainder of the sampling season. The mean water transparency was 2.12 m greater then the combined mean transparency for all lakes involved in the program.

3.1.3 Burn Lake

A total of four readings were taken between September 1 and October 11, 1996. The maximum recorded depth was 4.35 m, the minimum recorded depth was 4.15 m, and the mean depth for 1996 was 4.24 m (Figure 4). Station depth, determined during the audit, was approximately 6.5 m.

Sampling on Burn Lake was limited due to the late acquisition of a Secchi disk. There were four readings taken between September 1 and October 11, an average of one reading approximately every 10 days. Water transparency was very similar throughout the sampling period, and the yearly mean was 0.8 m lower than the combined mean of all lakes being monitored.

3.1.4 Deka Lake - Northern Basin

A total of eight readings were taken between July 25 and October 3, 1996. The maximum recorded depth was 11.88 m, the minimum recorded depth was 8.60 m, and the mean depth for 1996 was 10.41 m (Figure 5). Station depth, determined from a bathymetric map, was approximately 36 m.

Deka Lake is another of the larger lakes involved in the program. The lake has two main basins separated by a narrow, shallow channel. The shoreline of the larger northern basin is almost completely undeveloped, but logging pressures exist. Sampling on the northern basin of Deka Lake was fairly consistent, although limited due to the late acquisition of a Secchi disk. There were eight readings taken between July 25 and October 23, an average of one reading approximately every 9 days. The northern basin had the greatest mean water transparency of all the lakes which were monitored. Water transparency fluctuated throughout the sampling period.

3.1.5 Deka Lake - Southern Basin

A total of 21 readings were taken between May 16 and October 25, 1996. The maximum recorded depth was 8.50 m, the minimum recorded depth was 3.60 m, and the mean depth for 1996 was 6.19 m (Figure 6). Station depth, determined from a bathymetric map, was approximately 27 m.

The shoreline of the southern basin of Deka lake is largely developed, and has a much greater recreational use compared to the northern basin. Sampling on the southern basin of Deka Lake was consistent. There were 21 readings taken between May 16 and October 25, an average of one reading approximately every 8 days. The southern basin has a mean water transparency of 1.1 m greater than the combined mean of lakes in the program, but it is significantly less (4.2 m) than the northern basin. The decreased water transparency of the southern basin may be explained by siltation due to logging in the watershed, increased boat activity causing shore edge erosion, surface erosion from commonly used access points and increased nutrient levels due to the large number of septic systems at the south end (Dennis Wilders, Personal Communication). The previous explanations for decreased water transparency are speculative in nature, and do not have any supporting data. Water transparency steadily increased to a high of 8.50 m on July 25, then steadily decreased until September 19 after which it remained constant around 5.0 m.

3.1.6 Eugene Lake

A total of 14 readings were taken between July 26 and October 25, 1996. The maximum recorded depth was 8.40 m, the minimum recorded depth was 6.29 m, and the mean depth for 1996 was 7.46 m (Figure 7). The station depth, determined during the audit, was greater than 18 m (the length of the tape attached to the Secchi disk).

Eugene Lake is of moderate size and has low development pressures and low recreational use. Sampling was very consistent, with 14 readings taken between July 26 and October 25 (an average of one reading approximately every 7 days). Eugene Lake has a mean water transparency 2.1 m greater than the combined mean of all lakes in the program. Water transparency fluctuated throughout the sampling season.

3.1.7 Fawn Lake

A total of 14 readings were taken between June 20 and October 11, 1996. The maximum recorded depth was 5.56 m, the minimum recorded depth was 3.20 m, and the mean depth for 1996 was 3.99 m (Figure 8). Station depth, determined from a bathymetric map, was approximately 8 m.

Fawn Lake is moderate in size and has low development pressures with only one resort and a couple other shoreline residences. Sampling was very consistent except for a gap in mid-September due to bad weather. There were 14 readings taken between June 29 and October 11, an average of one reading approximately every 8 days. Fawn Lake has a mean water transparency of 1.1 m less than the combined mean of all lakes in the program. Water transparency remained around 3.2 m until late August, and then increased to around 5.5 m for the remainder of the sampling season.

3.1.8 Hansen Lake

A total of 14 readings were taken between July 3 and October 23, 1996. The maximum recorded depth was 2.24 m, the minimum recorded depth was 1.32 m, and the mean depth for 1996 was 1.85 m (Figure 9).

Hansen is one of the smallest lakes being monitored. Sampling was fairly consistent with two gaps in the data due to illness. There were 14 readings taken between July 3 and October 23, an average of one reading taken approximately every 8 days. Hansen Lake has one of the lowest mean water transparency of the lakes being monitored (3.2 m less then the combined mean). Water transparency fluctuated throughout the sampling period.

3.1.9 Hathaway Lake

A total of 12 readings were taken between July 15 and October 15, 1996. The maximum recorded depth was 7.80 m, the minimum recorded depth was 6.45 m, and the mean depth for 1996 was 7.04 m (Figure 10). Station depth, determined from a bathymetric map, was approximately 43 m.

Hathaway lake is moderate in size, and has 22 shoreline residences (Petch and Zirnhelt, 1996). Sampling was consistent except for a couple of gaps in September due to bad weather. There were 12 readings taken between July 15 and October 15, an average of one reading approximately every 8 days. Hathaway Lake has a mean water transparency of 2.0 m greater than the combined mean of all lakes in the program. Water transparency remained relatively constant throughout the sample period, with a slight increase towards late September and October.

3.1.10 Henley Lake

A total of 14 readings were taken between July 3 and October 23, 1996. The maximum recorded depth was 3.74 m, the minimum recorded depth was 1.98 m, and the mean depth for 1996 was 2.93 m (Figure 11).

Henley is another of the smaller lakes being monitored. Sampling was fairly consistent with two gaps in the data due to illness. There were 14 readings taken between July 3 and October 23, an average of one reading taken approximately every 8 days. Henley Lake has a mean water transparency of 2.1 m lower than the combined mean of all lakes being monitored. Water transparency fluctuated throughout the sampling period.

3.1.11 Higgins Lake

A total of six readings were taken between July 11 and October 4, 1996. The maximum recorded depth was 4.06 m, the minimum recorded depth was 3.29 m, and the mean depth for 1996 was 3.71 m (Figure 12). Station depth, determined from a bathymetric map was approximately 11 m.

There were six readings taken between July 11 and October 4, an average of one reading taken approximately every 14 days. Higgins Lake has a mean water transparency 1.3 m less than the combined mean of all lakes being monitored. Water transparency remained relatively constant over the six readings.

3.1.12 Horse Lake

A total of 20 readings were taken between May 23 and October 11, 1996. The maximum recorded depth was 7.80 m, the minimum recorded depth was 5.75 m, and the mean depth for 1996 was 6.66 m (Figure 13). Station depth, determined from a bathymetric map was approximately 30 m.

Horse Lake is one of the larger lakes being monitored, and has considerable shoreline development with 297 residences and 79% of the shoreline privately owned (Petch and Zirnhelt, 1996). Sampling was consistent, with 20 readings taken between May 23 and October 11 (an average of one reading taken approximately every 7 days). Horse Lake has a mean water transparency 1.6 m greater than the combined mean of all lakes being monitored. Water transparency was constant until jumping to a high of 7.8 m on June 26, after which it fluctuated for the remainder of the sampling period.

In addition to this year's data, there are two other years of Secchi data collected on Horse Lake. In 1979 ten readings were taken, with a mean depth of 5.99 m; in 1994, 27 readings were taken with a mean depth of 6.03 m (Figure 25). This year's mean (6.66 m) is slightly larger then the previous years, suggesting an increase in water transparency. Data from all years were collected at the same site (0603100 - Horse Lake at Deepest Point), but by different samplers.

3.1.13 Knight Lake

A total of 16 readings were taken between July 3 and October 23, 1996. The maximum recorded depth was 4.80 m, the minimum recorded depth was 3.10 m, and the mean depth for 1996 was 4.09 m (Figure 14).

Knight Lake is one of the smaller lakes in the program, and has low development pressures. Sampling was very consistent, with 16 readings taken between July 3 and October 23 (an average of one reading taken approximately every 7 days). Knight Lake has a mean water transparency 1.0 m less than the combined mean of all lakes being monitored. Water transparency showed small fluctuations throughout the sampling season.

3.1.14 Lower Stack Lake

Data from 1996 was not submitted for inclusion in this report. The sampler responsible for both Lower and Middle Stack Lake found it unnecessary to sample both lakes and therefore concentrated his efforts on Middle Stack Lake.

3.1.15 Middle Stack Lake

A total of 12 readings were taken between July 6 and October 12, 1996. The maximum recorded depth was 3.52 m, the minimum recorded depth was 3.10 m, and the mean depth for 1996 was 3.26 m (Figure 15).

Middle Stack Lake is relatively small, and has low development pressures. Sampling was fairly consistent, with 12 readings taken between July 6 and October 12 (an average of one reading taken approximately every 8 days). Middle Stack Lake has a mean water transparency 1.8 m less than the combined mean of all lakes in the program. Water transparency remained relatively constant throughout the sampling season, fluctuating between 3 and 3.5 m.

3.1.16 Otter Lake

A total of 18 readings were taken between May 20 and October 14, 1996. The maximum recorded depth was 4.17 m, the minimum recorded depth was 2.20 m, and the mean depth for 1996 was 3.90 m (Figure 16). Station depth, determined from a bathymetric map, was approximately 15 m.

Otter Lake is of moderate size, and presently has a low development pressure with only 5 shoreline residences (Petch and Zirnhelt, 1996). Sampling was fairly consistent, with 18 readings taken between May 20 and October 14 (an average of one reading taken approximately every 8 days). Otter Lake has a mean water transparency 1.8 m less than the combined mean of all lakes being monitored. Water transparency fluctuated throughout the sampling season, with two maximums occurring on June 17 and August 19.

3.1.17 Roe Lake

A total of 13 readings were taken between July 7 and October 6, 1996. The maximum recorded depth was 5.33 m, the minimum recorded depth was 4.30 m, and the mean depth for 1996 was 4.93 m (Figure 17). Station depth, determined from a bathymetric map, was approximately 24 m.

Roe Lake is small in size, and has comparatively high development pressures with 15 shoreline residences and farms. The shoreline is 100% privately owned (Petch and Zirnhelt, 1996). Sampling was consistent with two gaps due to bad weather. There were 13 readings taken between July 7 and October 6, an average of one reading taken approximately every 7 days. Water transparency in Roe Lake is very similar to the combined mean of other lakes involved in the program. Transparency showed small fluctuations throughout the sampling season.

3.1.18 Sheridan Lake

A total of 19 readings were taken between May 15 and October 19, 1996. The maximum recorded depth was 12.85 m, the minimum recorded depth was 7.40 m, and the mean depth for 1996 was 9.66 m (Figure 18). Station depth, determined from a bathymetric map, was approximately 30 m.

Sheridan Lake is one of the largest lakes being monitored and has a very developed shoreline with 68% being privately owned (Petch and Zirnhelt, 1996). Sampling was fairly consistent with 19 readings taken between May 15 and October 19, an average of one reading taken approximately every 8 days. Sheridan Lake has one of the greatest mean water transparencies of all lakes being monitored (4.6 m greater than the combined mean for all lakes). Water transparency fluctuated throughout the sampling period showing several peaks (Figure 18).

In addition to this year's data, three other years of Secchi data have been collected by the Friends of Sheridan Lake. In 1993, 24 readings were taken with a mean depth of 7.48 m. In 1994, 22 readings were taken with a mean depth of 7.77 m. In 1995, 20 readings were taken with a mean depth of 7.91 m. In 1996, 18 reading were taken with a mean depth of 6.99 m (Figure 24).

Data collected in 1996 by Pat Silverton has a significantly larger mean than previous year's data collected by the Friends of Sheridan Lake. This might suggest an increase in water transparency from previous years, however, data collected by the Friends of Sheridan Lake during 1996 showed a decrease in mean water transparency compared to previous years. This is an example of the difficulties which arise when different people sample. Data collected in 1995 and 1996 are shown in Figure 25 for comparative purposes. All three graphs show similar fluctuations in water transparency during the sampling season. Data from all years were collected at the same site (E216929 - Sheridan Lake at Center).

3.1.19 Sulphurous Lake

A total of 24 readings were taken between May 16 and October 17, 1996. The maximum recorded depth was 11.20 m, the minimum recorded depth was 4.90 m, and the mean depth for 1996 was 8.66 m (Figure 19). Station depth, determined from a bathymetric map, was approximately 30 m.

Sulphurous Lake is one of the larger lakes in the program, and has moderate development pressures from shoreline residences. One side of the lake is largely privately owned, having 100 residences (Petch and Zirnhelt, 1996). Sampling was consistent, with 24 readings taken between May 16 and October 17 (an average of one reading taken approximately every 7 days). Sulphurous Lake has one of the greatest water transparencies of all lakes involved in the program (3.6 m greater than the combined mean for all lakes). Transparency fluctuated during the year, with several peaks.

3.1.20 Wavey Lake

Data from 1996 was not submitted for inclusion in this report. If data is submitted it will be included in a future report.

3.1.21 Webb Lake

A total of four readings were taken between August 14 and October 8, 1996. The maximum recorded depth was 1.80 m, the minimum recorded depth was 1.30 m, and the mean depth for 1996 was 1.61 m (Figure 20). Station depth, determined during the audit, was 2.5 m.

Webb Lake is another of the smaller lakes in the program, and has eight shoreline residences (Petch and Zirnhelt, 1996). Only four readings were taken, due to the late acquisition of a Secchi disk. Webb Lake water transparency is the lowest of all lakes involved, with a mean Secchi depth of only 1.61 m. There were too few samples to determine any seasonal pattern in the data.

3.1.22 West Twin Lake

A total of 12 readings were taken between July 13 and September 29, 1996. The maximum recorded depth was 3.40 m, the minimum recorded depth was 1.20 m, and the mean depth for 1996 was 1.95 m (Figure 21). Station depth, determined by Morley Farwell, was 5.8 m.

Sampling was consistent with 12 readings taken between July 13 and September 29, an average of one reading taken approximately every 7 days. West Twin Lake has one of the lowest water transparencies, with a mean 3.1 m less than the combined mean for all lakes. Water transparency decreased until mid-August, and then remained constant for the rest of the sampling season.

3.1.23 Whitley Lake

A total of seven readings were taken between July 21 and October 9, 1996. The maximum recorded depth was 3.20 m, the minimum recorded depth was 1.15 m, and the mean depth for 1996 was 1.90 m (Figure 22). Station depth, determined by Nel Hanemaayer, was 8.23 m.

Whitley Lake is a smaller lake, with low development pressures. There were seven readings taken between July 21 and October 9, an average of one reading taken approximately every 11 days. Whitley Lake has one of the lowest mean water transparencies of all the lakes being monitored, with a mean 3.2 m less than the combined mean for all lakes. Water transparency in September and October was significantly lower than water transparency in July.

3.2 1996 Audit

Audit results were encouraging, with the majority of the volunteers using the correct Secchi disk procedure. Raw data from the audit can be found in Table 2. The mean difference between the readings taken by MELP staff and those by volunteers was 3.39%. The maximum difference between two readings was 19.7% for values of 3.95 m (MELP) and 3.30 m (volunteer). On three occasions values obtained by MELP staff and the volunteer were the same. Figure 26 shows the frequency of the percent difference between MELP and volunteer Secchi values.

The most common error, made by several volunteers, was to record the depth at which the disk disappeared as the Secchi depth. The proper procedure is to record the average of the depth of disappearance and reappearance of the disk. Another error made by a couple of volunteers was not considering which was the protected, shady side of the boat when taking the reading. In addition, although the procedure given to the volunteers suggested readings be taken to the nearest 0.10 meters, many of the volunteers measured to the nearest 0.01 meters.

Due to the several instances where the outlined Secchi disk procedure was not followed, it would be useful to hold a refresher training session at the beginning of each sampling season to ensure that everyone is using the correct procedure. This could also be a time to answer any questions regarding the new sampling season, to train new volunteers, and to distribute any new equipment.

Of the volunteers which were audited, only one used an anchor during windy conditions. Some of the volunteers regularly had other people along who were able to assist in keeping the boat stationary. A couple of times during the audit an anchor would have been beneficial to stop drift, and allow for a more accurate reading. A drifting boat can make the disk hard to see, and can lead to false readings. Anchors would also aid in positioning the boat so a reading could be taken on the protected, shady side. The approximate cost of a 10 lb. folding four-pronged anchor is $15, plus an additional $15 would be needed for an average of 20 m of rope per volunteer (3\8 inch yellow poly). Some of the volunteers have access to anchors and need encouragement to use them.

Another difficulty in obtaining readings was expressed by volunteers using canoes (five of the people audited). The more unstable nature of canoes made it hard to lean over the edge to observe the disk safely. This was only a problem for volunteers going out in a canoe alone. Other observations made during the audit included a need for better descriptions of the weather and water conditions, as well as having the volunteers realize the importance of having the same person take the reading throughout the sampling season (where possible).

This year the audit was conducted in late September and October. If staff time permits, it would be beneficial to conduct the audit early in the sampling season. An earlier audit would enable the prompt correction of any errors in procedures at the beginning of each sampling season, as well as take advantage of better weather conditions. Rain and snow were a factor on several occasions during this year's audit, and it seemed to result in hasty readings, and less time on the lake to discuss sampling with the volunteers. The problems of seasonal residency and lakes freezing over would also be avoided with an earlier audit.

3.3 The Great 1996 Secchi DipIn

The Secchi DipIn is a concerted effort by over 7,000 volunteer monitors to gather transparency data on the world's lakes, rivers, and estuaries during a single week. It is a yearly event sponsored by the North American Lake Management Society, and the United States Environmental Protection Agency. This year the DipIn was held between June 29 and July 7. There were seven volunteers from the Bridge Creek Watershed VLMP that participated: John Bianchi, Nick Culic, Joanne Perrier, Neil and Cathy Sampson, Pat Silverton, and Bruno Sprecher. Results from this year are still being tabulated, and will be posted as soon as possible by the organizers on the World Wide Web at http://humboldt.kent.edu/~dipin. Funding has been approved for a 1997 Secchi DipIn, and forms will be forwarded to the Bridge Creek Watershed VLMP when they become available.

3.4 Program Expansion

There are many useful parameters which can be measured by volunteers. A comparison of parameters measured in various VLMPs is shown in Table 3. For this first year of the Bridge Creek Watershed VLMP, parameters were limited to Secchi readings and field notes, due to staff and budget constraints in setting up a larger program.

Expansion of the program to include more parameters would be beneficial but depends on staff time and budget allowances. Increasing the number of parameters measured to mirror those measured in the Omineca Peace Region VLMP would be a realistic goal. In addition, the monitoring of the various nitrogen forms should also be considered (ammonia, Kjeldahl nitrogen, nitrate, nitrite, nitrite + nitrate, total nitrogen and total organic nitrogen). The Omineca Peace Region VLMP was developed by Rick Nordin, Bob Grace and Bruce Carmichael, and was based on VLMPs currently operating (Carmichael, personal communication). One objective of the Omineca Peace VLMP was to "...provide an example of volunteer lake monitoring on which a province wide program ... can be developed and maintained" (Rex and Carmichael, 1995). Having BC VLMPs measuring the same parameters would aid in comparing lakes from across the province.

The estimated cost to measure the parameters included in the Omineca Peace Region VLMP and the various nitrogen forms on one lake is $11,505 plus 10 MELP staff days per lake for one sampling season (based on biweekly sampling from May - October). The cost would be reduced to $6240 per lake if the various nitrogen parameters were not included. New parameters not currently measured in the Bridge Creek Watershed VLMP would include station depth, water color, water odour, temperature profile, dissolved oxygen, phosphorus (total, ortho, and total dissolved), nitrogen (ammonia, Kjeldahl nitrogen, nitrate, nitrite, nitrite + nitrate, total nitrogen and total organic nitrogen) and chlorophyll *a*. The estimate of staff time includes contacting volunteers, training and auditing the volunteers, travel, purchasing equipment, miscellaneous support, data compiling, report writing, and processing and shipping the samples. Chlorophyll *a* samples would have to be filtered by MELP staff before being shipped to the lab for analysis. Based on this estimate, a student hired for one Co-op term would be able to manage an expanded program on eight lakes through one summer[3].

The estimated cost largely consists of lab analysis which would cost $10,650 for sampling one site biweekly for one season ($5385 if the various nitrogen parameters are omitted). Other costs include equipment purchase (student point sampler, sample bottles, Hach kit[4], and anchor), miscellaneous travel costs, and courier fees. Samples will have to be shipped from 100 Mile House to Williams Lake for processing, and then from Williams Lake to Vancouver for lab analysis. Assumptions are made that volunteers will already have a Secchi disk, and MELP coolers will be used to transport the samples. The complete breakdown of costs can be found in Table 4.

Information gathered from measuring additional parameters would be used to learn more about the individual lakes. Chlorophyll *a* is a photosynthetic pigment found in all green plants, and is used as a measure of algal biomass (Ripley, 1993). Phosphorous and nitrogen are both aquatic plant nutrients, either of which can be a limiting factor for plant growth and algal biomass. Cariboo lakes are generally phosphorus limited.

Three phosphorus forms are typically analyzed: total phosphorous, orthophosphorus and total dissolved phosphorus. Total phosphorus is the sum of all forms that are either unavailable to the biological community or available at various rates. Total dissolved phosphorus is the sum of all forms that will pass

---

[3] Estimate based on 35 hours per work week, 17 weeks per Co-op term.
[4] Hach kit is used to determine dissolved oxygen.

through a 0.45 æm filter and includes dissolved organic phosphorus that will become available for algal growth after conversion to orthophosphorus (Rex and Carmichael, 1995). Orthophosphorus is the inorganic form that can be directly taken up by algae, and is a rough index of the amount of phosphorus immediately available for algal growth (Ripley, 1993).

For monitoring long term trends, the measurement of more than one parameter aids in verifying changes in nutrient concentration. Therefore, nitrogen should be monitored as well as phosphorus. Nitrogen has a complex cycle, with many different forms capable of undergoing various transformations depending on environmental conditions. There are three major forms of nitrogen in the aquatic environment: nitrate, nitrite and ammonia. Natural sources of nitrate include atmospheric precipitation, the complete oxidation of vegetable and animal debris, and animal excrement. Nitrite is generally not generated from natural sources as it is an unstable intermediate form. Nitrite can be transformed from nitrate or ammonia. The major natural sources for ammonia include atmospheric precipitation, dry fallout, the decomposition of organic material, and soil erosion (Nordin and Pommen, 1986). There are many anthropogenic sources of nitrogen which could lead to elevated levels, and nutrient enrichment in lakes.

The usefulness of temperature and dissolved oxygen is explained by Rex and Carmichael (1995):

> "Vertical temperature profiles help determine the degree of lake stratification, provide some clue to oxygen levels present at depth and can infer future algal blooms. Thermal stratification, in conjunction with dissolved oxygen, helps to delineate phosphorous cycles, indicates areas of major plant growth and identifies potential health risks to other lake biota."

Collecting water samples to be analyzed for the above parameters has certain transport considerations. Water samples must be kept cool (4°C), in the dark, and analyzed within 72 hours. Samples would have to be shipped by the volunteers immediately to Williams Lake for processing, and then sent the next day to Vancouver for analysis.

Lakes recommended for expanded monitoring[5] by Zirnhelt *et al.* (in prep.) should be considered first. Other lakes which should be considered for expanded

---

[5] There are two types of sampling which could be recommended for an expanded lake monitoring program: overturn sampling, and scheduled summer sampling. Monitoring at spring overturn gives the best indication of overall lake water quality from a single sample. This is because at overturn lakes circulate freely and nutrients are distributed equally across all strata (Petch and Zirnhelt, 1996). The expanded volunteer program which is discussed in this report would involve scheduled summer sampling on a bi-weekly basis. Samples would be taken from various depths and would provide information on the seasonal changes of the lake and lake water quality. Data obtained from overturn samples can be compared to historical data (if available) as a cost effective step to determine whether further study by way of scheduled summer sampling is warranted.

monitoring are lakes which showed unstable Secchi disk readings over the sampling period. Judging from this year's data, such lakes would include Eugene, Hansen, Henley, Otter, and Sheridan. Fluctuations in water transparency generally suggest cycles of algae bloom and decay which may be the result of elevated nutrient input into the lake.

It is not realistic to believe that there will be adequate funding to monitor all lakes for the additional parameters. Some additional parameters could be measured on all the lakes involved, without additional costs to the program. Station depth would be an easy parameter to include in future sampling. Station depth measured at the beginning of each sampling season would ensure adequate depth at the site to take a Secchi reading, as well as provide information on the consistency of the sample site location from year to year. On shallow lakes (< 15m), the measuring tape attached to the Secchi disk could be used for this purpose. For deeper sites, a depth sounder would have to be provided. Circulating a MELP depth sounder to the deep lakes at the beginning of the season would incur no further costs to the program. Other additional parameters which could be measured at no cost are water color and water odour. Without a point sampler, these parameters could only be measured at the water surface.

Surface temperature would yield useful information, and would be easy and relatively inexpensive to measure ($7 per thermometer). Surface temperature data would aid in explaining water transparency trends. For example, a decrease in Secchi depth compared to the previous year may be due to an unusually warm summer that results in algal blooms.

To summarize, increasing the number of parameters to include those measured in the Omineca Peace VLMP, plus the various nitrogen forms, would be costly. Essential to program expansion are volunteers who are willing to take the extra time to learn how to use the new equipment, and to spend the additional time to perform the biweekly sampling. Consistent data collection will be mandatory if the information gathered is to be useful.

4.0 CONCLUSIONS

The conclusions of this study can be summarized as follows:

1. Data collected by the volunteers will be invaluable background information. Many of the lakes being monitored have had little or no previous monitoring. Solid data collected over a three year period should produce adequate background data for the lakes in the Bridge Creek Watershed VLMP.

2. There was a great variability in water transparency between the different lakes involved in the program. The lowest mean Secchi depth was 1.85 m for Hansen Lake, and the highest mean Secchi depth was 10.41 m for Deka Lake (northern basin). Because lakes vary in water clarity naturally (Wetzel, 1983), adequate background data is essential in order for biologists to know in future if a lake is changing, i.e. becoming more eutrophic. Lakes with lower water transparency should not necessarily be considered polluted or impacted by humans.

3. Program expansion to include more water quality parameters should be considered if finances and staff time permit. Consistency and dedicated volunteers will be mandatory in an expanded program where more time will be required and more costs and equipment involved. One Co-op student hired for one term, $85,200 for lab costs, and $6840 for equipment purchase and other miscellaneous costs would be required to expand the program for eight lakes. Lab costs could be reduced to $43,800 if the various nitrogen forms were not analyzed.

4. It is important that procedures be followed exactly, otherwise the consistency and therefore, the reliability of the procedure will be jeopardized (Carlson, 1995). Improved consistency in data collection and more descriptive field notes should be a goal during the next sampling season.

5.0 RECOMMENDATIONS

1. Continue sampling the lakes where a full season of data was collected for a further two years. Burn, Deka (northern basin), Higgins, Webb, and Whitley lakes had few readings taken in 1996 and should be monitored for another three years. Three complete years of sampling should provide an adequate amount of background data.

2. As finances allow, expand the number parameters measured. Lakes with a high priority for monitoring as recommended by Zirnhelt *et al.* (in prep.) should be considered first.

3. Due to the several instances where the outlined procedure was not followed, it would be useful to hold a refresher training session at the beginning of each sampling season. This could also be a time when new volunteers are trained, and any new equipment distributed.

4. If staff time permits, conduct the audit early in the season. An early audit would enable the prompt correction of any procedural errors, as well as take

advantage of better weather and avoid the problems of lakes freezing and seasonal residency.

5. Supply volunteers with anchors and ropes to facilitate accurate readings during windy conditions. Anchors would especially assist people taking readings alone, and allow them to maneuver the boat to ensure the reading is being taken on the protected, shady side of the boat. Supplying volunteers with anchors and rope would cost $600, and should be pursued even if program expansion doesn't occur.

6. Supply volunteers with thermometers so surface temperature can be measured. Temperature data will aid in explaining water transparency trends. For example, decreased Secchi depth may be the result of an unusually warm summer that results in algal blooms, as opposed to algal blooms caused by increased nutrient loading. Supplying volunteers with thermometers would cost $140, and should be pursued even if program expansion doesn't occur.

7. Station depth should be recorded by the volunteers at the beginning of each sampling season. This would ensure that the lake is deep enough to take a Secchi reading at the site, as well as provide information on the consistency of the sample site from year to year.

8. Measurements should be taken to the nearest 0.01 m. It is not difficult to measure to the nearest centimeter, and many of the volunteers already measure to this scale.

6.0 REFERENCES

Carlson, R.E. 1995. The Secchi Disk and the Volunteer Monitor. Lakeline, North American Lake Management Society. 15(1):28 -37.

Carmichael, N.B. 1996. Personal Communication. Environmental Protection, Ministry of Environment, Lands, and Parks, Prince George, B.C.

Carmichael, N.B. 1995. Environmental Section 1995 Work Plan. Project Title: Volunteer Lake Monitoring Program. Unpublished.

Davey, T. 1996. Waterfront Cottages Could See Massive Devaluation if Water Clarity is Threatened. Environmental Science and Engineering, September 1996: 80-81.

Hart, S. 1995. Land Use and Water Quality Management in the Bridge Creek Basin. Prepared for Water Quality Branch, Environmental Protection Dept. of BC Environment, and Fraser Pollution Abatement Office, Fraser River Action Plan of Environment Canada. 49 p.

Nordin, R.N. and L.W. Pommen. 1986. B.C. Water Quality Criteria for Nitrogen (Nitrate, Nitrite and Ammonia). Technical Appendix. Water Management Branch, Ministry of Environment, Lands and Parks. 79 p.

Petch, R. and N. Zirnhelt. 1996. Bridge Creek Watershed Lake Monitoring Program: Prioritization of Lakes for Monitoring. Environmental Protection, Ministry of Environment, Lands and Parks. Williams Lake, B.C.

Rex, J.F. and N.B. Carmichael. 1995. Volunteer Lake Monitoring Program, Omineca Peace Region Year 1 Interim Report (Draft). Environmental Protection Branch, BC Environment, Northern Interior Region. 47 p. + appendices.

Ripley, P. 1993. Citizen Volunteer Monitoring Programs of the Upper Midwest. Lakeline, North American Lake Management Society. 13(3):10-14.

Wetzel, R. G. 1983. Limnology. W.B. Saunders Company, Philadelphia. 743 p.

Wilders, D. 1996. Personal Communication. Fish and Wildlife, Ministry of Environment, Lands and Parks, Williams Lake, B.C.

Zirnhelt, N., R. Petch, and T. Byleveld. (In prep.). Water Quality, Lake Sensitivity Ratings, and Septic Seepage Surveys of Six Lakes in the Bridge Creek Basin. Environmental Protection. Ministry of Environment, Lands, and Parks. Williams Lake, B.C.

TABLES

Table 1. Volunteer information.

Name	Phone Number	Lake Being Monitored
Art Andrews	593 - 4539	Deka Lake (northern basin)
John Bianchi	593 - 4659	Bridge Lake
Steve Budd	593 - 4761	Eugene Lake
Erich and Irene Borter	593 - 4605	Knight Lake
Nick and Margaret Culic	593 - 4137	Deka Lake (southern basin)
Henny DeGruiter	593 - 4654	Fawn Lake
Paul Desaulniers	593 - 4431	Henley and Hansen Lakes
Morley Farwell	593 - 4945	West Twin Lake
Maureen Glueck	593 - 4781	Burn and Big Rutherford Lakes
Mel Grahn	593 - 4913	Webb Lake
John and Nel Hanemaayer	593 - 4733	Whitley Lake
Jim Luton	398 - 1190	Wavey Lake
Dennis McCoy	593 - 4681	Roe Lake
Dolores Miller	593 - 4772	Higgins Lake
Eric Paddison	593 - 4853	Middle and Lower Stack Lakes
Scott Salter and Joanne Perrier	593 - 4616	Otter Lake
Neal and Cathy Sampson	593 - 4561	Sulphurous Lake
Pat Silverton	593 - 4388	Sheridan Lake
Bruno and Dora Sprecher	395 - 3766	Horse Lake
Gerry Swope	593 - 4006	Hathaway Lake
Roy Tomlinson	593 - 4527	Hathaway Lake

Table 2. Audit data.

Volunteer	Lake	Date	Time	MELP Value (m)	Volunteer Value (m)	Weather Conditions
Art Andrews	Deka (northern basin)	96/09/26	12:26	10.05 10.05	9.85 9.35	Overcast but bright, slight wind, small ripples.
Steve Budd	Eugene	96/10/04	9:57	7.20 7.25	7.73 7.88	Overcast, raining, slight wind, small waves.
Irene Borter	Knight	93/09/24	13:57	3.95 3.85	3.30 3.80	Calm, sunny with a few high clouds, slight ripple.
Nick Culic	Deka (southern basin)	96/10/25	10:16	6.45 6.10	6.00 6.10	Small ripples, overcast.
Henny DeGruiter	Fawn	96/09/20	9:55	5.51 5.55	5.56 5.55	Overcast (80%) but bright, high cloud,. rippled surface.
Paul Desaulniers	Hansen	96/09/20	11:57	2.55 2.50	2.28 2.27	Overcast (80%), slight ripple.
Maureen Glueck	Burn	96/09/26	13:50	3.87 3.85	3.97 3.99	Overcast (80%), calm, slight ripple.
Mel Grahn	Webb	96/09/20	13:05	1.06 1.10	1.30 1.30	Calm, no waves, cloudy with slight rain.
Nel Hanemaayer	Whitley	96/09/24	12:57	1.33 1.53	1.47 1.36	Calm, sunny, a few high clouds, slight ripple.
Dennis McCoy	Roe	96/09/20	10:49	4.35 4.85	4.35 4.20	Partly cloudy, slight ripples.
Dolores Miller	Higgins	96/09/24	9:10	4.17 3.98	3.80 3.43	Calm, sunny with some high clouds.
Eric Paddison	Middle Stack	96/10/04	8:37	3.85 3.90	3.28 3.28	Overcast, slight rain, ripples.
Neal Sampson	Sulphurous	96/10/17	9:20	8.94 8.90	8.75 8.65	Overcast, small waves.
Pat Silverton	Sheridan	96/10/23	11:46	7.30 7.32	7.05 7.25	Wavy, snow, overcast.
Bruno Sprecher	Horse	96/10/23	2:00	5.20 5.20	5.10 5.75	Overcast, small waves.
Roy Tomlinson	Hathaway	96/09/24	10:50	7.29 7.45	6.82 7.55	Calm, sunny, a few high clouds.

Table 3. Lake parameters measured by volunteer monitoring programs. Adapted from Ripley (1993) and Carmichael (Unpublished).

Parameter	IL	IN	MI	MN	OH	WI	AB	BC (Omineca Peace Region)	BC (Bridge Creek Watershed)
Secchi Depth	✓	✓	✓	✓	✓	✓	✓	✓	✓
Station Depth	✓			✓	✓			✓	
Lake Level	✓				✓	✓			
Rainfall	✓				✓	(✓)			
Field Notes	✓	✓	✓	✓	✓	✓	✓	✓	✓
Recreational Suitability				✓					
Water Colour	✓	✓		✓	✓	✓		✓	
Water Odour								✓	
Surface Temp.					✓		✓	✓	
Temp. Profile						(✓)		✓	
Dissolved Oxygen								✓	
D.O. Profile						(✓)		✓	
Suspended Solids	(✓)						✓		
Nitrogen	✓								
Phosphorus	✓	✓				✓	✓	✓	
Chlorophyll *a*		✓				✓	✓	✓	
Zebra Mussels	✓								
Loon Sightings			✓						

Notes: 1) **(✓)** means that the parameter is measured only in the advanced sampling component of the program.
2) IL = Illinois, IN = Indiana, MI = Michigan, MN = Minnesota, OH = Ohio, WI = Wisconsin, AB = Alberta.

Table 4. Estimation of cost to Ministry of Environment Lands and Parks to monitor one lake biweekly at one site for one sampling season (May -October).

MELP average person days/lake:

Activity	Days	Comments
Initial volunteer contact	0.25	
Travel (for two trips)	1.0	
Training volunteers	0.5	
Auditing volunteers	0.5	
Equipment purchase	0.25	
Sample reception/processing	5.0	Based on 15 sample days per season (bi-weekly) and .3 days per lake per sample day. Includes shipping, and filtering chlorophyll *a* samples.
Volunteer support	0.5	Miscellaneous telephone support.
Data compiling/reporting	2.0	
Total Per Lake:	10	

MELP Capital cost:

Item	Cost
Student point sampler	$ 200
Sample bottles	$ 75
Hach kit	$ 80
Hach D.O. extra bottles	$ 100
Anchor (with rope)	$ 30
Total per lake:	**$ 485**

MELP operating costs:

Item	Cost
Travel (gas, misc.)	$ 100
Courier (from 100 Mile - WL, WL - Van; two lakes per cooler, 15 times)	$ 270
Total Per Lake	**$ 370**

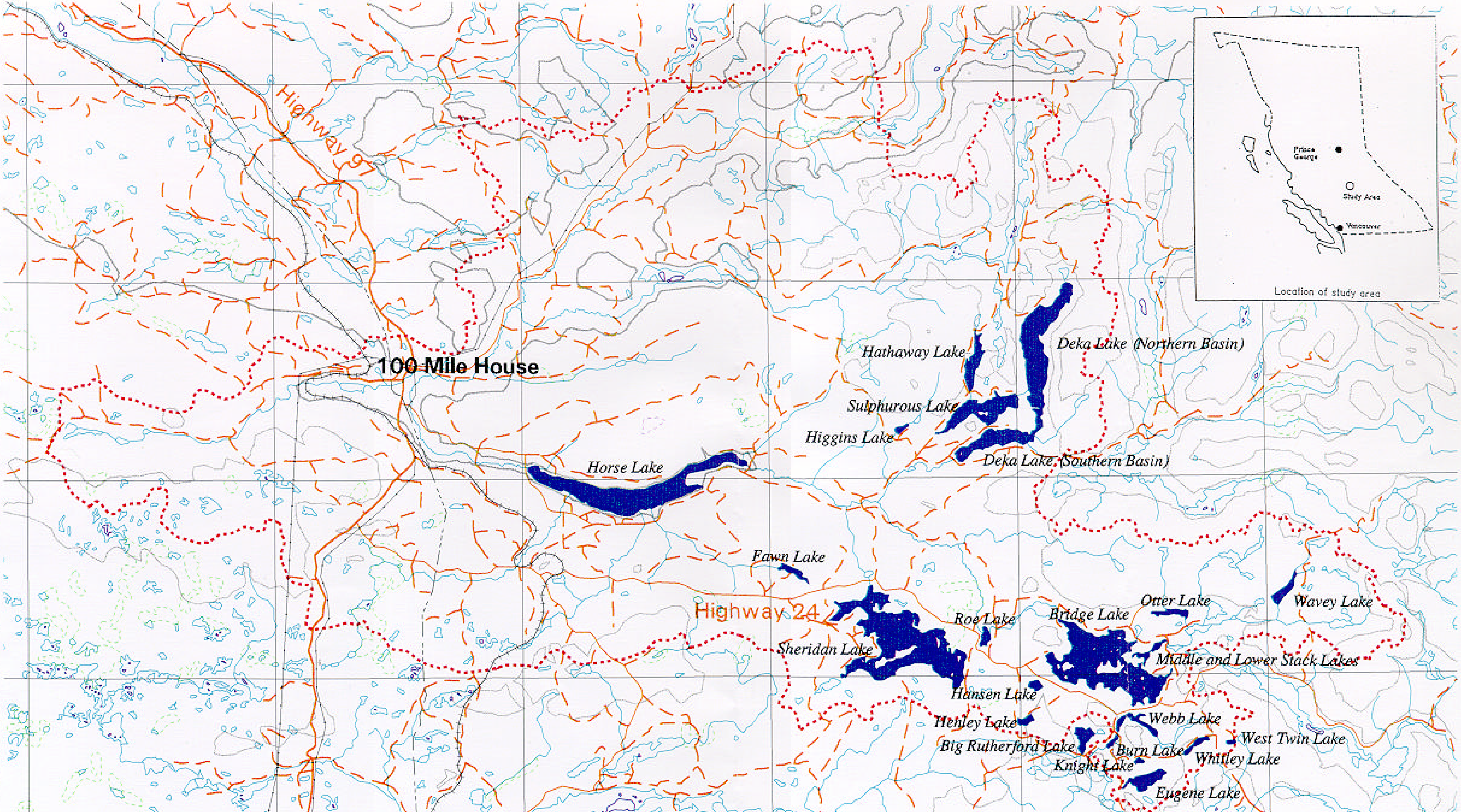
MELP Lab cost per site:

Parameter	Unit Cost	3 Depths	Duplicate	DI and Pt. Sampler Blank	Total cost for one site
pH	$ 4.50	$ 13.50	$ 4.50	$ 9.00	$ 27.00
Specific conductance	$ 4.50	$ 13.50	$ 4.50	$ 9.00	$ 27.00
Total phosphorus	$ 16.50	$ 49.50	$ 16.50	$ 33.00	$ 99.00
Orthophosphorus	$ 12.00	$ 36.00	$ 12.00	$ 24.00	$ 72.00
Total dissolved phosphorus	$ 16.50	$ 49.50	$ 16.50	$ 33.00	$ 99.00
Chlorophyll *a*	$ 35.00	-	Included	-	$ 35.00
Ammonia *	$ 13.50	$ 40.50	$ 13.50	$ 27.00	$ 81.00
Kjeldahl nitrogen *		Calculated from other parameters			-
Nitrate *		Calculated from other parameters			-
Nitrite *	$ 10.50	$ 31.50	$ 10.50	$ 21.00	$ 63.00
Nitrite + nitrate *	$ 10.50	$ 31.50	$ 10.50	$ 21.00	$ 63.00
Total organic nitrogen *		Calculated from other parameters			-
Total nitrogen *	$ 24.00	$ 72.00	$ 24.00	$ 48.00	$ 144.00
Total per lake					**$ 710.00**
Total for 15 sample days					**$10650.00**
Total per lake without various Nitrogen parameters (*)					**$ 359.00**
Total for 15 sample days without various Nitrogen parameters (*)					**$ 5385.00**

Grand total to sample one lake biweekly at one site for one sampling season: **$11,505.00** plus 10 person days or **$6240.00** plus 10 person days if various nitrogen parameters are not measured.

FIGURES

Figure 1: Bridge Creek Basin Lakes Volunteer Secchi Disk Monitoring Program - 1996



Ministry of Environment, Lands & Parks, November 1996

Scale 1:200 000 - Échelle 1/200 000

Kilometres 5 0 5 10 15 20 Kilomètres

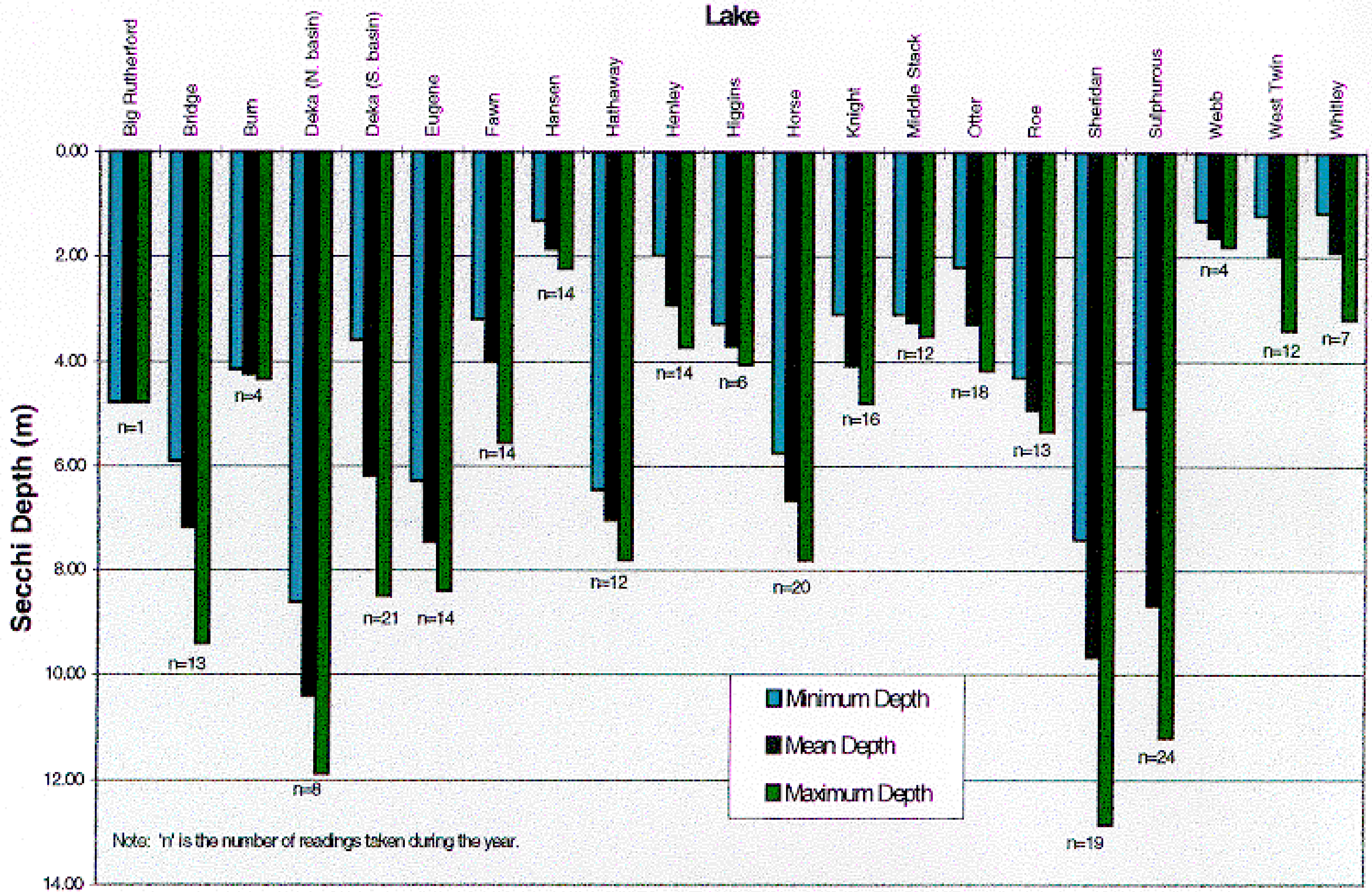


FIGURE 2. Comparison of the minimum, mean and maximum Secchi depths for all lakes in the Bridge Creek Watershed VLMP.

Date	Time	Weather	Water Conditions	Secchi (m)
May - 24	10:00			5.90
Jun - 01	14:00			6.30
Jun - 15	9:00	Sun		6.45
Jun - 23	11:00			7.20
Jul - 01	10:00			8.20
Jul - 12	10:00			8.60
Jul - 21	11:00	Sun		9.40
Jul - 29	10:00			8.50
Aug - 07	10:00			8.40
Aug - 18	11:00			6.10
Aug - 28	10:00			6.20
Sep - 07	16:00			5.90
Sep - 20	10:00			6.10

Statistics

Mean Depth:	**7.17**
Maximum Depth:	**9.40**
Minimum Depth:	**5.90**
Number of Readings:	**13**

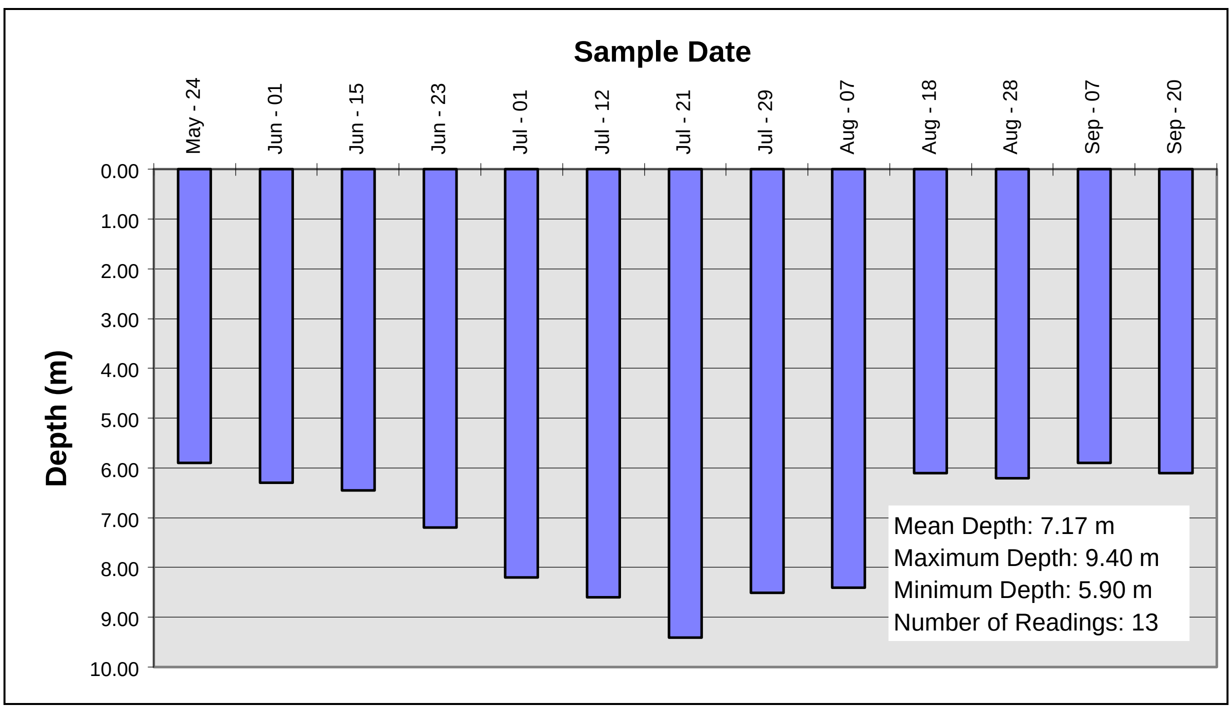


Figure 3. Summary data from 1996 Bridge Lake Secchi disk readings. Data collected by John Bianchi.

Date	Time	Weather	Water Conditions	Secchi (m)
Sep - 01	12:45	windy, dull	wavy	4.16
Sep - 26	11:45	bright but overcast	calm, still	4.35
Oct - 04	11:45	dull grey	calm, still	4.15
Oct - 11	11:30	bright	calm	4.29

Statistics

Mean Depth:	**4.24**
Maximum Depth:	**4.35**
Minimum Depth:	**4.15**
Number of Readings:	**4**

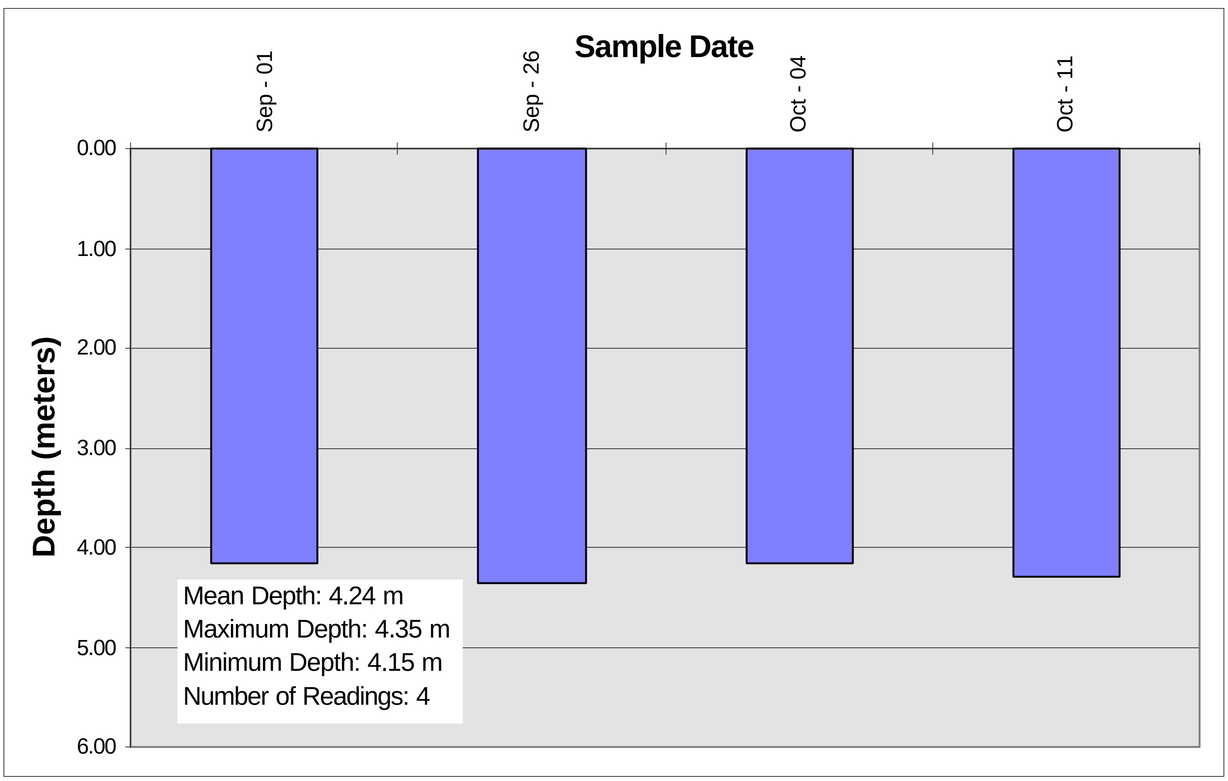


Figure 4. Summary data from 1996 Burn Lake Secchi disk readings. Data collected by Mike and Maureen Glueck.

Date	Time	Weather	Water Conditions	Secchi (m)
Jul - 25	12:00	sunny	ripples	11.00
Aug - 01	13:00	sunny	ripples	11.88
Aug - 08	12:00	sunny	ripples	10.56
Aug - 15	11:45	overcast	slight ripple	8.60
Aug - 22	12:10	sunny	ripples	10.84
Sep - 05	14:00	cloudy	choppy	10.01
Sep - 26	12:26	overcast	slight ripple	9.85
Oct - 03	12:00	overcast	choppy	10.56

Statistics

Mean Depth:	**10.41**
Maximum Depth:	**11.88**
Minimum Depth:	**8.60**
Number of Readings:	**8**

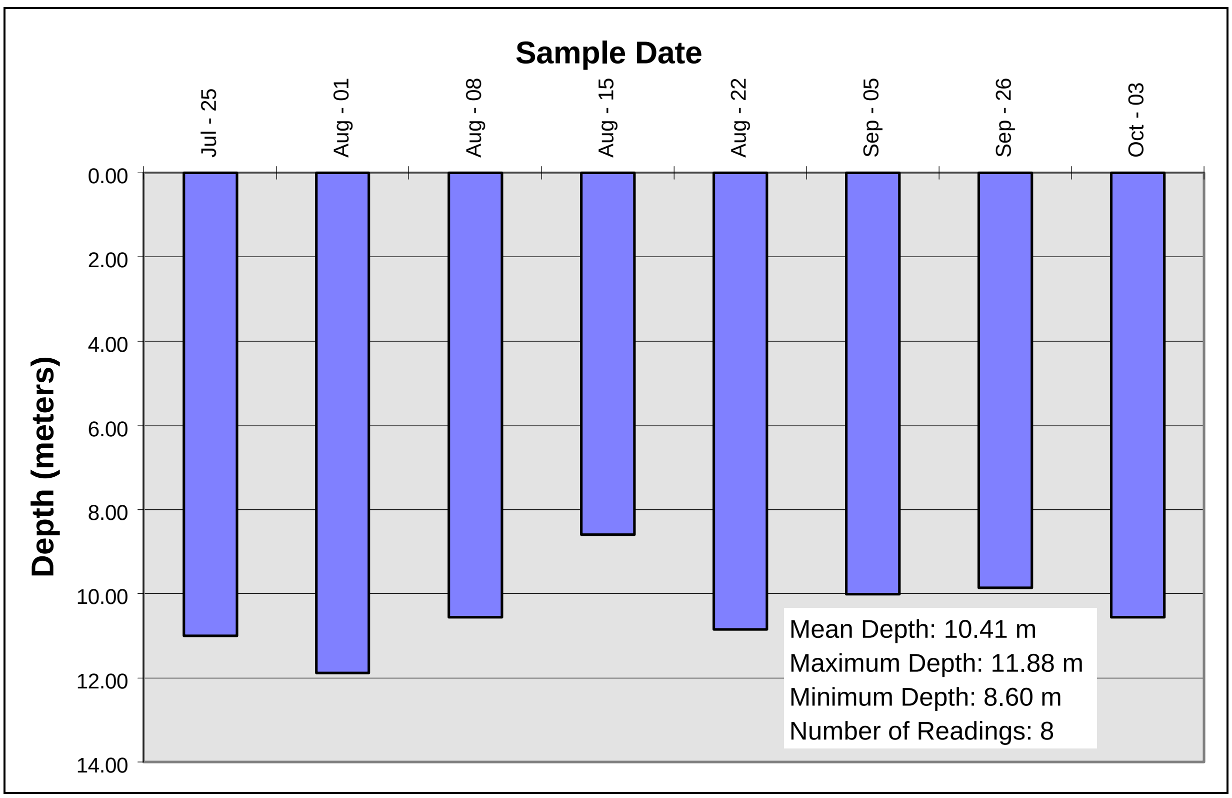


Figure 5. Summary data from 1996 Deka Lake (northern basin) Secchi disk readings. Data collected by Art and Carol Andrews.

Date	Time	Weather	Water Conditions	Secchi (m)
May - 16	13:52	cloudy	rippled	4.40
May - 23	14:35	sunny	calm	4.50
May - 30	15:20	cloudy	rippled	3.60
Jun - 06	14:50	sunny	rippled	4.40
Jun - 13	14:20	cloudy	rippled	4.85
Jun - 20	13:40	sunny	rippled	5.40
Jun - 27	14:15	cloudy	calm	6.00
Jul - 04	13:10	cloudy	rippled	6.50
Jul - 11	13:55	sunny	calm	7.20
Jul - 18	14:10	sunny	rippled	8.30
Jul - 25	13:58	sunny	calm	8.50
Aug - 01	14:55	cloudy	calm	8.20
Aug - 08	13:05	sunny	rippled	8.10
Aug - 15	14:08	cloudy	calm	7.70
Aug - 25	14:05	sunny	rippled	6.20
Sep - 12	13:35	cloudy	calm	6.50
Sep - 19	13:09	sunny	rippled	5.90
Sep - 26	13:30	cloudy	calm	6.00
Oct - 03	12:30	clear	rippled	5.90
Oct - 10	13:40	sunny	rippled	5.90
Oct - 25	10:16	cloudy	rippled	5.90

Statistics

Mean Depth:	**6.19**
Maximum Depth:	**8.50**
Minimum Depth:	**3.60**
Number of Readings:	**21**

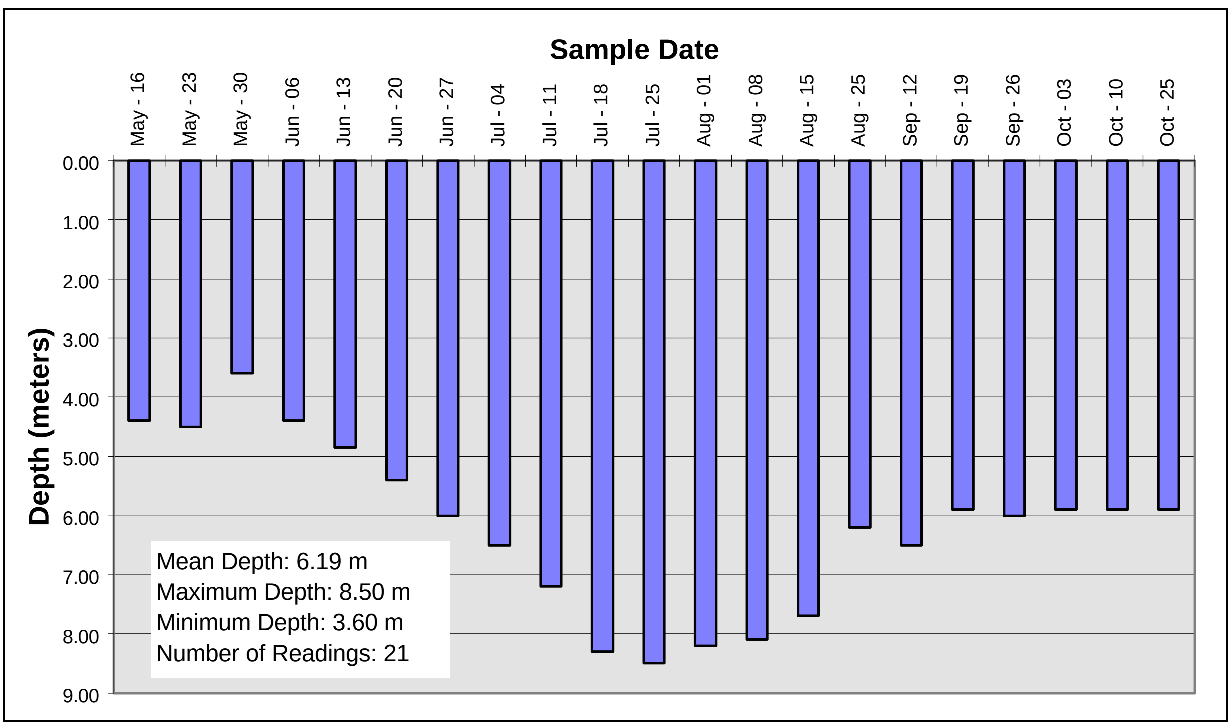


Figure 6. Summary data from 1996 Deka Lake (southern basin) Secchi disk readings. Data collected by Nick and Margaret Culic.

Date	Time	Weather	Water Conditions	Secchi (m)
Jul - 26	14:00	sunny	calm	7.37
Aug - 02	12:00	overcast	choppy	6.29
Aug - 09	11:00	sunny	calm	7.44
Aug - 16	13:00	sunny	rippled	6.70
Aug - 23	14:00	sunny	calm	7.33
Aug - 30	14:00	sunny	calm	8.10
Sep - 06	12:30	light overcast	rippled	7.20
Sep - 13	11:30	light overcast	rippled	8.00
Sep - 20	12:30	sunny	calm	8.30
Sep - 27	12:30	sunny	calm	8.40
Oct - 04	10:00	overcast	rippled	7.75
Oct - 11	12:00	sunny	calm	8.40
Oct - 18	13:00	overcast	rough	6.30
Oct - 25	11:00	overcast	calm	6.85

Statistics

Mean Depth	**7.46**
Maximum Depth:	**8.40**
Minimum Depth:	**6.29**
Number of Readings:	**14**

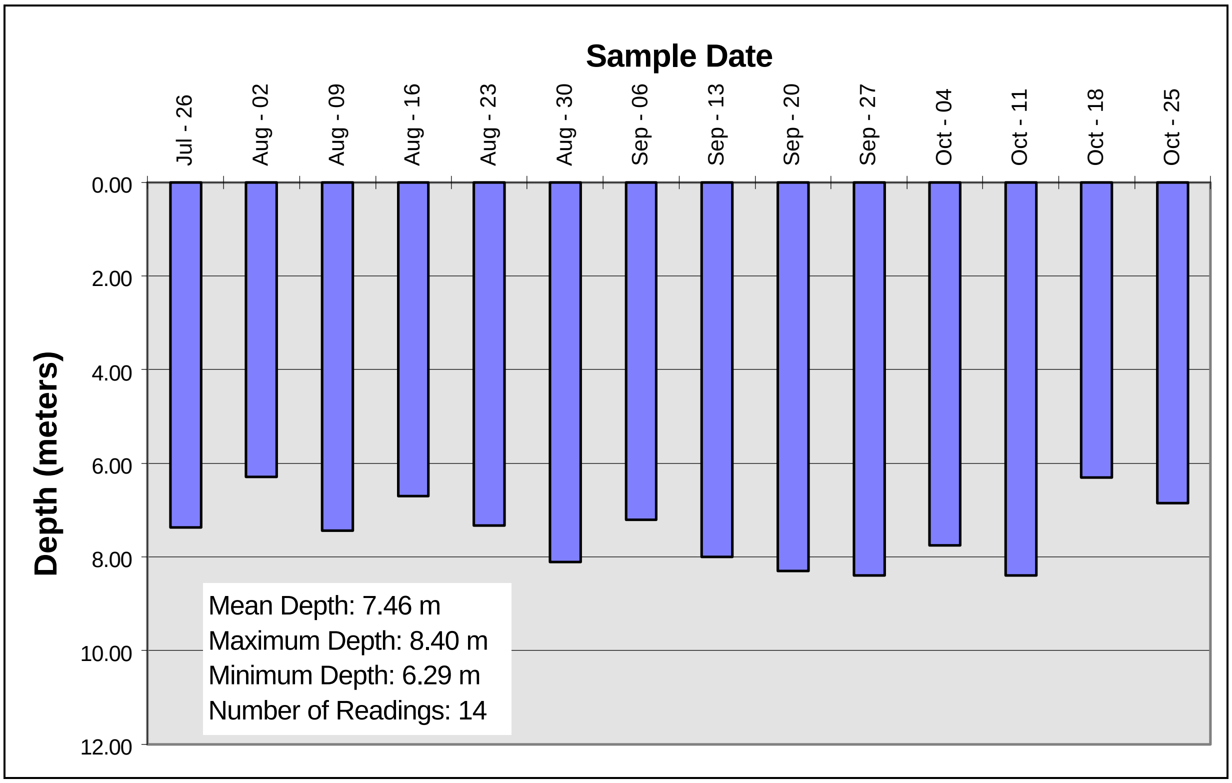


Figure 7. Summary data from 1996 Eugene Lake Secchi disk readings. Data collected by Steve Budd.

Date	Time	Weather	Water Conditions	Secchi (m)
Jun - 29	11:00	windy, cold		3.20
Jul - 07	12:00	sun/cloud		3.25
Jul - 13	11:30	clouds/rain		3.25
Jul - 20	10:00	sun/clouds		3.20
Jul - 27	13:00	sun		3.30
Aug - 03	14:00	rain, wind		3.25
Aug - 10	14:00	sun/clouds		3.25
Aug - 17	13:00	sun		3.20
Aug - 26	14:00	sun		3.37
Sep - 01	11:30	mixed		4.52
Sep - 20	10:00	sun/cloud		5.56
Sep - 27	10:30	sun/cloud		5.49
Oct - 04	10:30	rain		5.50
Oct - 11	10:00	sun		5.53

Statistics

Mean Depth:	**3.99**
Maximum Depth:	**5.56**
Minimum Depth:	**3.20**
Number of Readings:	**14**

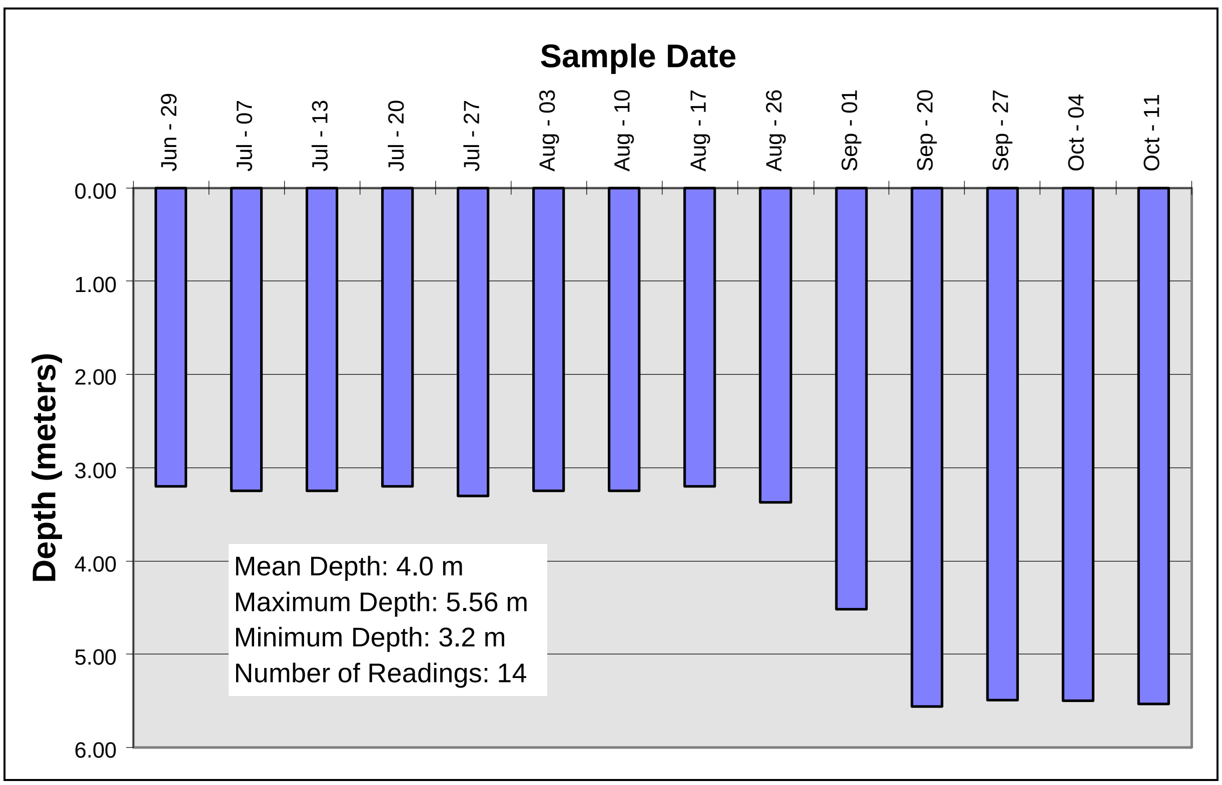


Figure 8. Summary data from 1996 Fawn Lake Secchi disk readings. Data collected by Henny and Tjerk DeGruiter.

Date	Time	Weather	Water Conditions	Secchi (m)
Jul - 03	14:45	sun, windy		1.83
Jul - 10	14:55	cloudy, windy		2.21
Jul - 17	15:15	cloudy, raining		2.13
Jul - 24	14:50	cloudy, raining		2.13
Jul - 31	14:55	sun, windy		1.92
Aug - 07	14:50	sun		2.18
Aug - 10	14:45	sun		2.24
Aug - 28	14:15	sun		1.96
Sep - 12	12:30	cloudy		1.32
Sep - 25	14:15	cloudy		1.45
Oct - 02	14:05	cloudy		1.57
Oct - 09	14:30	sun		1.74
Oct - 16	14:20	cloudy		1.69
Oct - 23	14:00	cloudy		1.54

Statistics

Mean Depth:	**1.85**
Maximum Depth:	**2.24**
Minimum Depth:	**1.32**
Number of Readings:	**14**

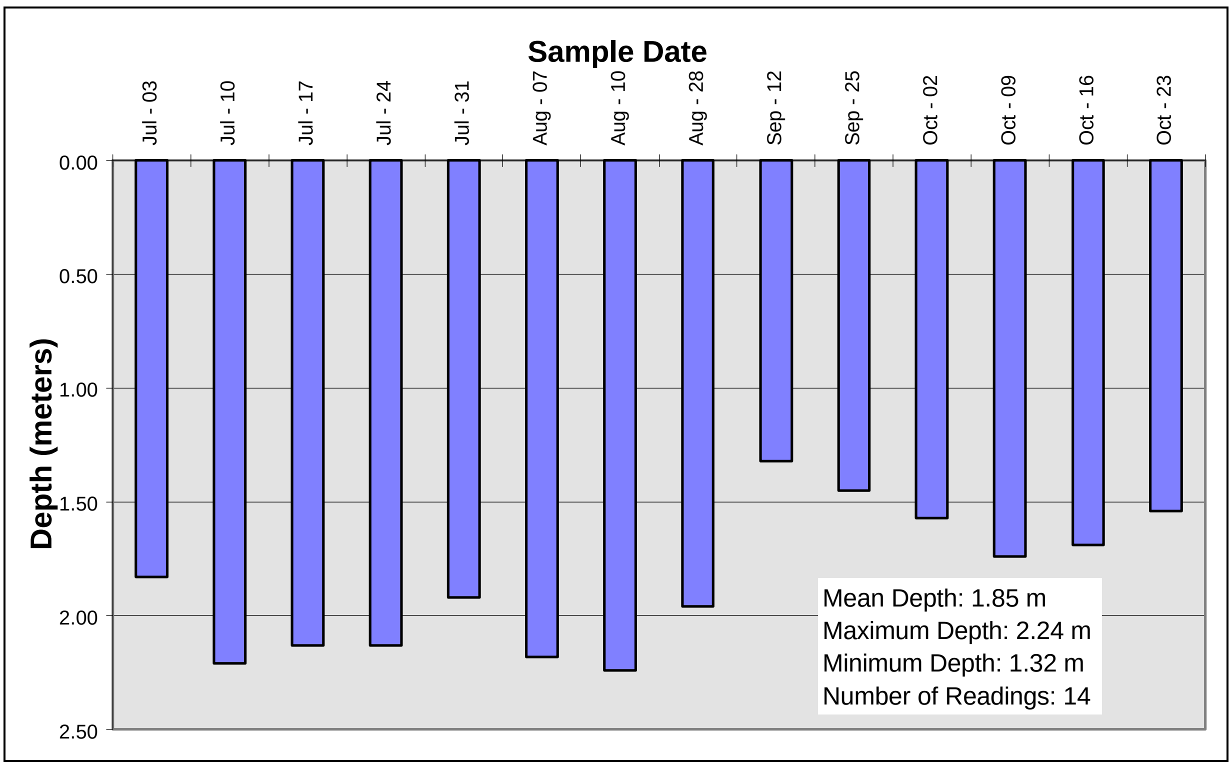


Figure 9. Summary data from 1996 Hansen Lake Secchi disk readings. Data collected by Paul Desaulniers.

Date	Time	Weather	Water Conditions	Secchi (m)
Jul - 15	12:21	sunny, windy	light ripple	6.47
Jul - 22	11:30	sunny, light wind	light ripple	6.45
Jul - 29	10:48	sunny, windy	light ripple	6.50
Aug - 06	11:11	sunny, light wind	light ripple	6.80
Aug - 12	11:52	sunny	flat	6.90
Aug - 19	11:00	windy, raining	choppy	6.75
Aug - 26	12:13	sunny	slight ripple	7.05
Sep - 09	11:35	partly cloudy	flat	7.35
Sep - 24	10:50	sunny	flat	7.55
Oct - 01	11:37	sunny	flat	7.15
Oct - 08	10:47	sunny	slight ripple	7.80
Oct - 15	10:58	partly cloudy	slight ripple	7.70

Statistics

Mean Depth	**7.04**
Maximum Depth:	**7.80**
Minimum Depth:	**6.45**
Number of Readings:	**12**

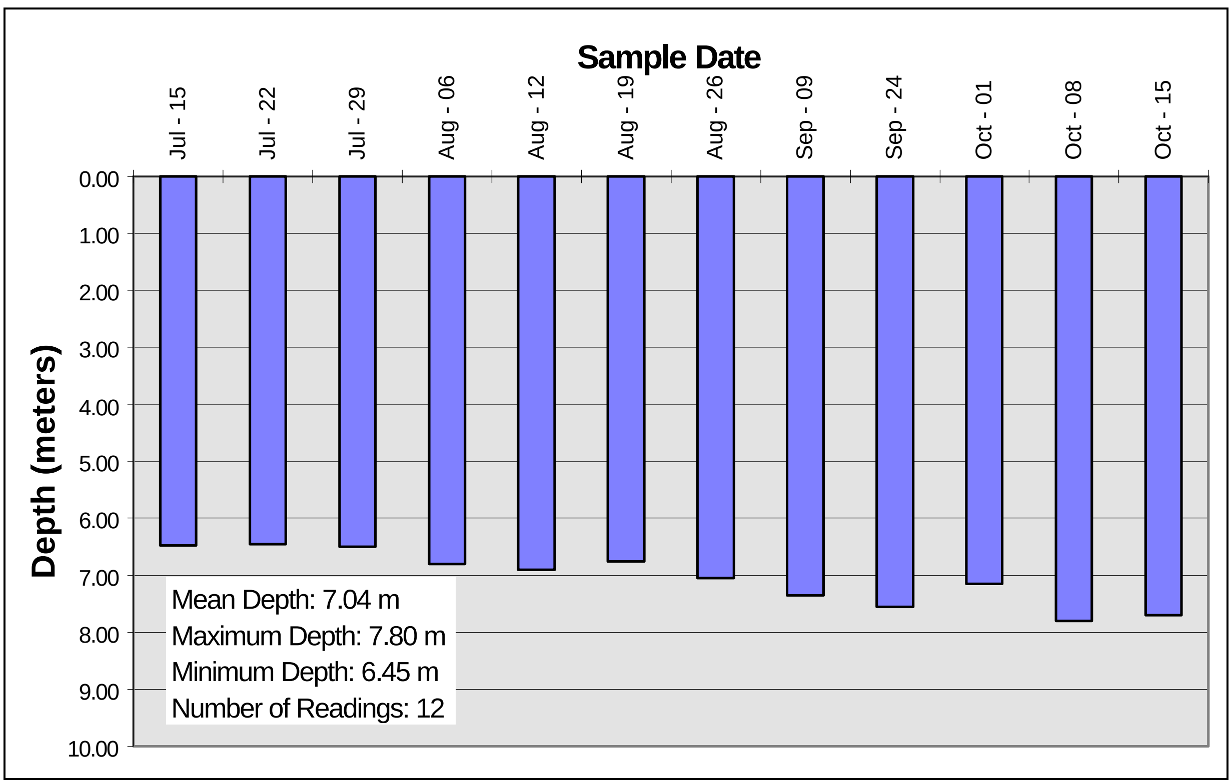


Figure 10. Summary data from 1996 Hathaway Lake Secchi disk readings. Data collected by Gerry Swope and Roy Tomlinson.

Date	Time	Weather	Water Conditions	Secchi (m)
Jul - 03	14:00	sun, windy		3.13
Jul - 10	14:10	cloudy, windy		3.74
Jul - 17	14:45	cloudy, raining		3.36
Jul - 24	14:15	cloudy, raining		3.33
Jul - 31	14:30	sun, windy		3.14
Aug - 07	14:20	sun		3.30
Aug - 10	14:10	sun		3.23
Aug - 28	13:45	sun		3.49
Sep - 12	12:00	cloudy		1.98
Sep - 25	14:00	cloudy		2.45
Oct - 02	13:45	cloudy		2.37
Oct - 09	14:10	sun		2.63
Oct - 16	14:00	cloudy		2.47
Oct - 23	13:45	cloudy		2.43

Statistics

Mean Depth:	**2.93**
Maximum Depth:	**3.74**
Minimum Depth:	**1.98**
Number of Readings:	**14**

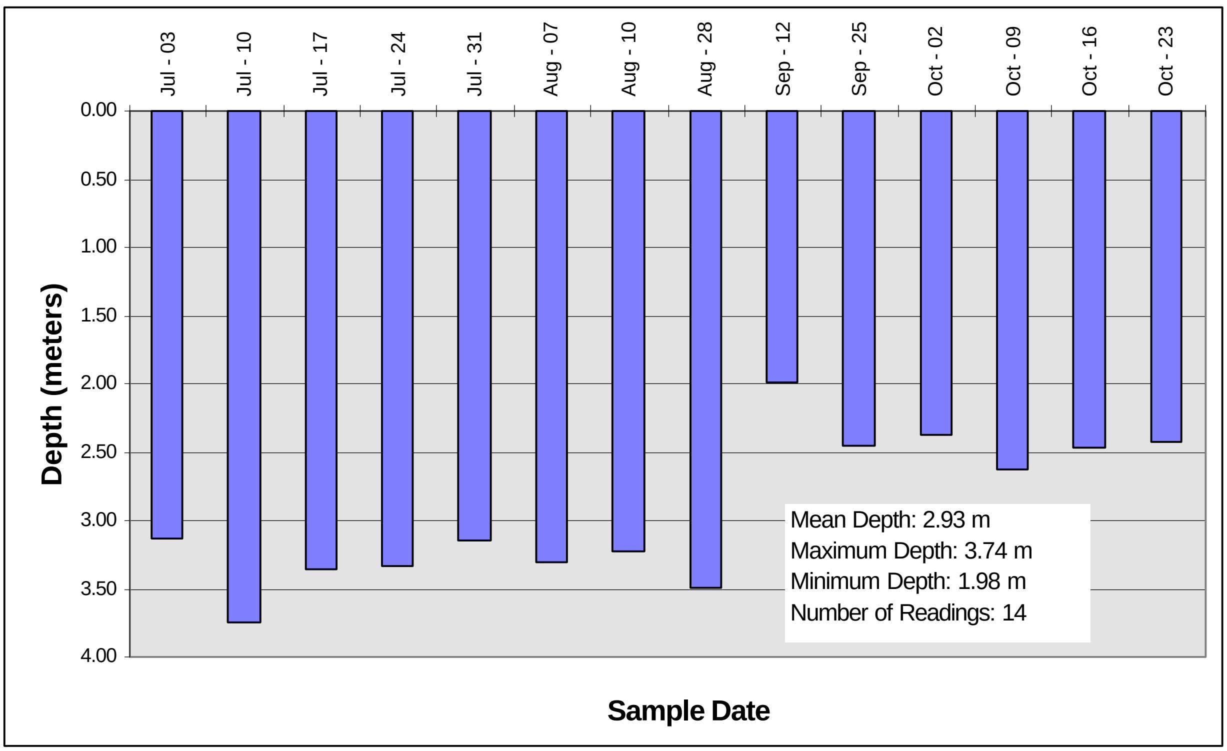


Figure 11. Summary data from 1996 Henley Lake Secchi disk readings. Data collected by Paul Desaulniers.

Date	Time	Weather	Water Conditions	Secchi (m)
Jul - 11	12:35	sunny, windy		3.82
Jul - 25	11:40	cloudy, breeze		3.78
Aug - 14	12:05	cloudy	calm	4.06
Aug - 29	13:10	sunny, breeze		3.29
Sep - 24	10:20	sunny	calm	3.80
Oct - 04	12:30	cloudy, windy		3.53

Statistics

Mean Depth	**3.71**
Maximum Depth:	**4.06**
Minimum Depth:	**3.29**
Number of Readings:	**6**

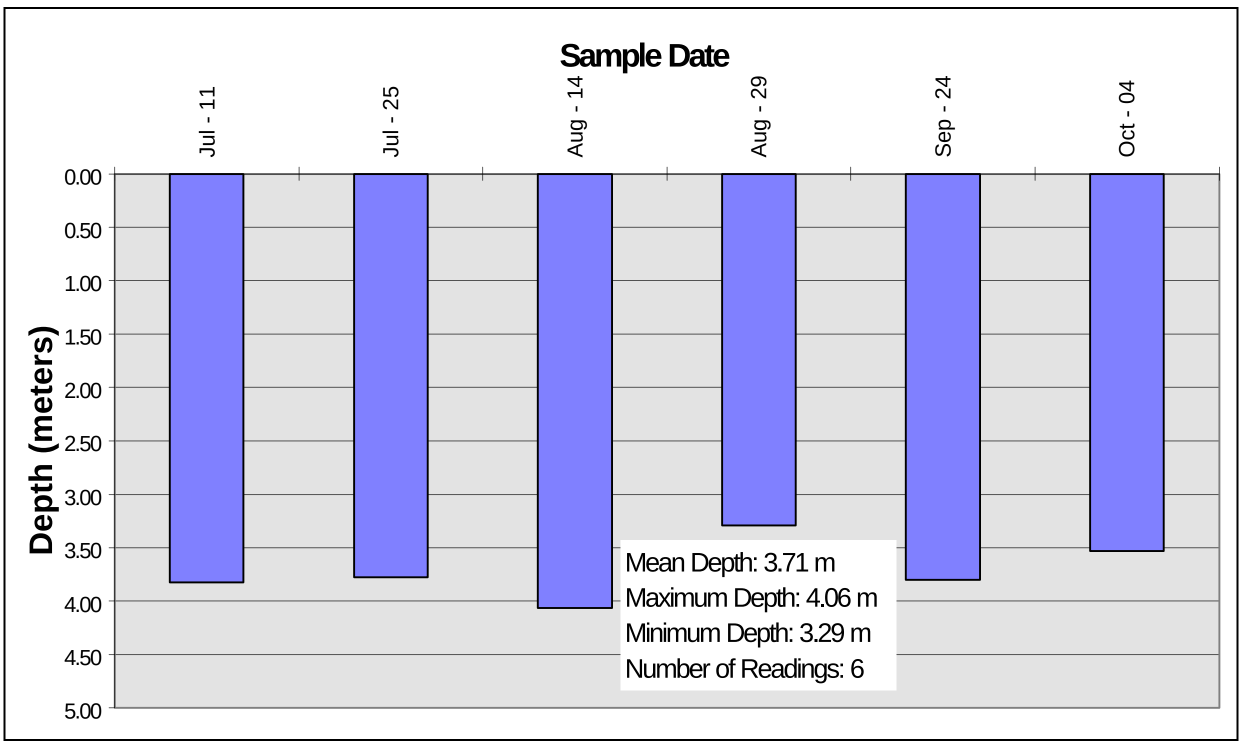


Figure 12. Summary data from 1996 Higgins Lake Secchi disk readings. Data collected by Dolores Miller.

Date	Time	Weather	Water Conditions	Secchi (m)
May - 23	17:37	sunny	calm	5.95
May - 30	14:00	clouds		6.00
Jun - 07	17:00	clouds, cold		6.00
Jun - 13	16:00	nice and warm		6.00
Jun - 18	16:00	clouds, wind, rain		5.75
Jun - 26	14:30	sunny with clouds		7.80
Jul - 05	18:46	cloudy	calm	6.85
Jul - 07	8:41	sunny	calm	7.40
Jul - 14	9:00	sunny	calm	7.50
Jul - 21	11:00	clouds, wind		7.20
Jul - 28	10:00	nice		7.30
Aug - 05	14:00	nice, windy		6.80
Aug - 11	15:00	nice, windy		6.90
Aug - 21	11:00	rain, windy		6.80
Aug - 30	10:00	rain, clouds		6.70
Sep - 05	11:00	rain		6.20
Sep - 12	11:15	rain		6.30
Sep - 18	12:00	rain		6.20
Oct - 05	14:00	clouds		6.80
Oct - 11	16:00	clouds		6.80

Statistics

Mean Depth:	**6.66**
Maximum Depth:	**7.80**
Minimum Depth:	**5.75**
Number of Readings:	**20**

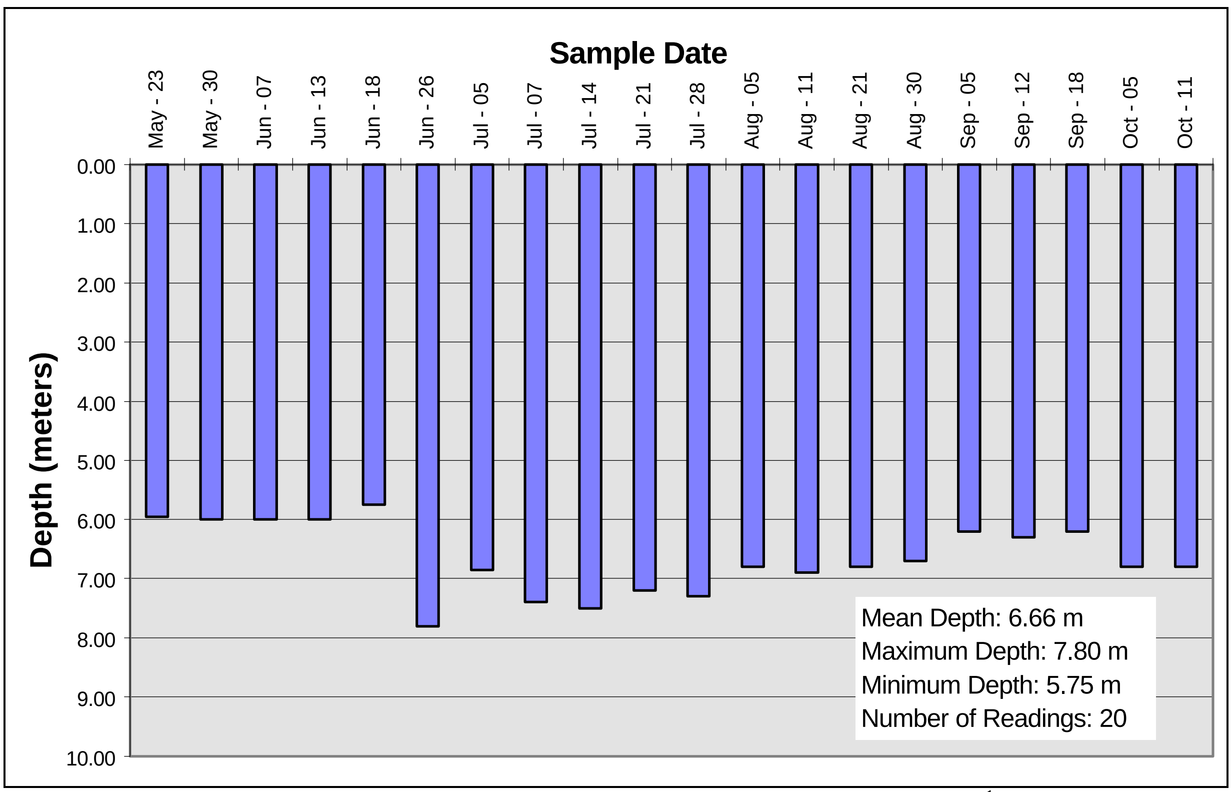


Figure 13. Summary data from 1996 Horse Lake Secchi disk readings[1]. Data collected by Bruno and Dora Sprecher.

---

[1] Horse Lake Secchi disk readings are available, from the Ministry of Environment, Lands and Parks, for 1979 and 1994.

Date	Time	Weather	Water Conditions	Secchi (m)
Jul - 03	13:00	cloudy, windy	wavy	4.00
Jul - 10	12:00	cloudy, windy	wavy	4.00
Jul - 18	14:00	cloudy, windy	wavy	4.10
Jul - 26	12:00	sunny	flat surface	4.30
Aug - 01	11:00	sunny	flat surface	4.60
Aug - 08	14:00	cloudy	flat surface	3.80
Aug - 15	12:00	sunny	flat surface	4.40
Aug - 22	12:00	sunny	flat surface	4.30
Aug - 29	13:00	cloudy	flat surface	4.40
Sep - 05	14:00	rain	wavy	4.80
Sep - 12	11:00	sunny	flat surface	4.70
Sep - 19	11:00	cloudy	wavy	4.10
Sep - 26	14:00	sunny	flat surface	3.80
Oct - 03	15:00	sunny	flat surface	3.90
Oct - 16	12:00	cloudy	wavy	3.20
Oct - 23	11:00	cloudy, windy	wavy	3.10

Statistics

Mean Depth:	**4.09**
Maximum Depth:	**4.80**
Minimum Depth:	**3.10**
Number of Readings:	**16**

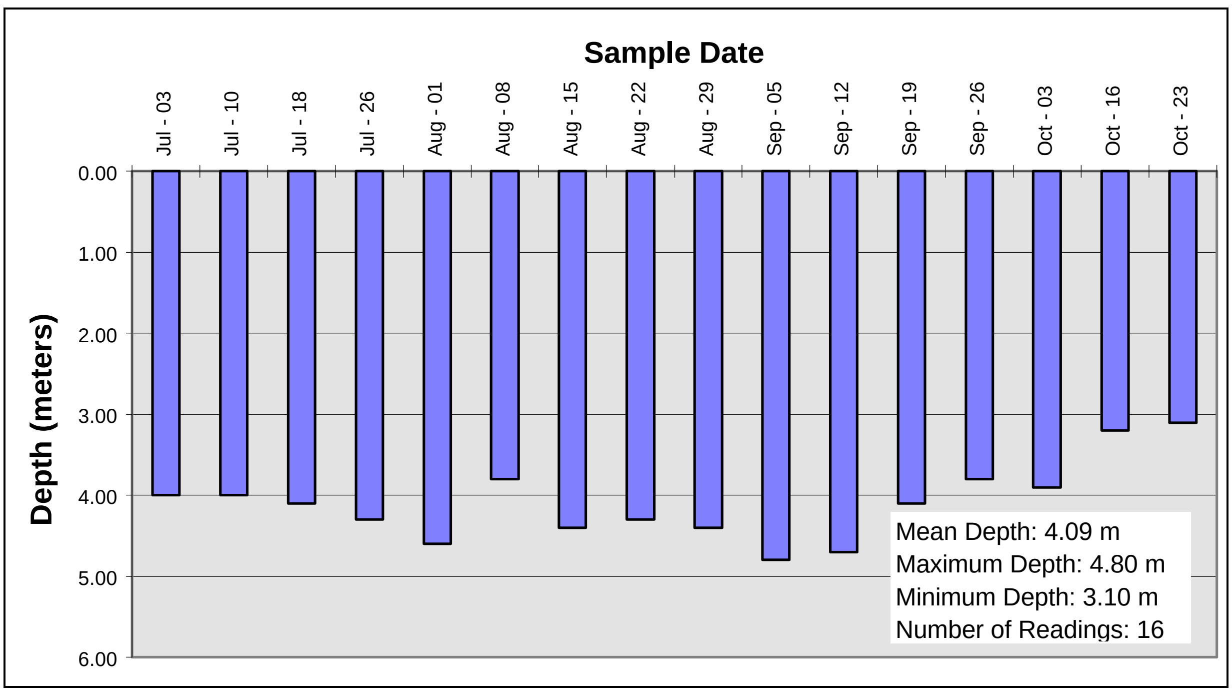


Figure 14. Summary data from 1996 Knight Lake Secchi disk readings. Data collected by Erich and Irene Borter.

Date	Time	Weather	Water Conditions	Secchi (m)
Jul - 06	11:00	sunny	rippled	3.10
Jul - 20	10:00	sunny	calm	3.25
Jul - 27	11:00	sunny	calm	3.22
Aug - 03	10:30	cloudy	calm	3.12
Aug - 10	10:00	sunny	calm	3.19
Aug - 18	11:30	sunny with clouds	rippled	3.10
Aug - 25	10:00	cloudy	rippled	3.13
Sep - 02	11:00	sunny	rippled	3.19
Sep - 10	11:00	cloudy	calm	3.35
Sep - 24	10:00	sunny	calm	3.50
Oct - 01	10:00	cloudy	calm	3.52
Oct - 12	10:00	cloudy	rippled	3.40

Statistics

Mean Depth:	**3.26**
Maximum Depth:	**3.52**
Minimum Depth:	**3.10**
Number of Readings:	**12**

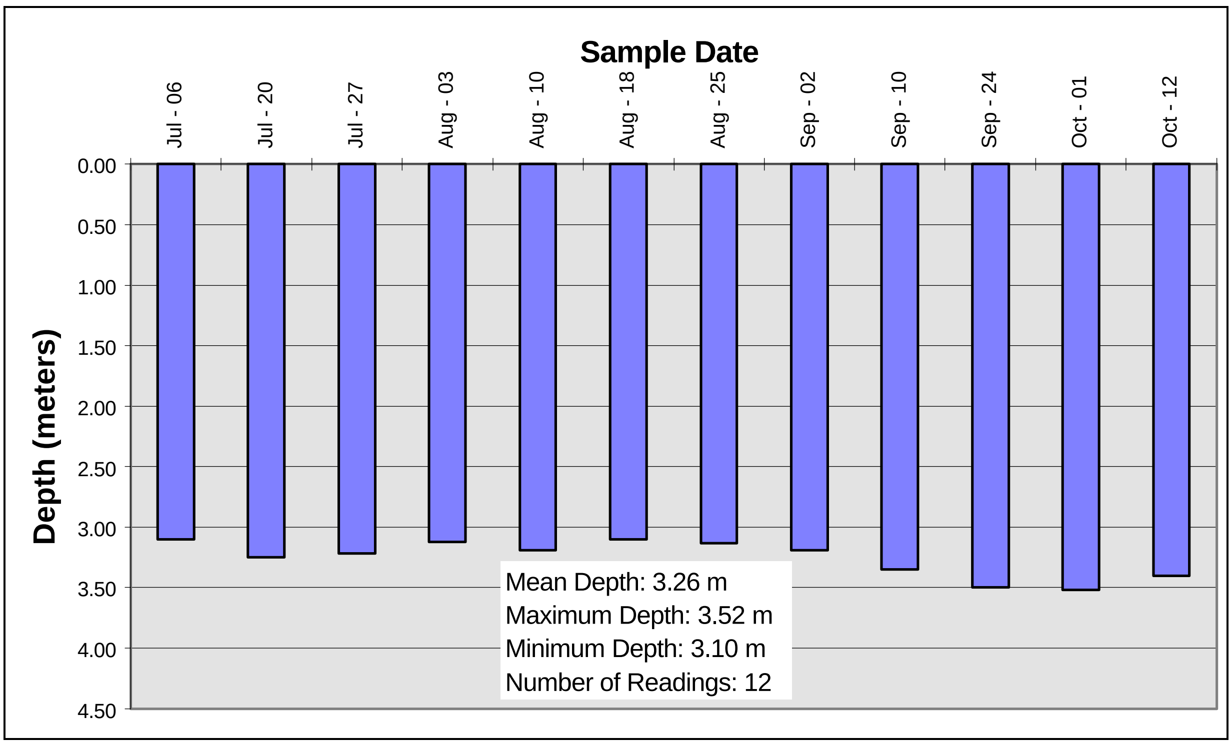


Figure 15. Summary data from 1996 Middle Stack Lake Secchi disk readings. Data collected by Eric Paddison.

Date	Time	Weather	Water Conditions	Secchi (m)
May - 20	14:15	cloudy	calm	2.20
May - 27	15:15	cloudy		2.83
Jun - 03	10:30	cloudy, windy	ripples	2.69
Jun - 10	10:45	cloudy, windy	ripples	3.68
Jun - 17	14:30	cloudy		3.73
Jun - 24	13:00	clear, sunny		3.10
Jul - 04	14:50	cloudy		3.15
Jul - 15	11:00	clear		3.33
Jul - 29	10:30	clear, sunny	calm	3.23
Aug - 12	9:30	clear		3.53
Aug - 19	15:30	clear		4.17
Aug - 27	10:00	cloudy	calm	3.68
Sep - 10	13:30	clear		4.04
Sep - 16	12:15	cloudy		3.73
Sep - 23	13:45	clear, windy		3.15
Sep - 30	12:30	cloudy		3.43
Oct - 07	13:30	cloudy		2.59
Oct - 14	11:30	snowing		2.92

Statistics

Mean Depth:	**3.29**
Maximum Depth:	**4.17**
Minimum Depth:	**2.20**
Number of Readings:	**18**

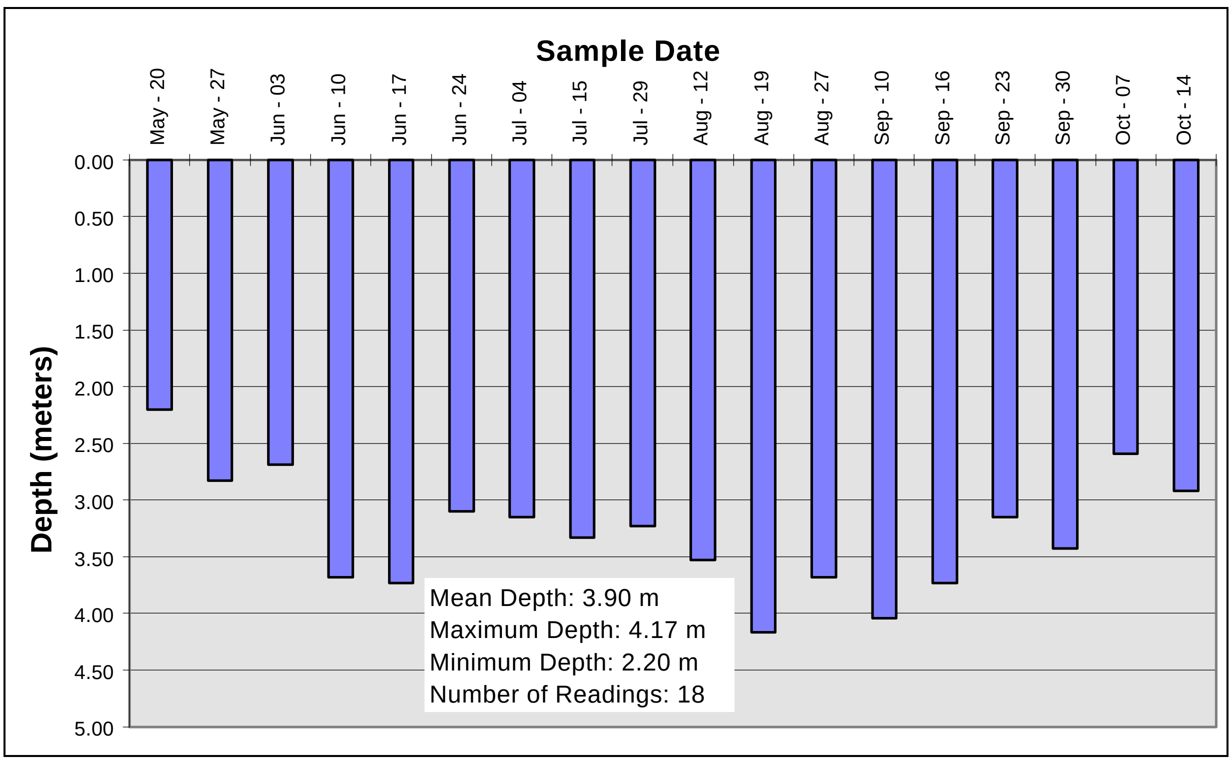
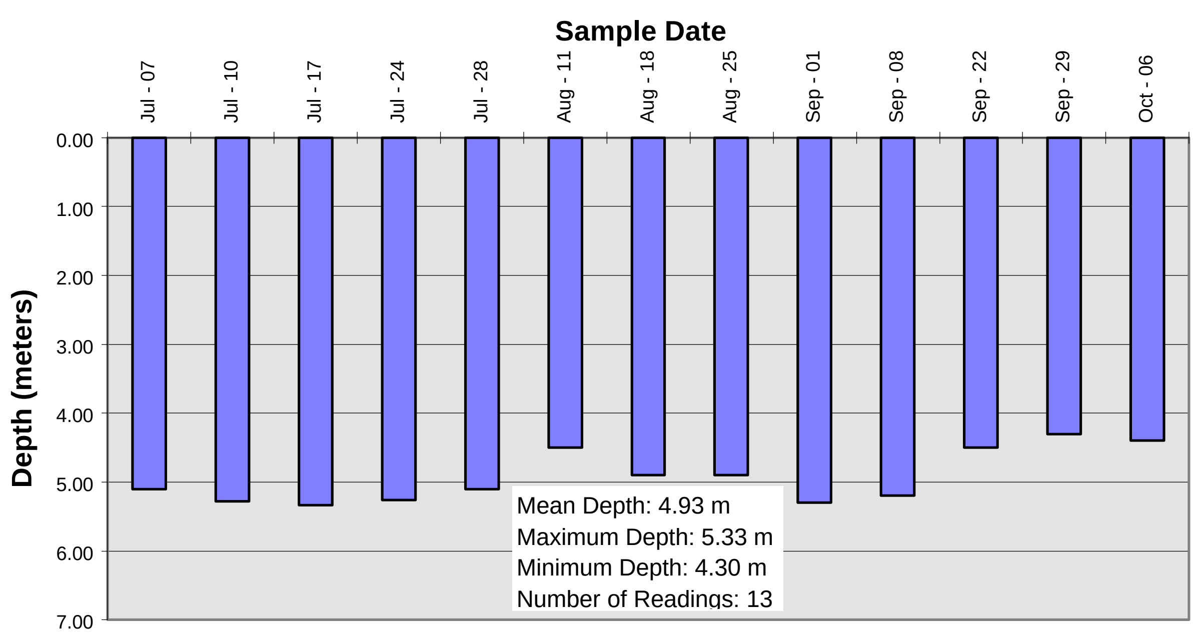


Figure 16. Summary data from 1996 Otter Lake Secchi disk readings. Data collected by Joanne Perrier and Scott Salter.

Date	Time	Weather	Water Conditions	Secchi (m)
Jul - 07	16:10	sun, windy		5.10
Jul - 10	15:40	sun, windy		5.28
Jul - 17	15:15	cloudy, rain		5.33
Jul - 24	15:20	sun, windy		5.26
Jul - 28	10:00	sunny	calm	5.10
Aug - 11	11:00	sunny	very windy	4.50
Aug - 18	10:45	partially cloudy	heavy ripples	4.90
Aug - 25	10:15	bright, overcast	calm	4.90
Sep - 01	10:15	sunny	calm	5.30
Sep - 08	10:20	partially cloudy	slight ripple	5.20
Sep - 22	10:20	sunny	calm	4.50
Sep - 29	10:30	cloudy	slight ripple	4.30
Oct - 06	10:00	partially cloudy	slight ripple	4.40

Statistics

Mean Depth:	**4.93**
Maximum Depth:	**5.33**
Minimum Depth:	**4.30**
Number of Readings:	**13**



Note: July 07 - July 24 readings were taken by Paul Desaulniers, the remainder by Dennis McCoy.

Figure 17. Summary data from 1996 Roe Lake Secchi disk readings. Data collected by Dennis McCoy.

Date	Time	Weather	Water Conditions	Secchi (m)
May - 15	10:55	sunny	wavy	10.25
May - 22	13:50	very dark clouds, wind	wavy	7.75
May - 29	10:45	overcast	very calm	11.40
Jun - 13	10:15	sunny, slight overcast	very calm	12.85
Jun - 19	11:30	cloudy, windy	wavy	11.25
Jun - 26	11:20	sunny	very wavy	9.90
Jul - 05	9:20	sunny	wavy	10.81
Jul - 24	11:15	sunny	wavy	8.30
Jul - 31	10:35	sunny	calm	8.90
Aug - 07	16:00	sunny	wavy	7.40
Aug - 14	19:00	sunny	calm	8.00
Aug - 23	14:30	sunny	slight wave	9.40
Sep - 01	10:50	sunny	calm	11.70
Sep - 08	11:00	sunny	calm	8.70
Sep - 20	16:00	sunny	calm	8.50
Sep - 27	12:00	sunny, slight overcast	calm	9.50
Oct - 04	14:30	sunny, slight overcast	calm	9.70
Oct - 11	10:00	sunny, slight overcast	calm	9.70
Oct - 19	11:00	sunny, slight overcast	calm	9.60

Statistics

Mean Depth:	**9.66**
Maximum Depth:	**12.85**
Minimum Depth:	**7.40**
Number of Readings:	**19**

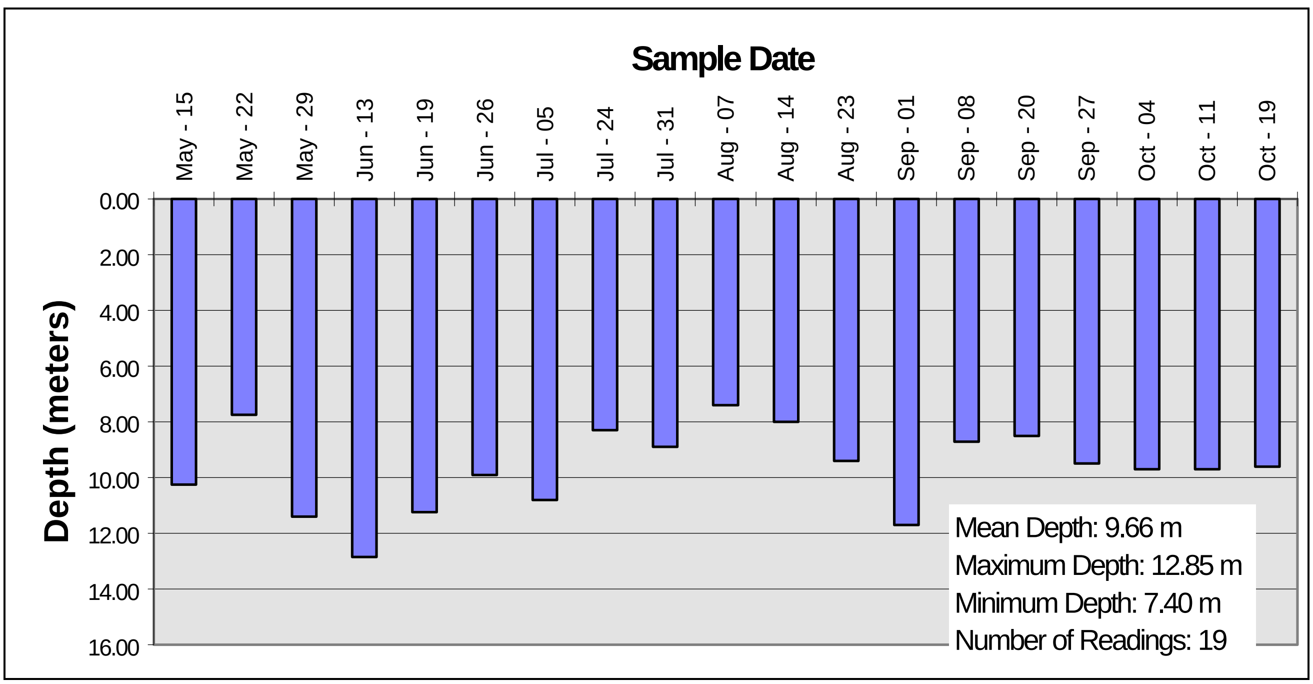


Figure 18. Summary data from 1996 Sheridan Lake Secchi disk readings. Data collected by Pat Silverton.

Date	Time	Weather	Water Conditions	Secchi (m)
May - 16	13:05	sunny with clouds	ripple	6.85
May - 23	12:30	cloudy	calm	7.50
May - 30	12:25	dark clouds, raining	ripple	5.45
Jun - 06	12:05	light overcast, heavy rain earlier in week	ripple	4.90
Jun - 12	13:20	hazy	calm	5.70
Jun - 19	13:40	sunny	slight ripple	6.90
Jun - 27	13:30	light overcast	calm	9.30
Jul - 04	13:45	sunny	waves	8.85
Jul - 11	13:40	sunny	calm	10.60
Jul - 18	12:45	sunny, windy	waves	9.05
Jul - 20	09:00	sunny	calm	11.20
Jul - 26	13:50	sunny	calm	10.95
Aug - 01	13:30	sunny	ripples	9.00
Aug - 08	12:55	sunny	ripples	9.05
Aug - 15	14:10	sunny	ripples	9.00
Aug - 22	13:45	sunny	ripples	8.85
Sep - 12	14:10	sunny	calm	8.85
Sep - 20	12:30	broken clouds	calm	9.40
Sep - 27	13:20	sunny	calm	8.75
Sep - 29	13:20	sunny	ripples	10.35
Oct - 01	13:30	sunny	perfectly calm	10.00
Oct - 04	14:00	sunny	ripples - waves	9.15
Oct - 11	12:30	sunny	calm	9.40
Oct - 17	09:20	clouds, breezy	ripples	8.75

Statistics

Mean Depth:	**8.66**
Maximum Depth:	**11.20**
Minimum Depth:	**4.90**
Number of Readings:	**24**

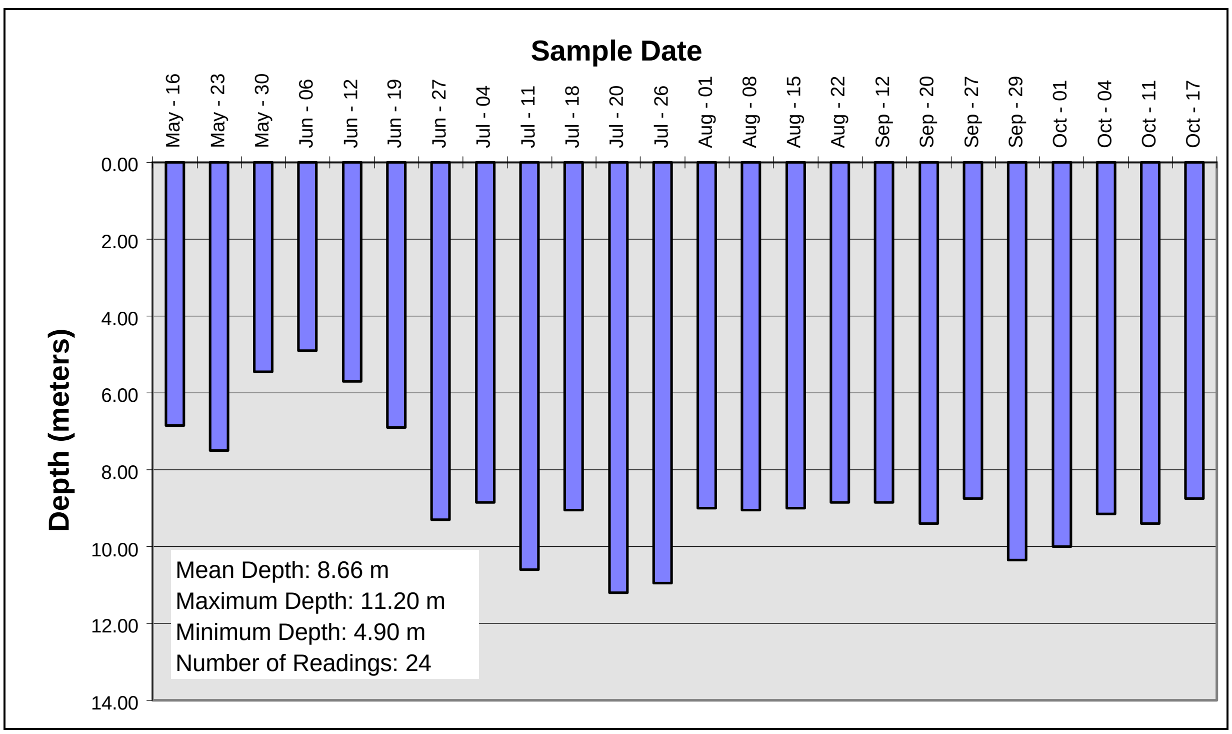


Figure 19. Summary data from 1996 Sulphurous Lake Secchi disk readings. Data collected by Neal and Cathy Sampson.

Date	Time	Weather	Water Conditions	Secchi (m)
Aug - 14	12:45	sunny	calm	1.62
Sep - 19	14:15	overcast, breezy	rippled	1.30
Sep - 27	15:30	sunny, breezy	rippled	1.70
Oct - 08	12:00	bright	calm	1.80

Statistics

Mean Depth:	**1.61**
Maximum Depth:	**1.80**
Minimum Depth:	**1.30**
Number of Readings:	**4**

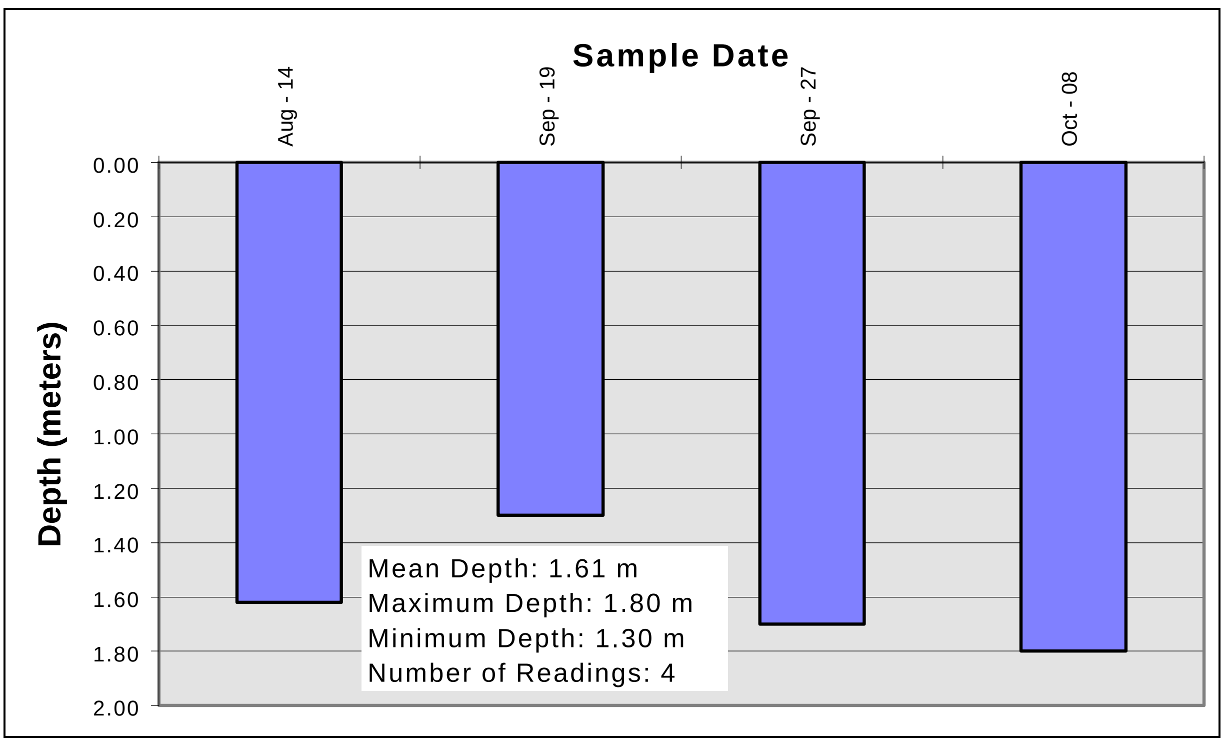


Figure 20. Summary data from 1996 Webb Lake Secchi disk readings. Data collected by Mel Grahn.

Date	Time	Weather	Water Conditions	Secchi (m)
Jul - 13	12:30	full sun, 15 km/hr wind	ripples	3.40
Jul - 21	12:15	full sun, 10 km/hr wind	ripples	3.00
Jul - 28	11:30	full sun, 10 km/hr wind	ripples	2.70
Aug - 03	13:30	partial overcast, 10 km/hr wind	ripples	2.30
Aug - 10	13:00	full sun, <5 km/hr wind	calm	2.60
Aug - 18	12:45	full sun, <5 km/hr wind	calm	1.30
Aug - 24	11:50	full sun, < 1km/hr wind	calm	1.50
Sep - 01	13:00	partly sunny, 5 km/hr wind	ripples	1.40
Sep - 08	12:30	partly sunny, <1 km/hr wind	calm	1.30
Sep - 15	13:10	overcast, drizzle, <1 km/hr wind	calm	1.30
Sep - 22	14:00	full sun, 15 km/hr wind	ripples	1.40
Sep - 29	13:05	overcast, 5 km/hr wind	ripples	1.20

Statistics

Mean Depth	**1.95**
Maximum Depth:	**3.40**
Minimum Depth:	**1.20**
Number of Readings:	**12**

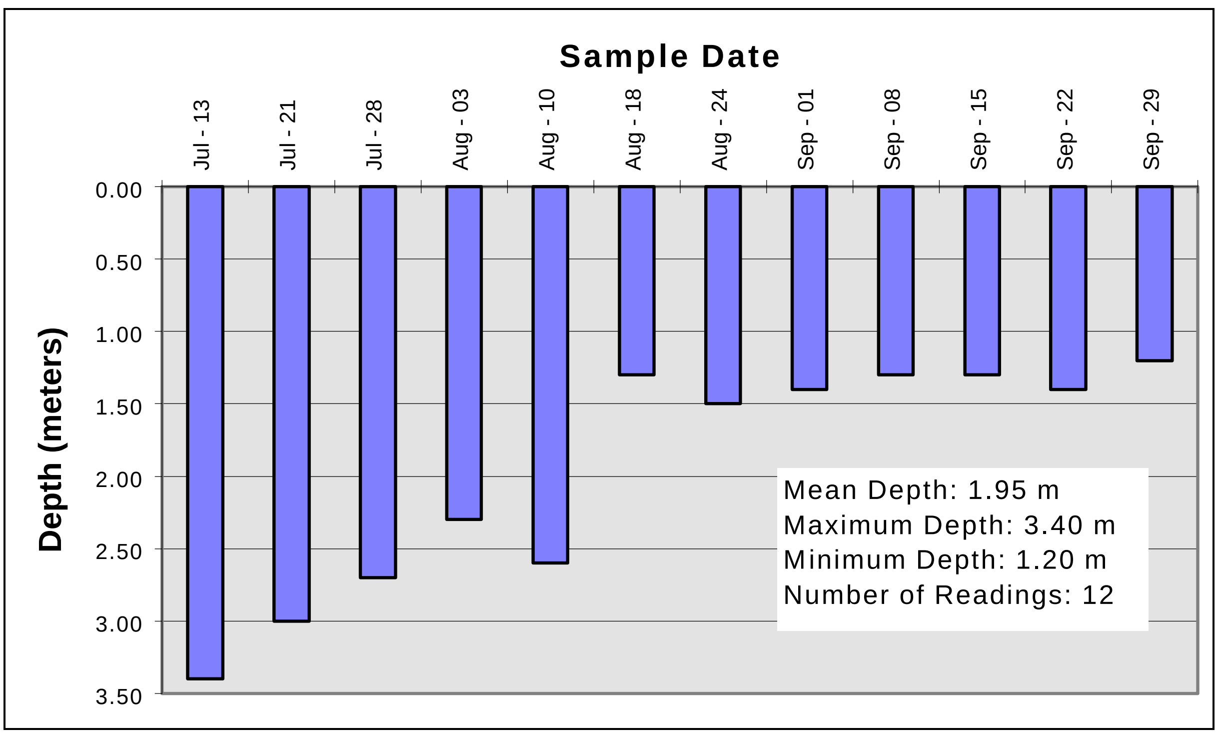


Figure 21. Summary data from 1996 West Twin Lake Secchi disk readings. Data collected by Morley Farwell.

Date	Time	Weather	Water Conditions	Secchi (m)
Jul - 21	13:30	standard conditions	standard conditions	3.04
Jul - 28	16:30	standard conditions	standard conditions	3.20
Sep - 10	13:00	standard conditions (clear sky)	standard conditions	1.80
Sep - 19	13:00	overcast, heavy rain-clouds		1.35
Sep - 24	13:00	sunny, clear sky		1.42
Oct - 03	13:00	overcast		1.32
Oct - 09	13:00	blue sky		1.15

Statistics

Mean Depth:	**1.90**
Maximum Depth:	**3.20**
Minimum Depth:	**1.15**
Number of Readings:	**7**

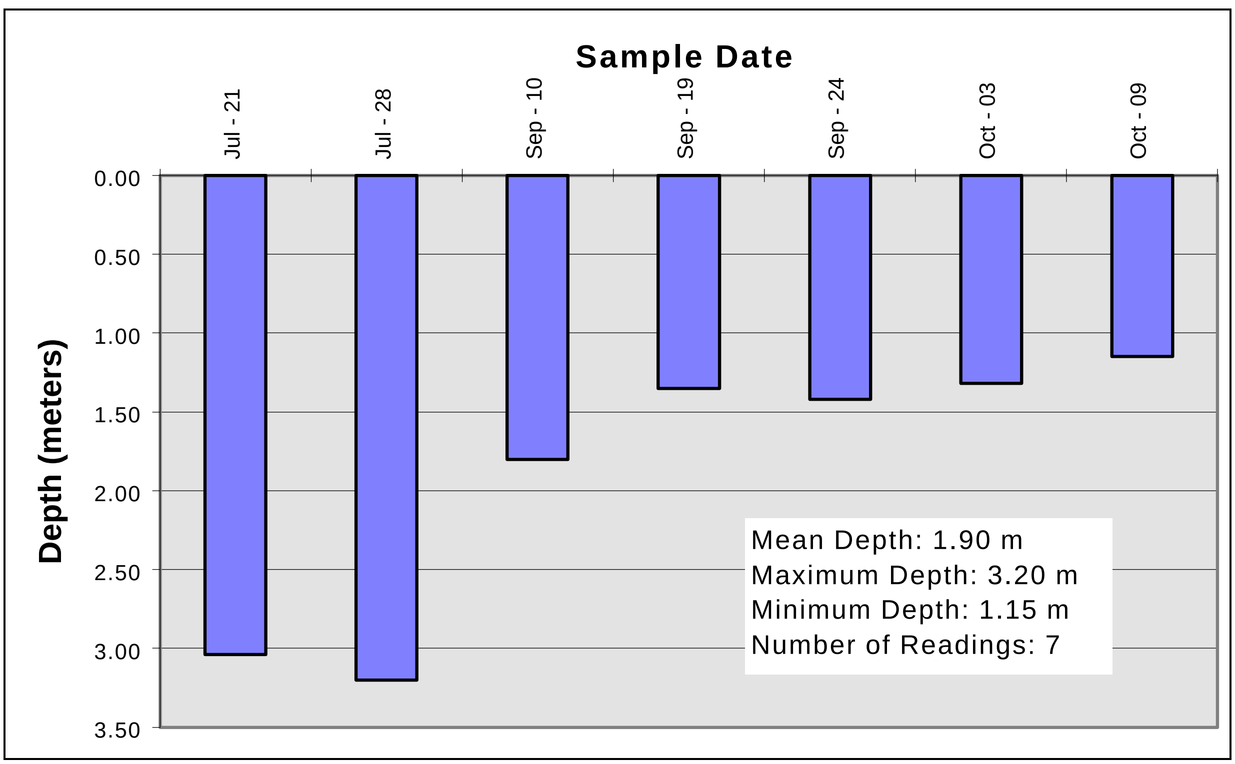


Figure 22. Summary data from 1996 Whitley Lake Secchi disk readings. Data collected by John and Nel Hanemaayer.

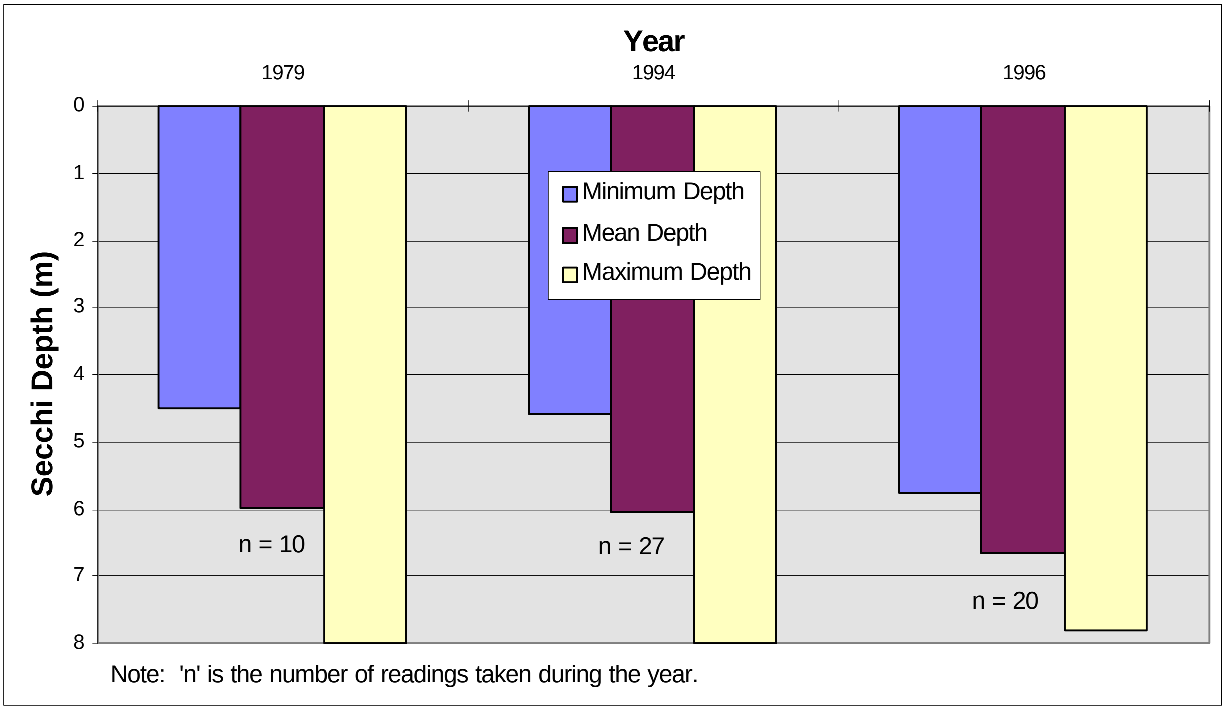


Figure 23. Summary of Secchi data collected from Horse Lake (1979, 1994 and 1996).

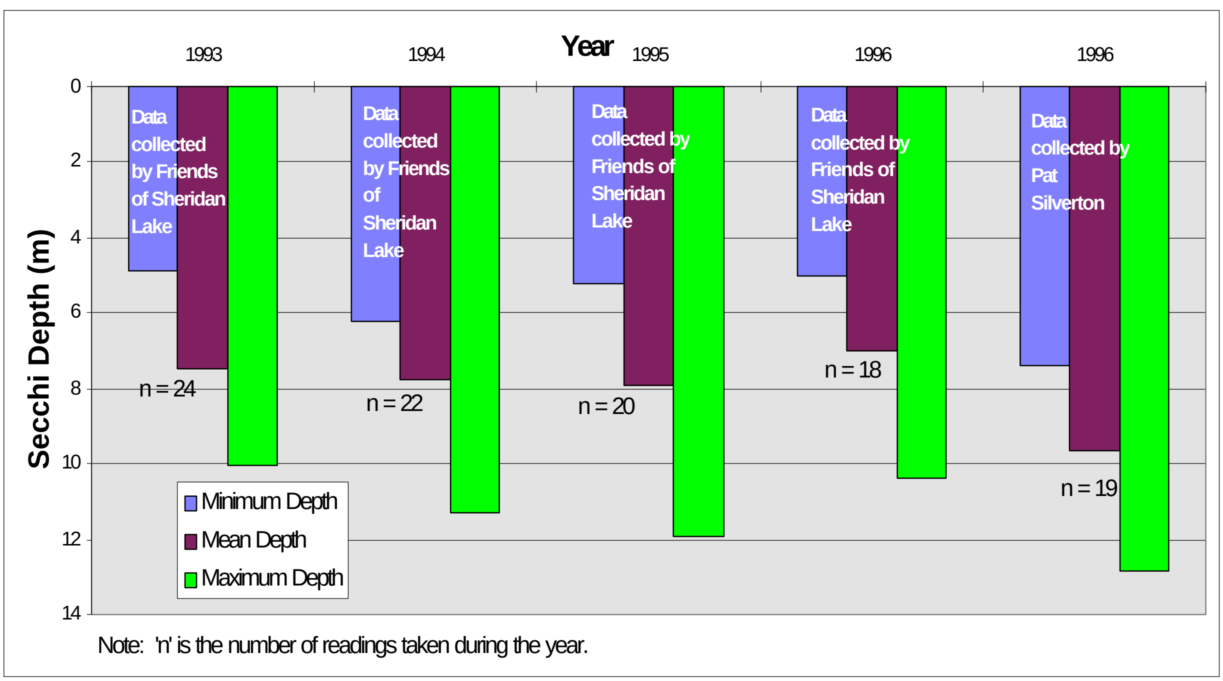


Figure 24. Summary of Secchi data collected from Sheridan Lake (1993 - 1996).

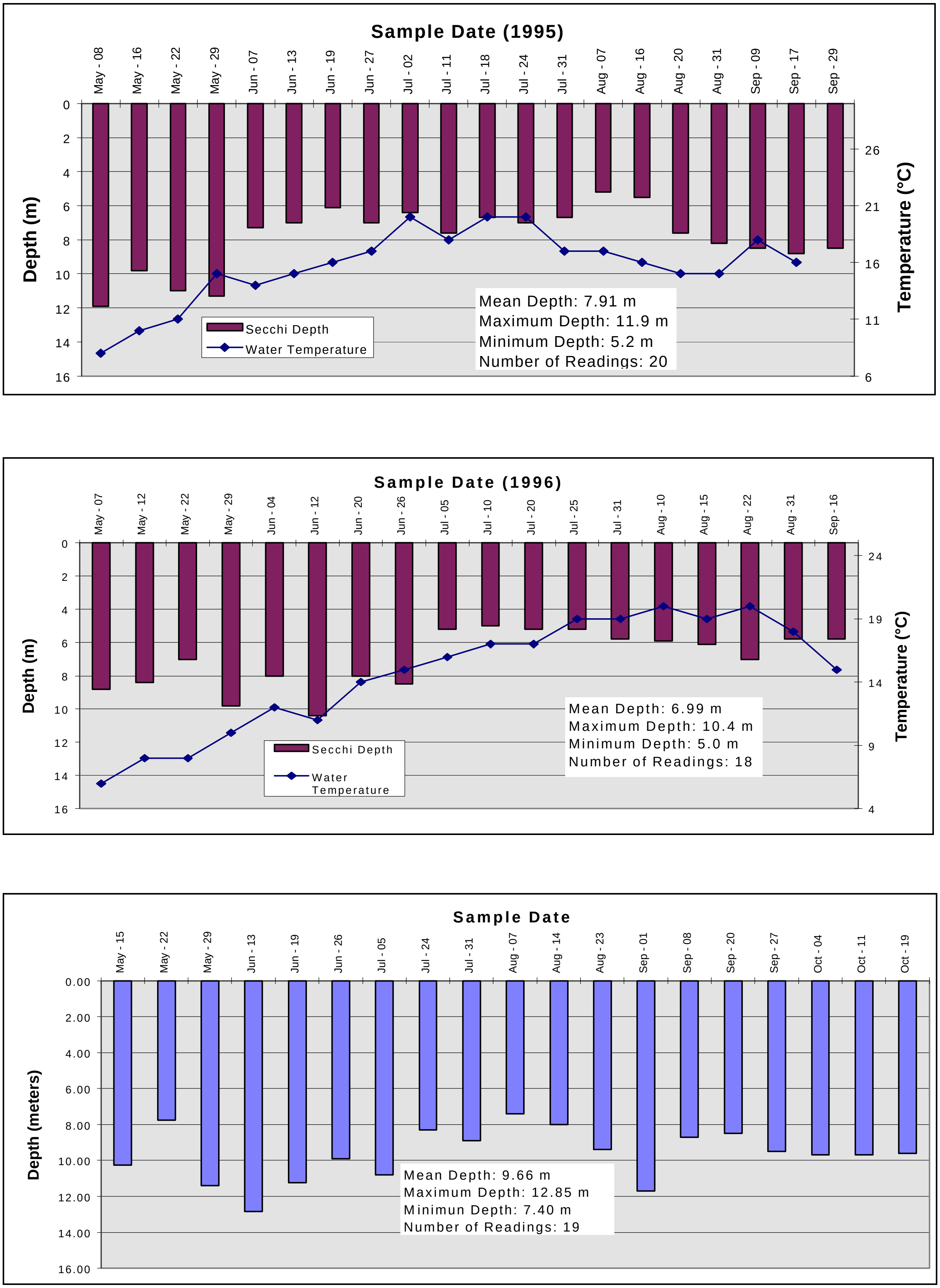


Figure 25. 1995, and 1996 Secchi data collected by Friends of Sheridan Lake (top two graphs) and 1996 Secchi data collected by Pat Silverton.

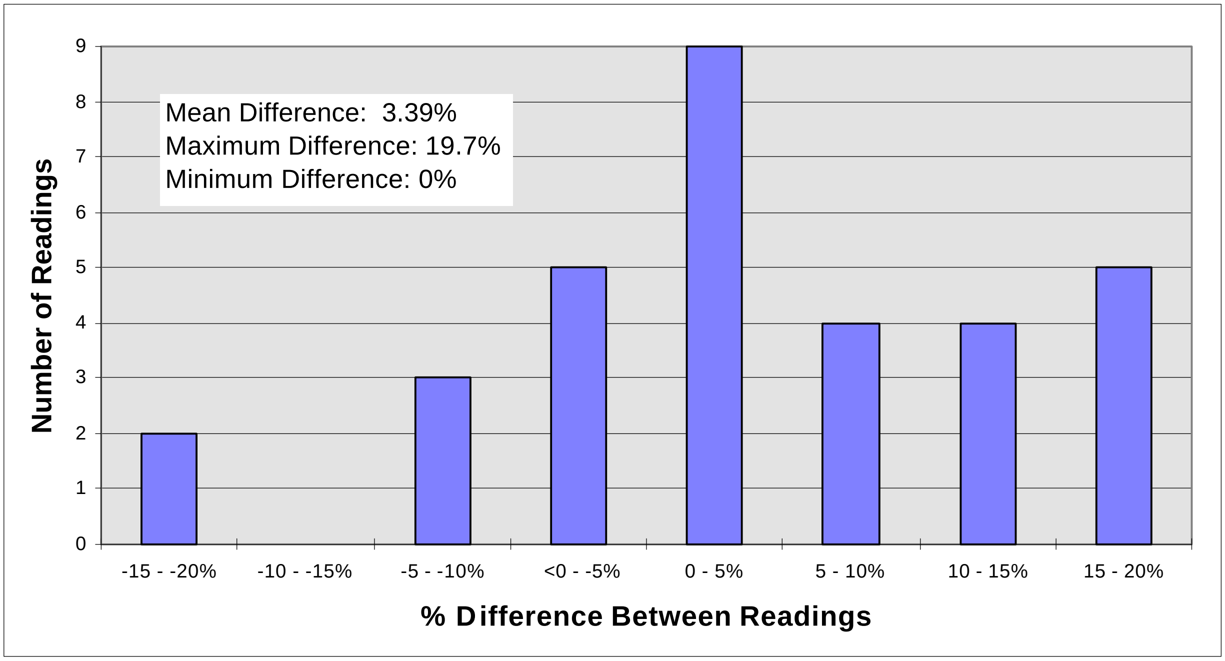
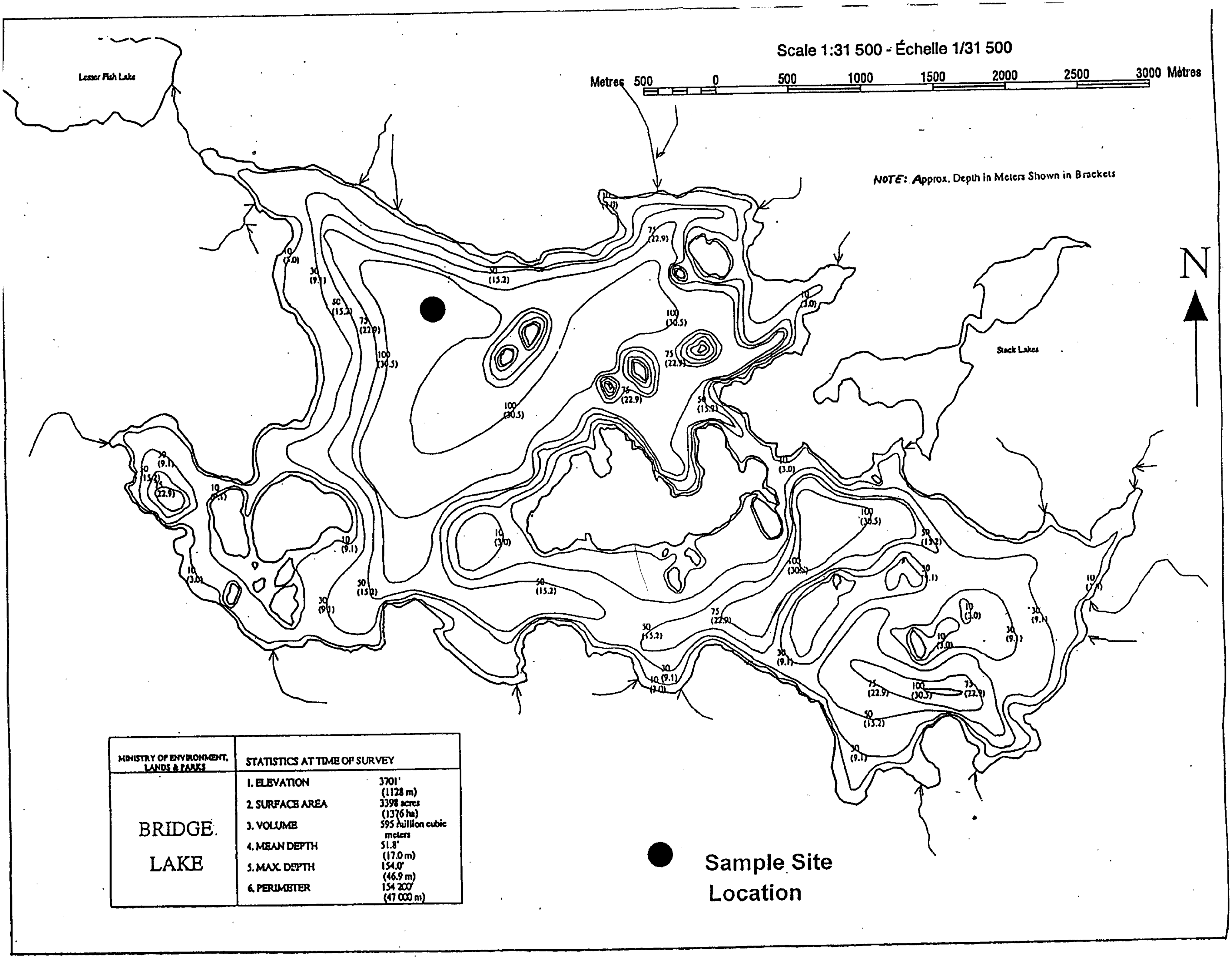


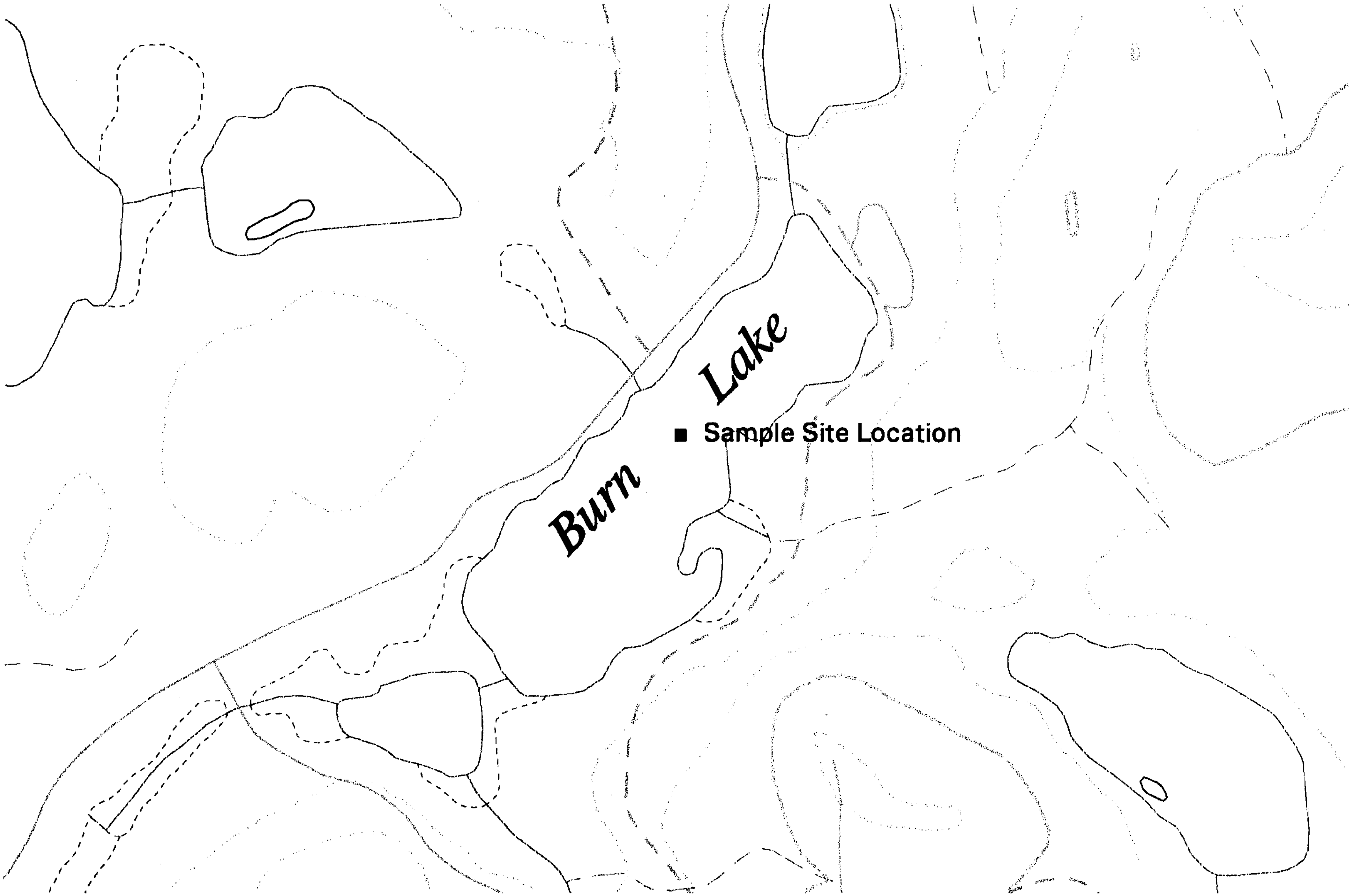
Figure 26. Frequency histogram of the percent difference between readings taken by MELP and the volunteers.

APPENDIX 1. Lake maps



MINISTRY OF ENVIRONMENT, LANDS & PARKS	STATISTICS AT TIME OF SURVEY	
BRIDGE LAKE	1. ELEVATION	3701' (1128 m)
	2. SURFACE AREA	3398 acres (1376 ha)
	3. VOLUME	595 million cubic meters
	4. MEAN DEPTH	51.8' (17.0 m)
	5. MAX. DEPTH	154.0' (46.9 m)
	6. PERIMETER	154 200' (47 000 m)

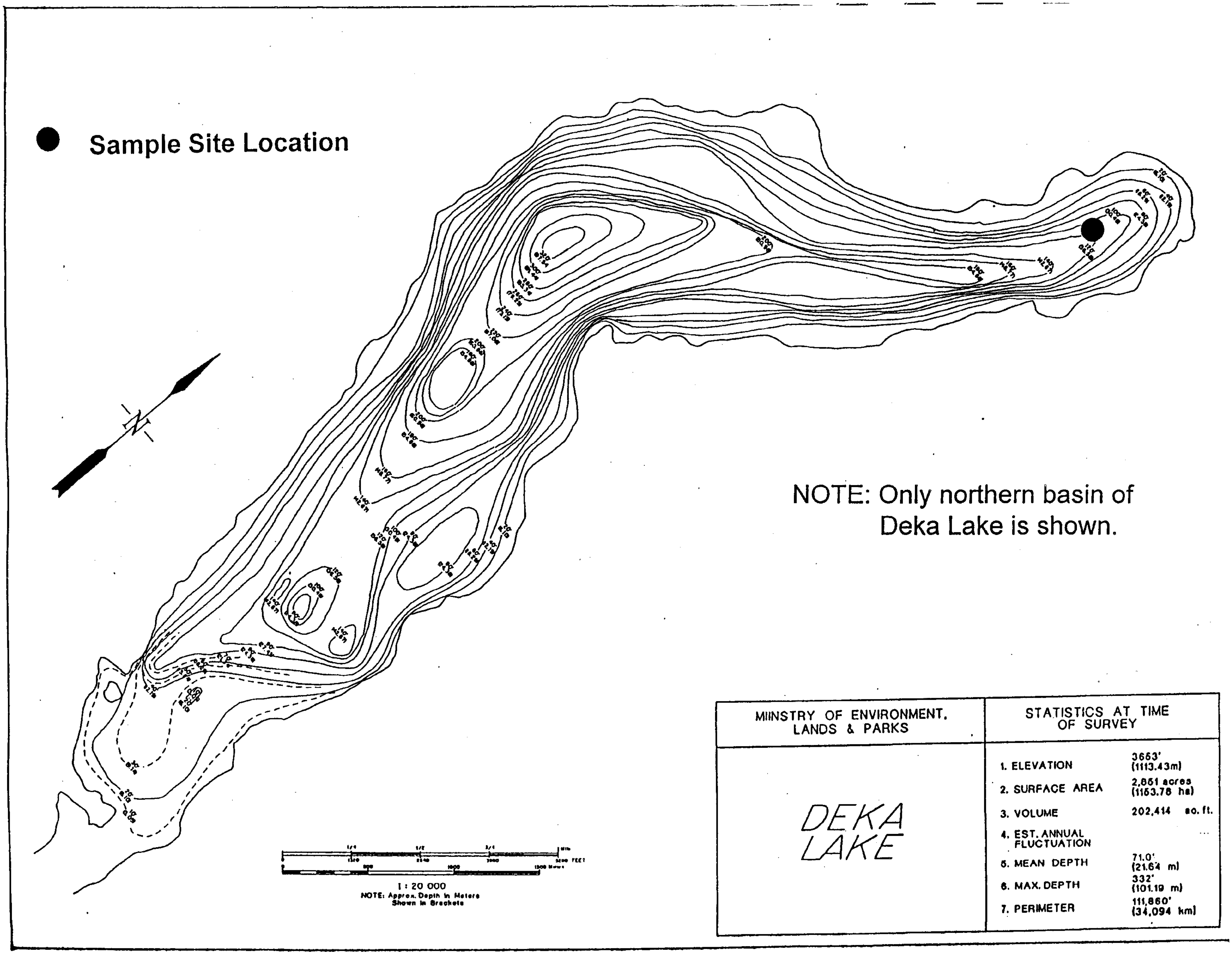
Burn Lake

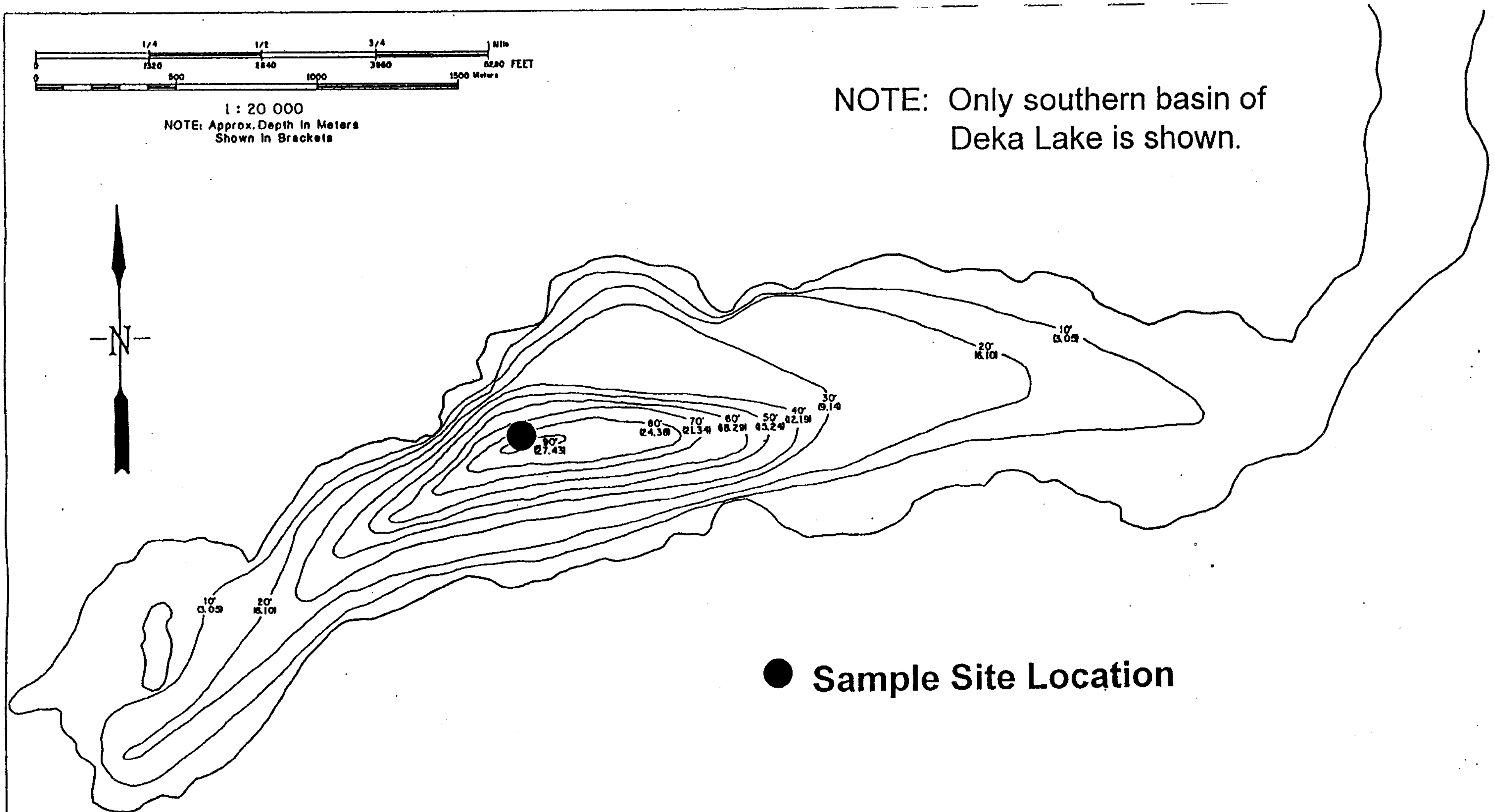


Ministry of Environment, Lands & Parks, November 1996

Scale 1:10 000 - Échelle 1/10 000

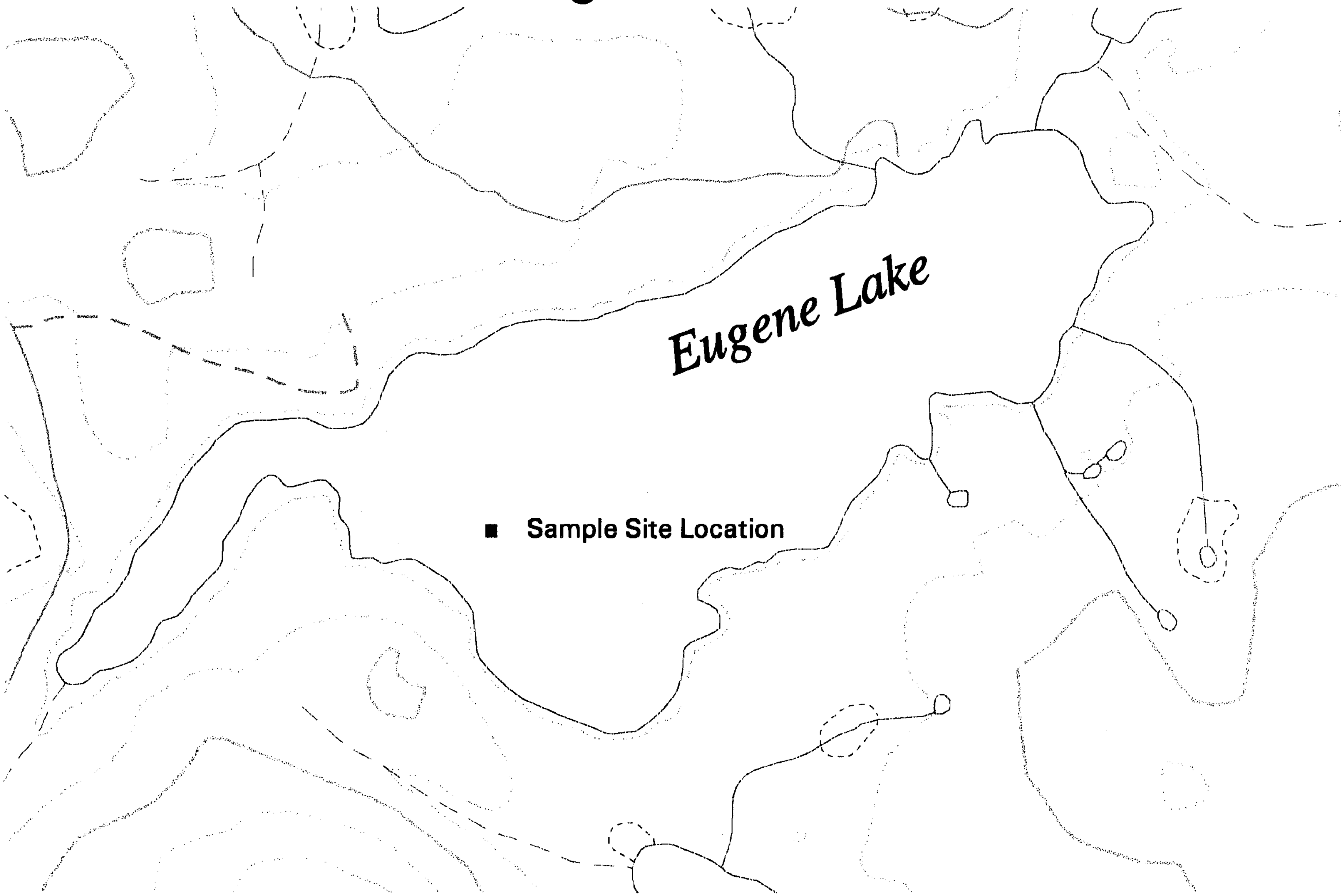
Metres 250 0 250 500 750 1000 Mètres


Sample Site Location
N
NOTE: Only northern basin of Deka Lake is shown.
1 : 20 000
NOTE: Approx. Depth in Meters Shown in Brackets
MIINSTRY OF ENVIRONMENT, LANDS & PARKS
DEKA LAKE
STATISTICS AT TIME OF SURVEY
1. ELEVATION 3653' (1113.43m)
2. SURFACE AREA 2,851 acres (1153.76 ha)
3. VOLUME 202,414 ac. ft.
4. EST. ANNUAL FLUCTUATION
5. MEAN DEPTH 71.0' (21.64 m)
6. MAX. DEPTH 332' (101.19 m)
7. PERIMETER 111,860' (34,094 km)



MIINSTRY OF ENVIRONMENT, LANDS & PARKS	STATISTICS AT TIME OF SURVEY	
DEKA LAKE	1. ELEVATION	3653' (1113.43m)
	2. SURFACE AREA	2,851 acres (1153.78 ha)
	3. VOLUME	202,414 ac. ft.
	4. EST. ANNUAL FLUCTUATION	
	5. MEAN DEPTH	71.0' (21.64 m)
	6. MAX. DEPTH	332' (101.19 m)
	7. PERIMETER	111,860' (34,094 km)

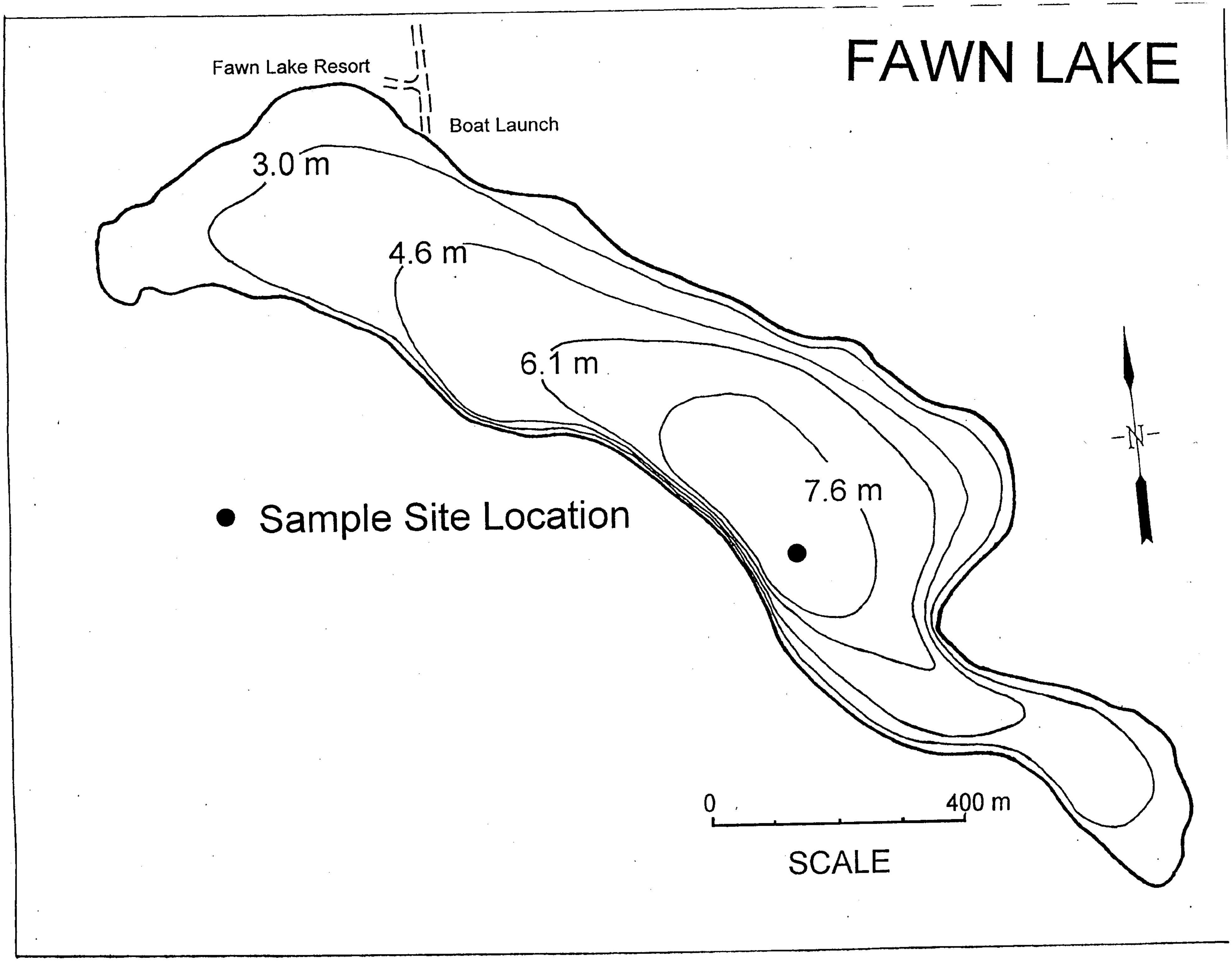
Eugene Lake



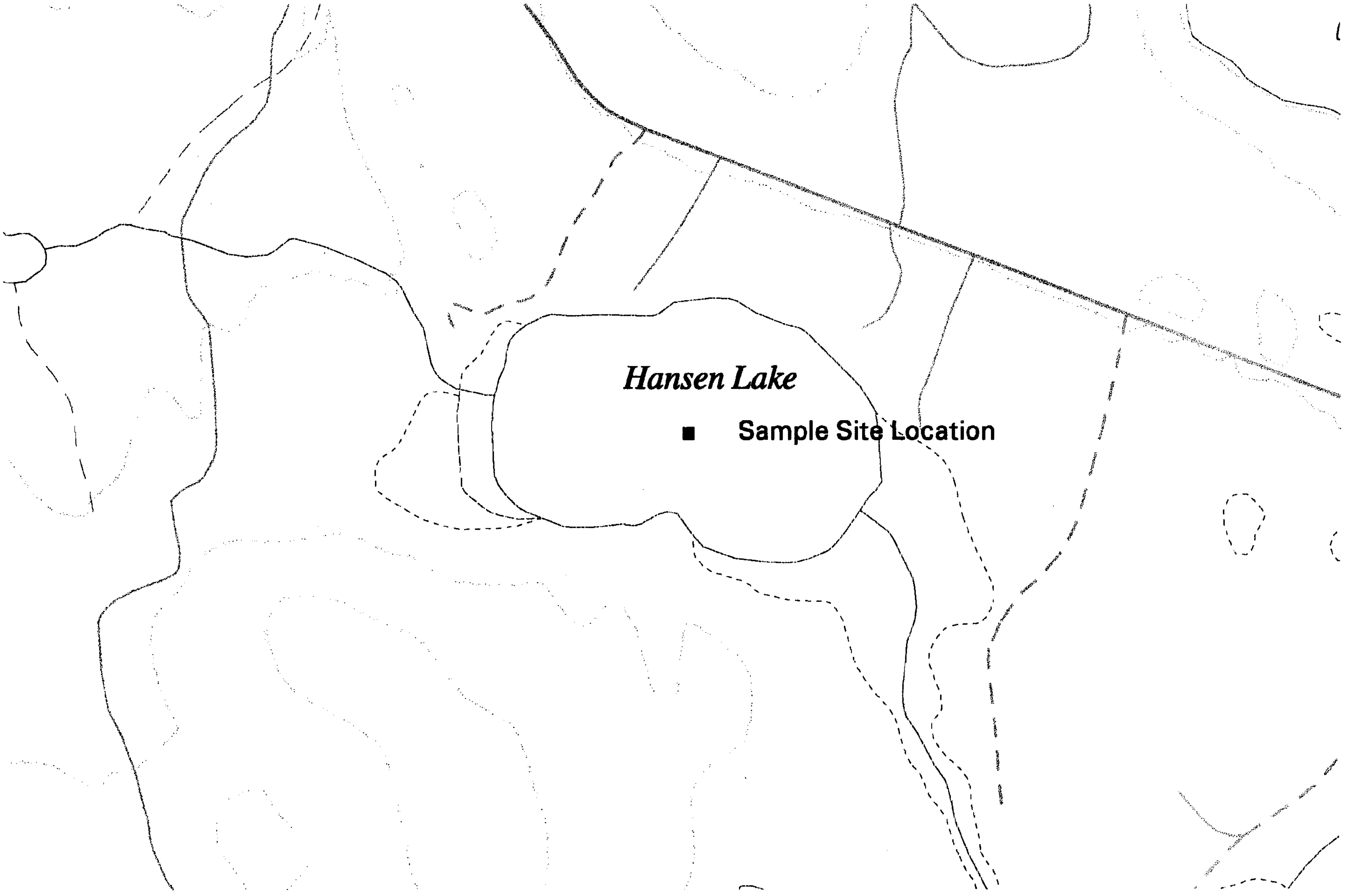
Ministry of Environment, Lands & Parks, November 1996

Scale 1:12 000 - Échelle 1/12 000

Metres 250 0 250 500 750 1000 Mètres


FAWN LAKE
Fawn Lake Resort
Boat Launch
3.0 m
4.6 m
6.1 m
7.6 m
Sample Site Location
N
0
400 m
SCALE

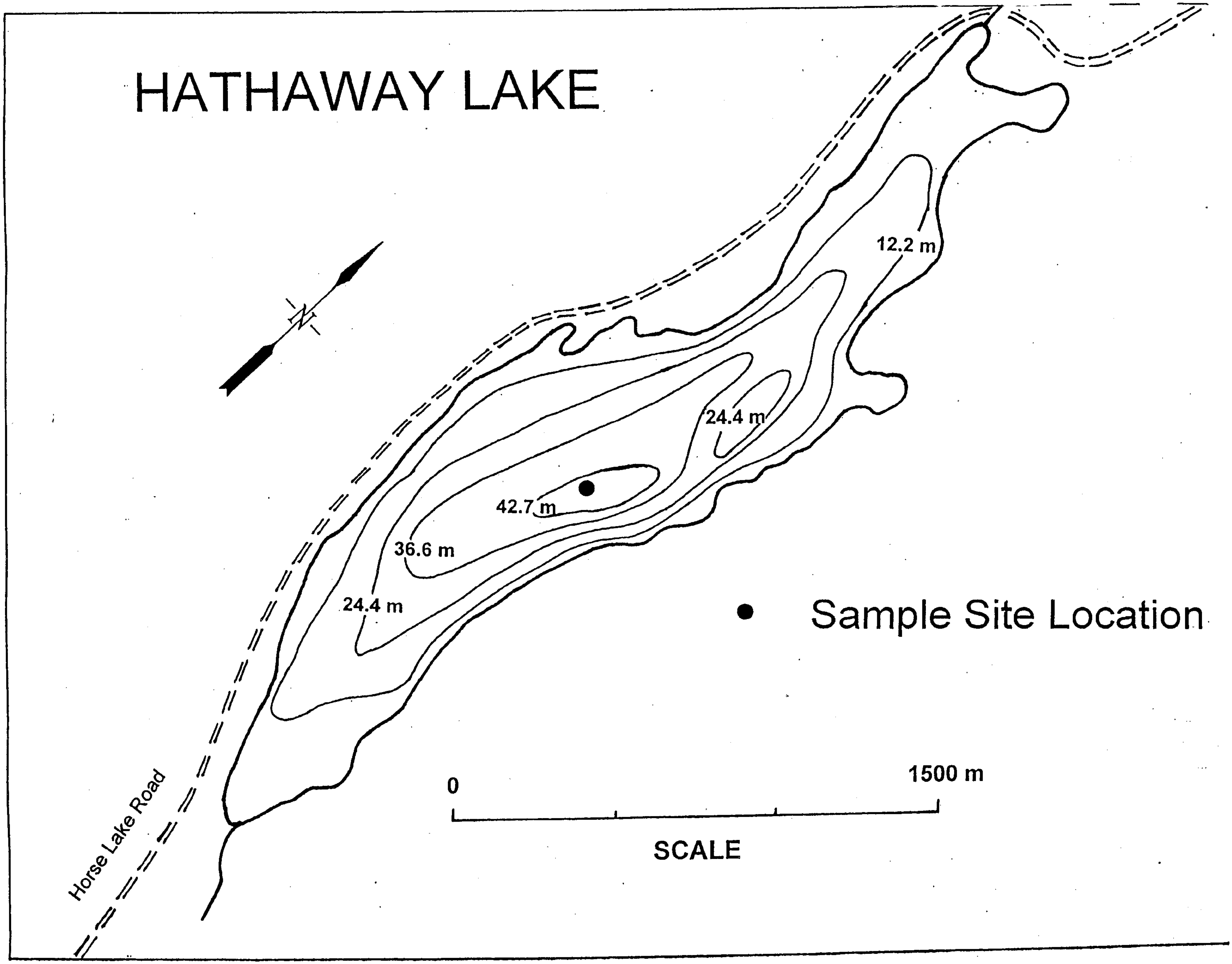
Hansen Lake



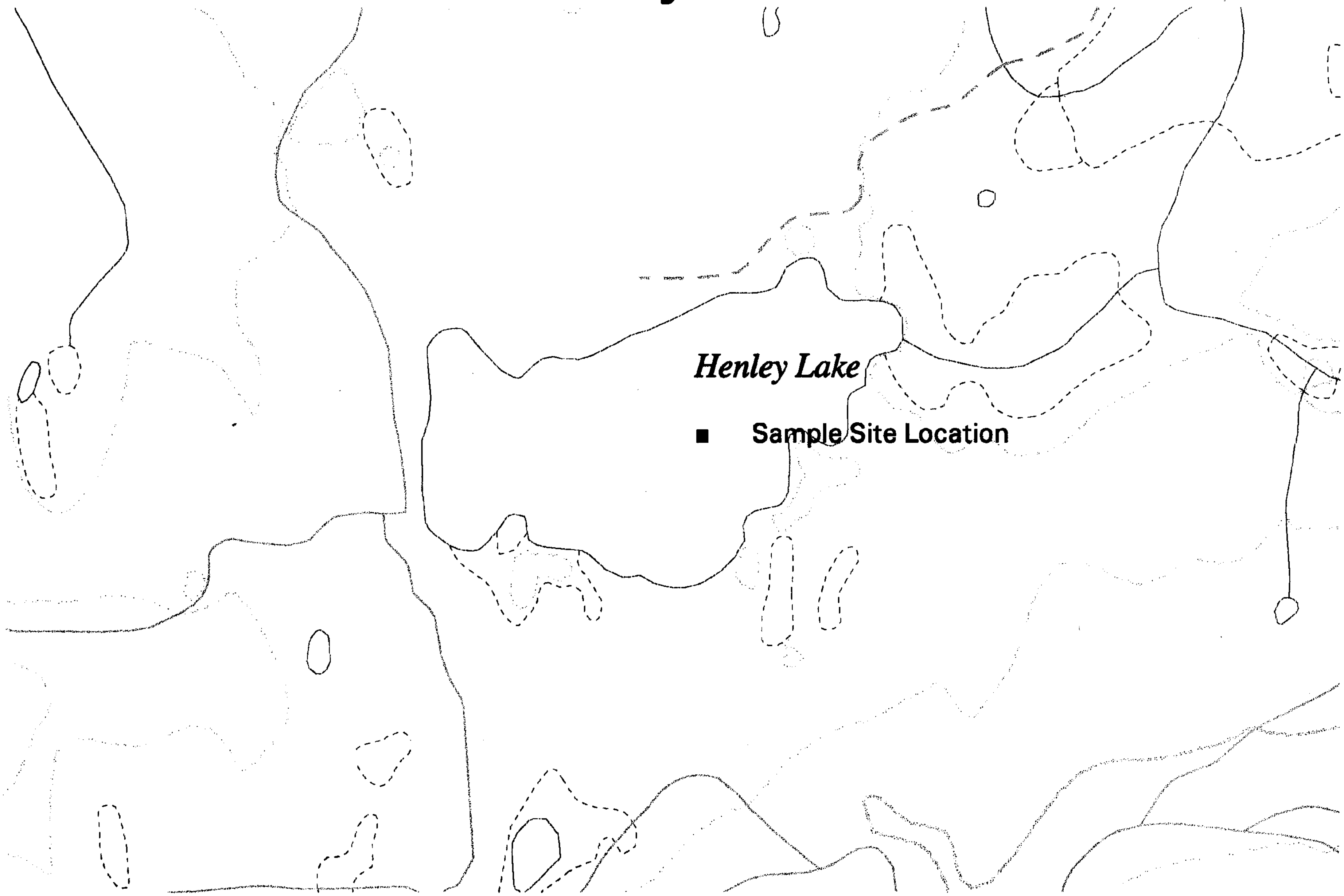
Ministry of Environment, Lands & Parks, November 1996

Scale 1:10 000 - Échelle 1/10 000

Metres 250 0 250 500 750 1000 Métres


HATHAWAY LAKE
N
12.2 m
24.4 m
42.7 m
36.6 m
24.4 m
Sample Site Location
0
1500 m
SCALE
Horse Lake Road

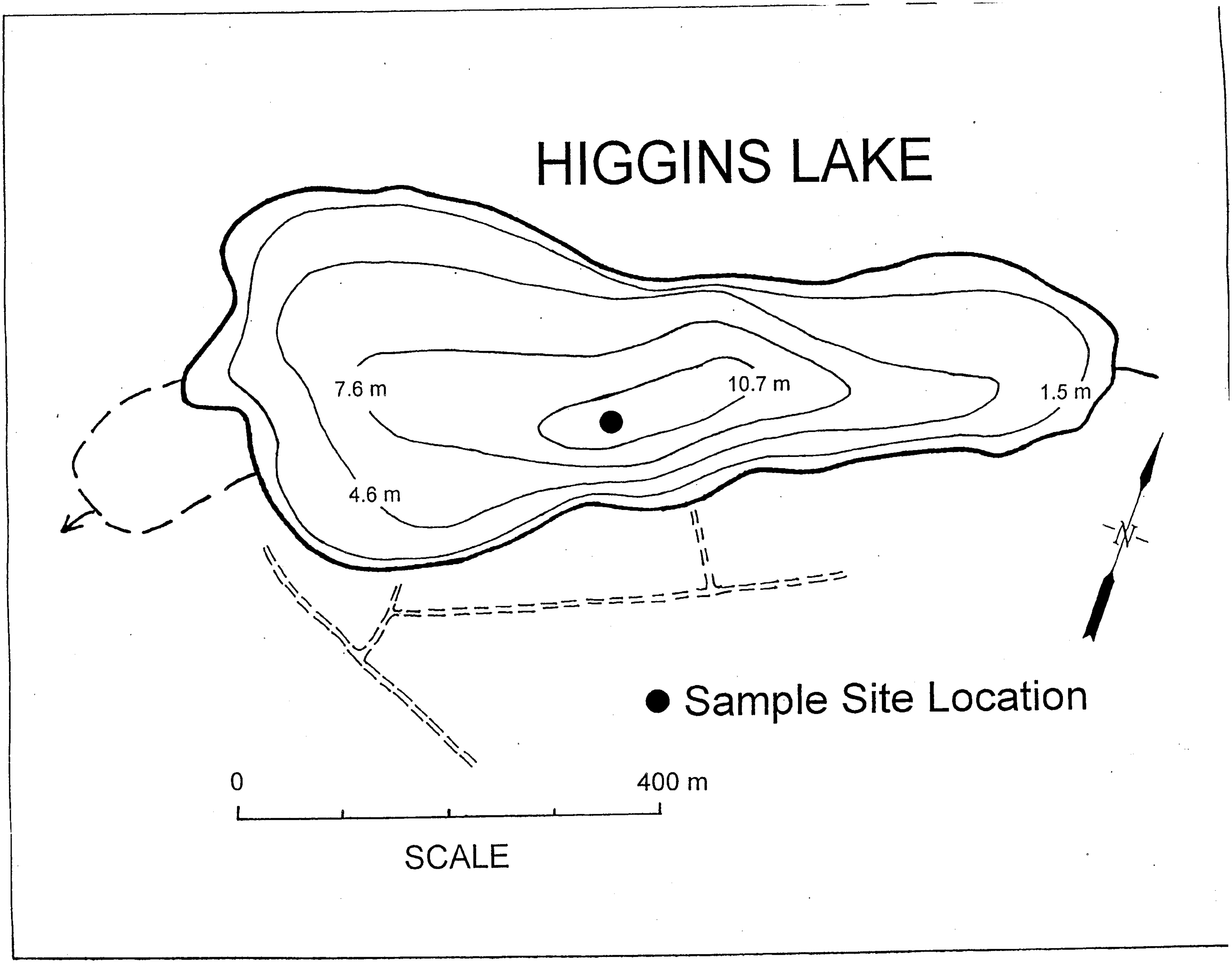
Henley Lake

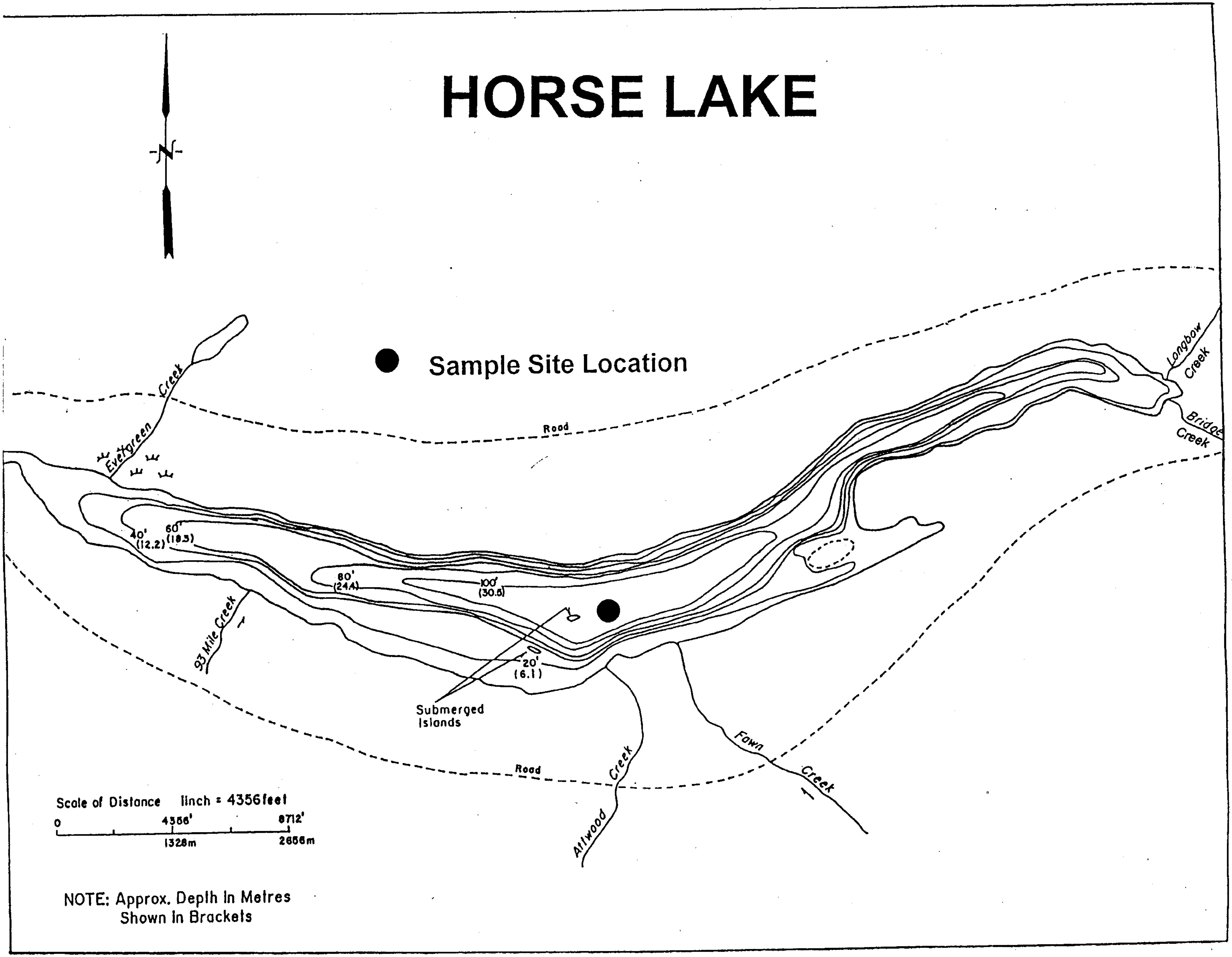


Ministry of Environment, Lands & Parks, November 1996

Scale 1:10 000 - Échelle 1/10 000

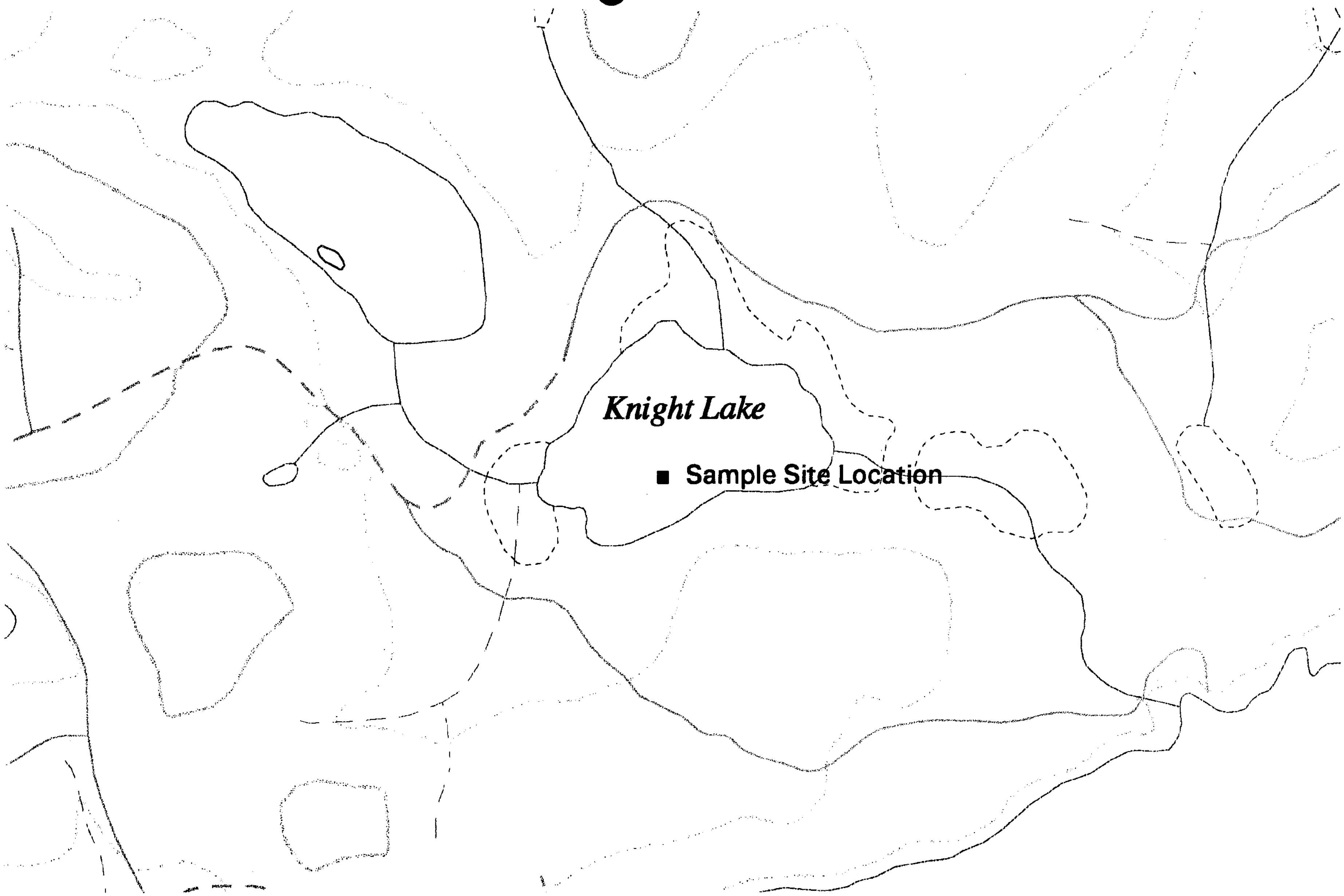
Metres 250 0 250 500 750 1000 Mètres


HIGGINS LAKE
7.6 m
10.7 m
1.5 m
4.6 m
Sample Site Location
0
400 m
SCALE



HORSE LAKE
N
Sample Site Location
Road
Road
Evergreen Creek
Longbow Creek
Bridge Creek
93 Mile Creek
Attwood Creek
Fawn Creek
40' (12.2)
60' (18.3)
80' (24.4)
100' (30.5)
20' (6.1)
Submerged Islands
Scale of Distance 1inch = 4356feet
0
4356'
8712'
1328m
2656m
NOTE: Approx. Depth In Metres Shown In Brackets

Knight Lake

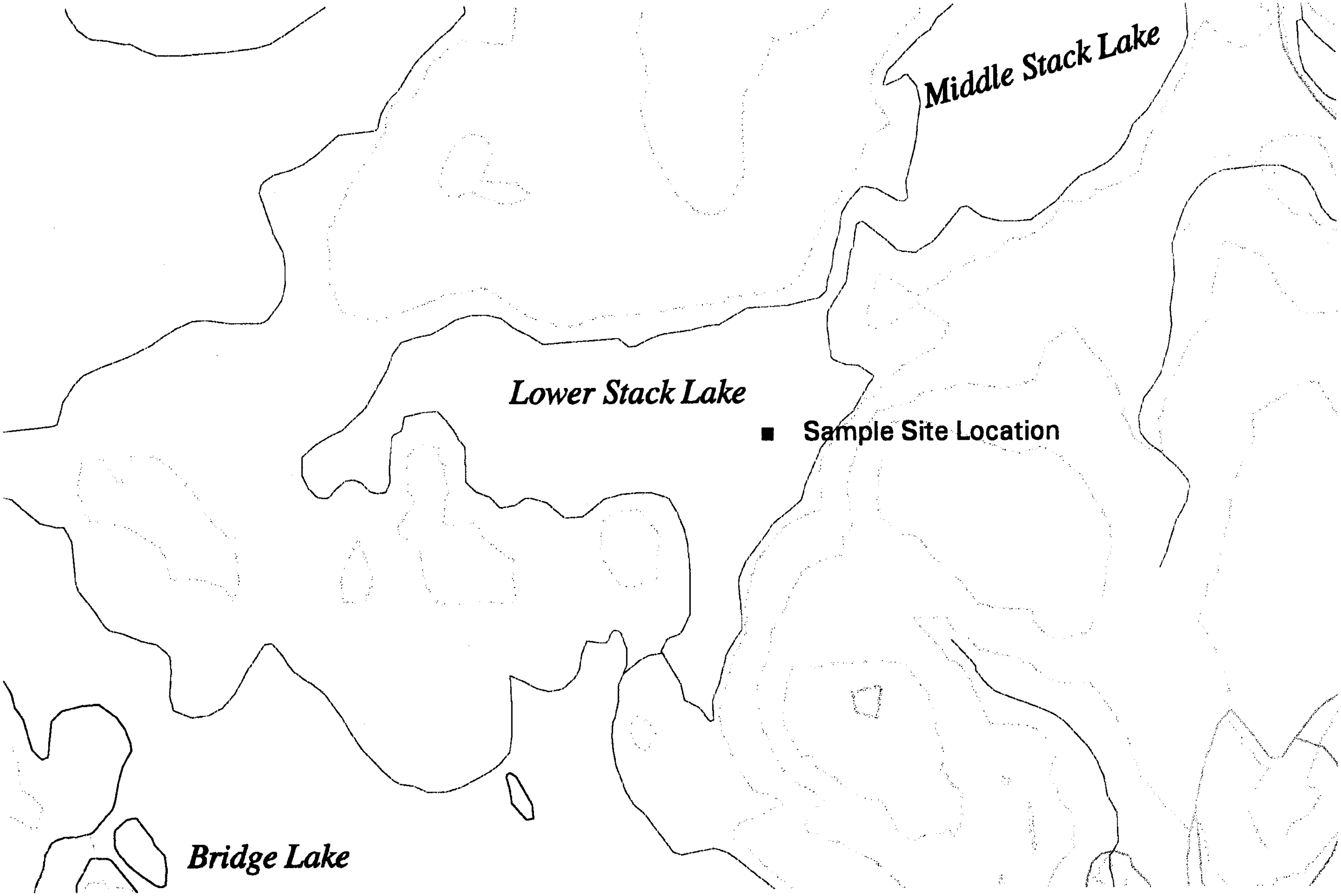


Ministry of Environment, Lands & Parks, November 1996

Scale 1:10 000 - Échelle 1/10 000

Metres 250 0 250 500 750 1000 Métres

Lower Stack Lake

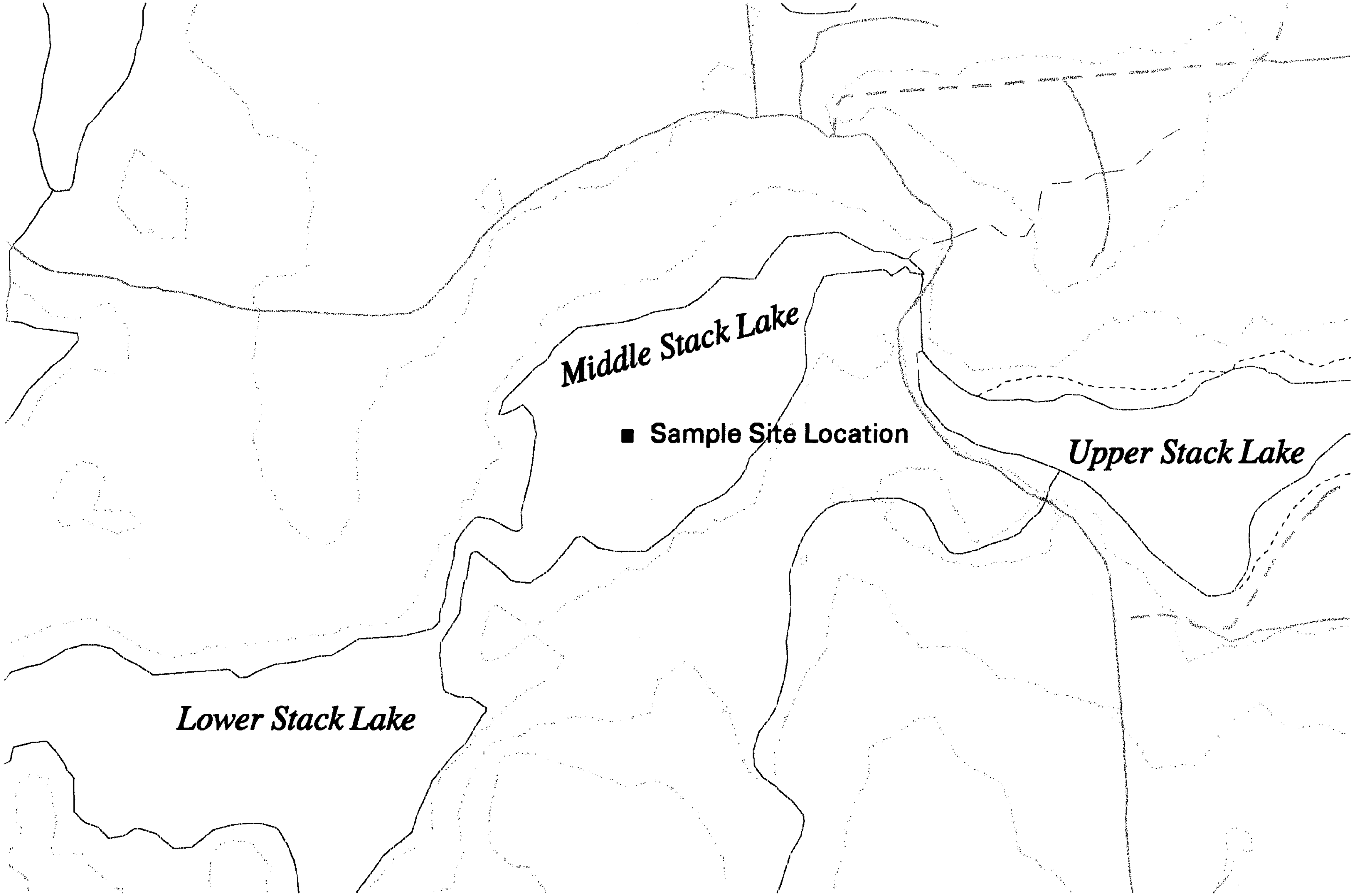


Ministry of Environment, Lands & Parks, November 1996

Scale 1:10 000 - Échelle 1/10 000

Metres 250 0 250 500 750 1000 Mètres

Middle Stack Lake

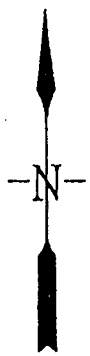


Ministry of Environment, Lands & Parks, November 1996

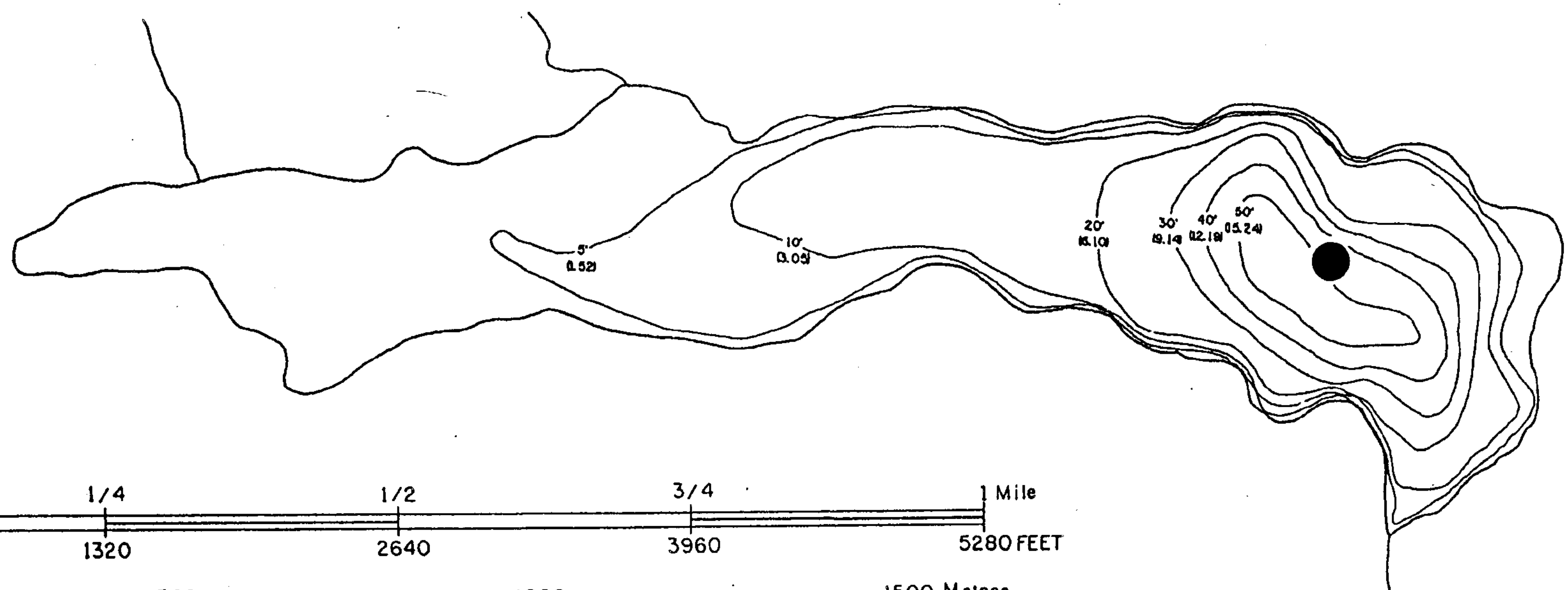
Scale 1:10 000 - Échelle 1/10 000

Metres 250 0 250 500 750 1000 Mètres

MIINSTRY OF ENVIRONMENT, LANDS & PARKS	STATISTICS AT TIME OF SURVEY	
OTTER LAKE	1. ELEVATION	3800' (1158.24 m)
	2. SURFACE AREA	131.4 acres (53.18 ha)
	3. VOLUME	1,848 ac. ft.
	4. EST. ANNUAL FLUCTUATION	
	5. MEAN DEPTH	14.1' (4.30 m)
	6. MAX. DEPTH	64' (16.46 m)
	7. PERIMETER	16,500' (5.029 km)



● **Sample Site Location**



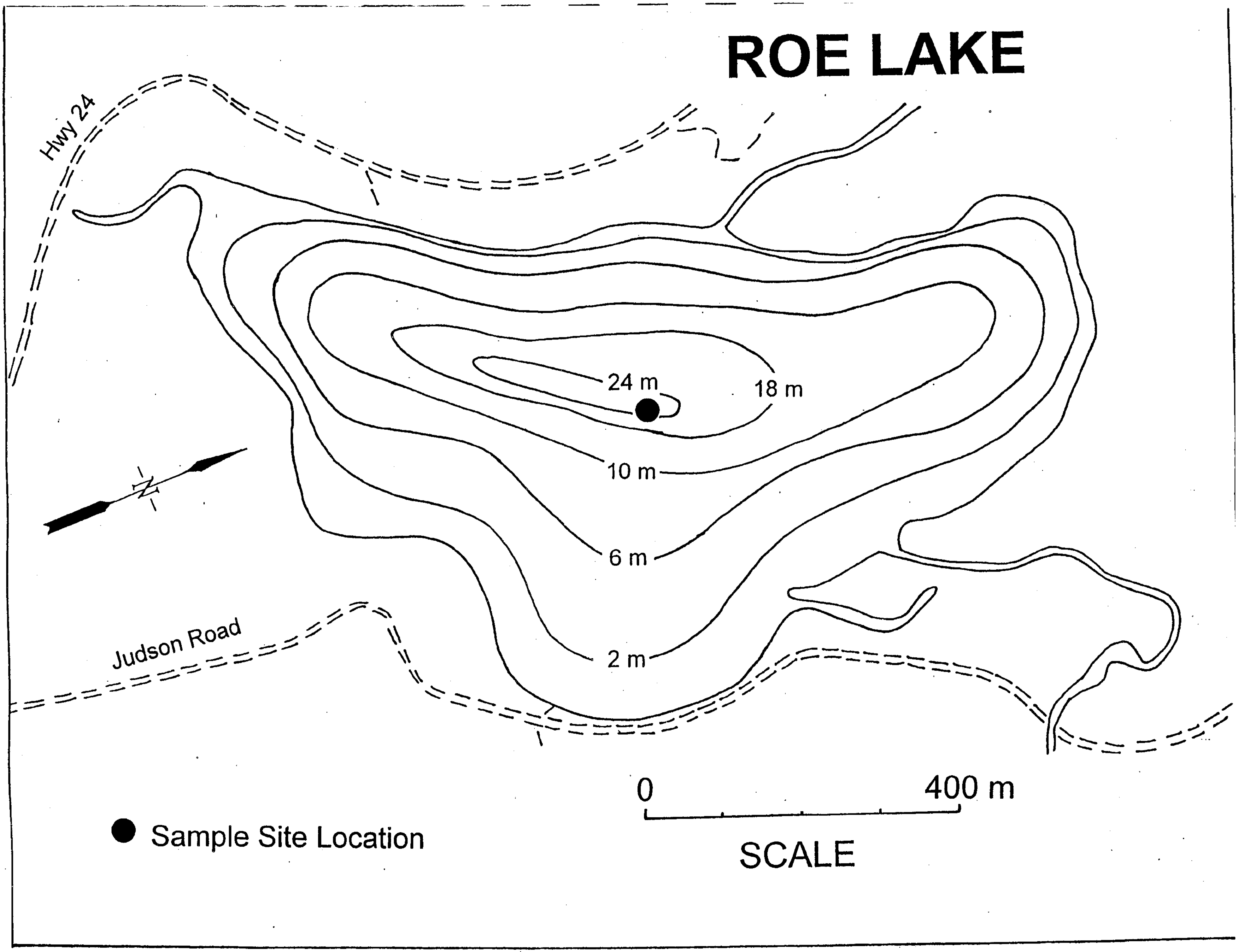
1/4 1/2 3/4 1 Mile

0 1320 2640 3960 5280 FEET

0 500 1000 1500 Metres

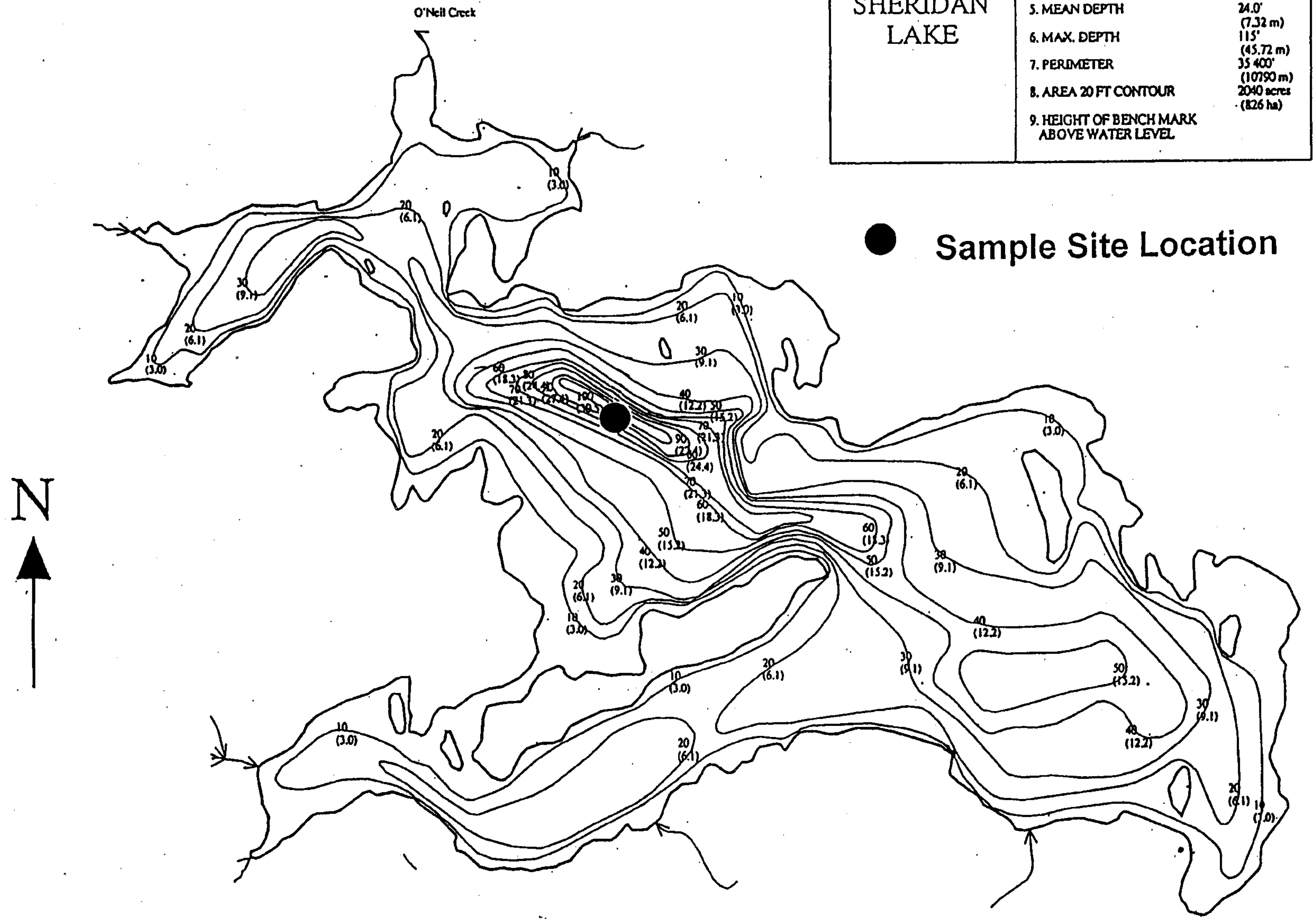
1 : 10 000

NOTE: Approx. Depth In Meters Shown In Brackets


ROE LAKE
Hwy 24
24 m
18 m
10 m
6 m
2 m
Judson Road
0
400 m
SCALE
Sample Site Location

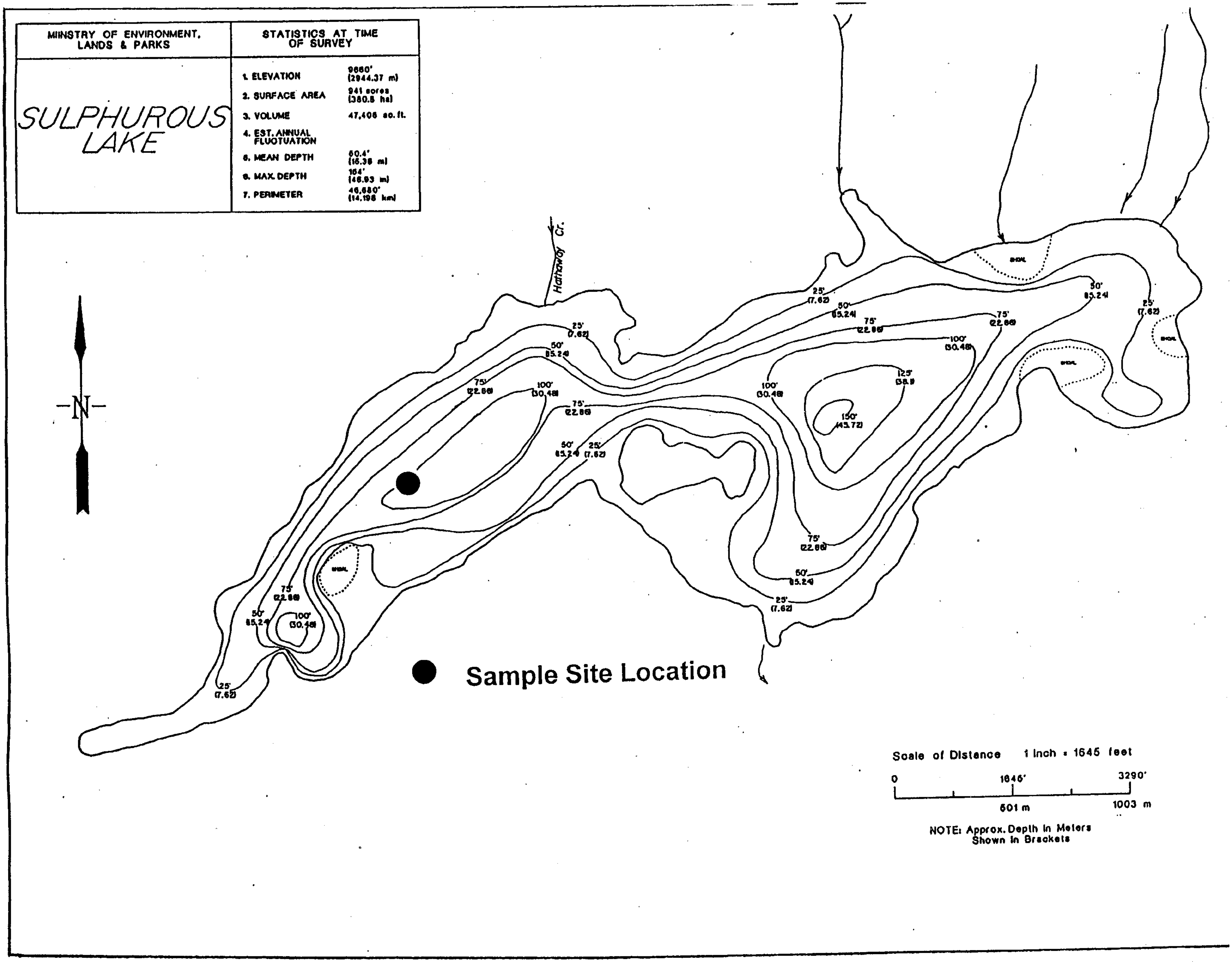
MINISTRY OF ENVIRONMENT, LANDS & PARKS	STATISTICS AT TIME OF SURVEY	
SHERIDAN LAKE	1. ELEVATION	3659' (1115 m)
	2. SURFACE AREA	4100 acres (1659 ha)
	3. VOLUME	98 280 ac.ft.
	4. EST. ANNUAL FLUCTUATION	
	5. MEAN DEPTH	24.0' (7.32 m)
	6. MAX. DEPTH	115' (45.72 m)
	7. PERIMETER	35 400' (10790 m)
	8. AREA 20 FT CONTOUR	2040 acres (826 ha)
	9. HEIGHT OF BENCH MARK ABOVE WATER LEVEL	

● Sample Site Location



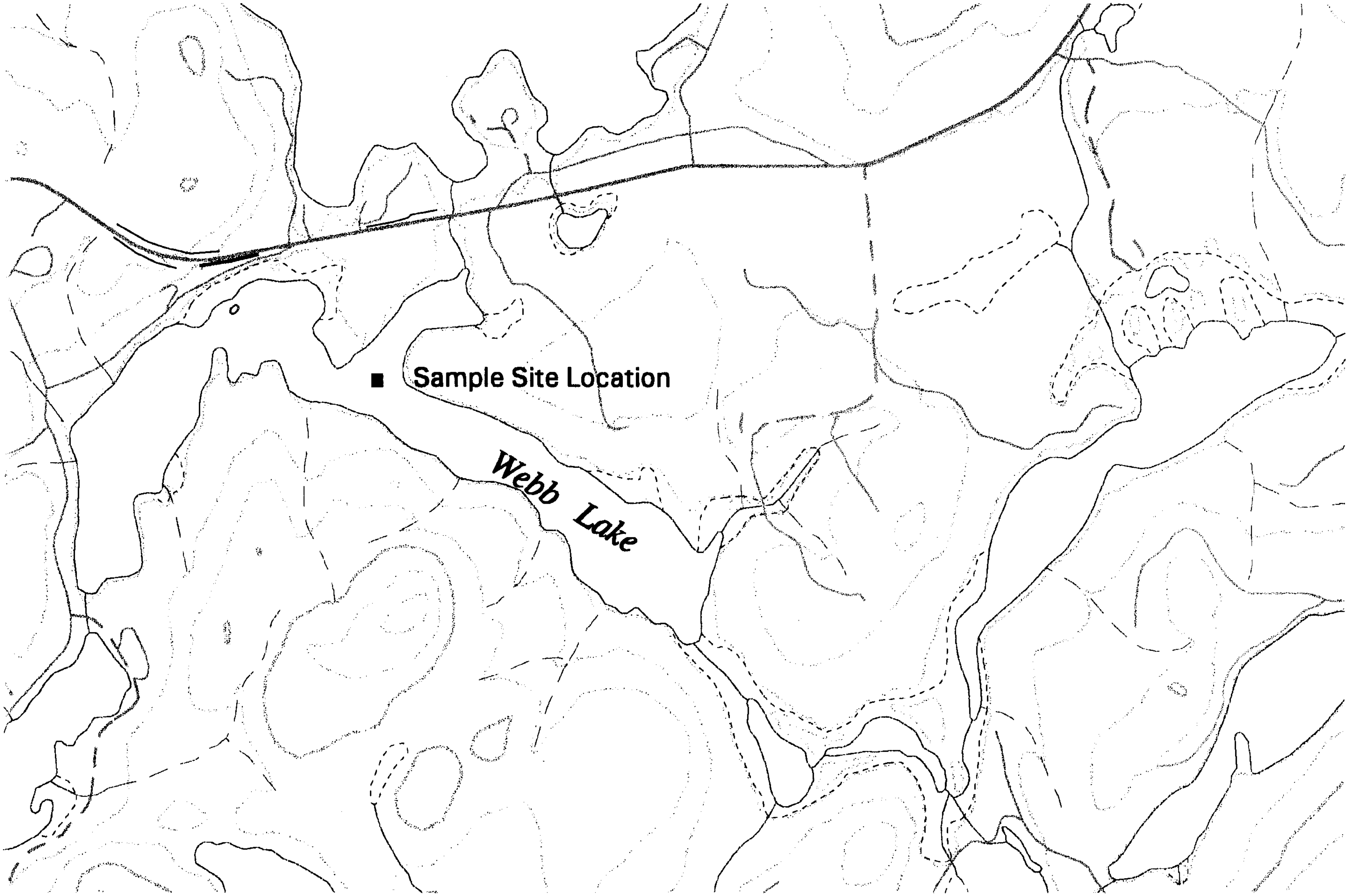
Scale 1:40 000 - Échelle 1/40 000

Kilometres 1 0 1 2 3 4 Kilomètres



MIINSTRY OF ENVIRONMENT, LANDS & PARKS
SULPHUROUS LAKE
STATISTICS AT TIME OF SURVEY
1. ELEVATION 9660' (2944.37 m)
2. SURFACE AREA 941 acres (380.8 ha)
3. VOLUME 47,406 ac. ft.
4. EST. ANNUAL FLUCTUATION
5. MEAN DEPTH 50.4' (15.36 m)
6. MAX. DEPTH 154' (46.93 m)
7. PERIMETER 46,580' (14.198 km)
N
Hathaway Cr.
25' (7.62)
50' (15.24)
75' (22.86)
100' (30.48)
125' (38.1)
150' (45.72)
Sample Site Location
Scale of Distance 1 inch = 1645 feet
0 1645' 3290'
501 m 1003 m
NOTE: Approx. Depth in Meters Shown in Brackets

Webb Lake

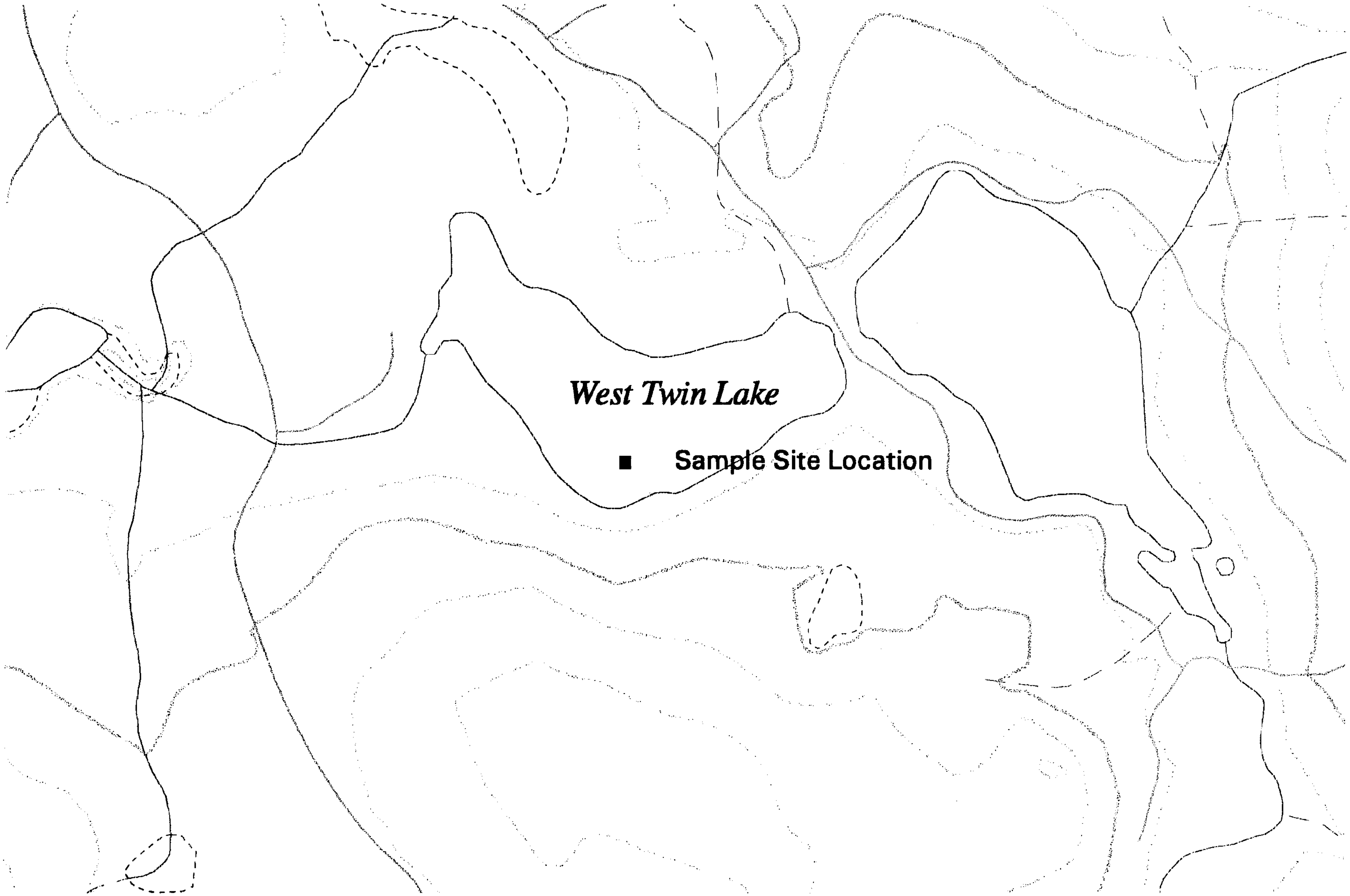


Ministry of Environment, Lands & Parks, November 1996

Scale 1:20 000 - Échelle 1/20 000

Metres 500 0 500 1000 1500 2000 Mètres

West Twin Lake

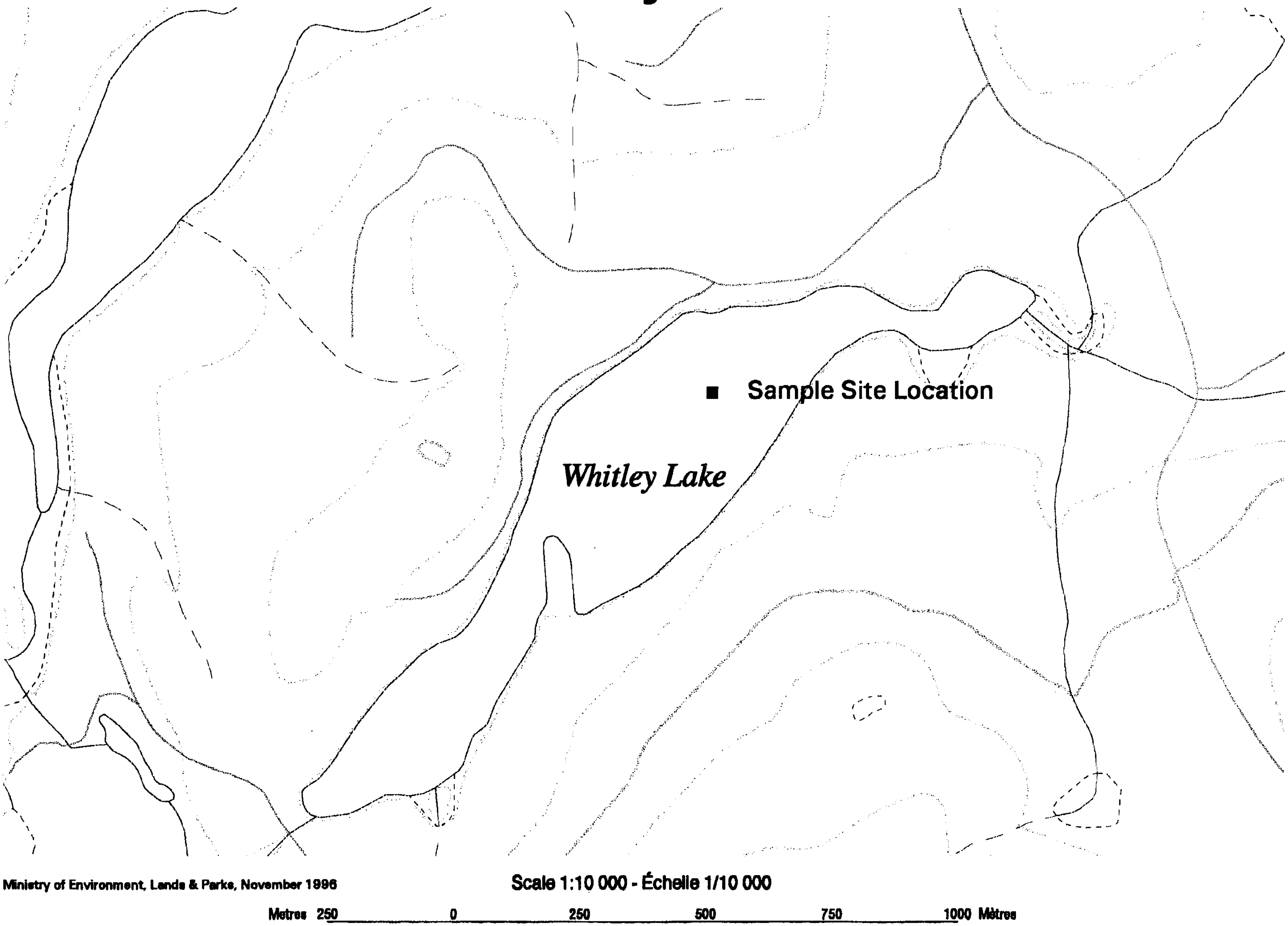


Ministry of Environment, Lands & Parks, November 1996

Scale 1:10 000 - Échelle 1/10 000

Metres 250 0 250 500 750 1000 Mètres

Whitley Lake



Ministry of Environment, Lands & Parks, November 1996

APPENDIX 2 - 1996 and proposed 1997 Secchi disk field forms

1996 Bridge Creek Basin Volunteer Lake Monitoring Program

SECCHI DISK READINGS

General Instructions

Lower the disk into the water and note depth at which it disappears, then lift it until it reappears again noting the depth. Record the average of these two readings.

Take readings to nearest 0.10 meters.

Standard conditions for the use of the Secchi disk are as follows:
Clear sky; sun directly overhead(between 10:00 a.m. and 2:00 p.m.); shaded, protected side of boat; under a sunshade; minimal waves or ripples. Sampling should be made as close to the same time and day as possible, each week, weather/water conditions permitting. Any departure from these conditions should be noted below.

Readings should be taken weekly.

Station:
Lake Name:___________________________________
Sampling Site Location Description:____
Sampler name(s): ____________________________________

Date (YYMMDD)	Time (24 hour clock)	Secchi Depth (meters)	Conditions (water surface, sunny, windy etc)

1997 Bridge Creek Basin Volunteer Lake Monitoring Program

SECCHI DISK READINGS

General Instructions

Lower the disk into the water and note depth at which it disappears, then lift it until it reappears again noting the depth. Record the average of these two readings.

Take readings to nearest 0.01 meters.

Standard conditions for the use of the Secchi disk are as follows:
Clear sky; sun directly overhead(between 10:00 a.m. and 2:00 p.m.); shaded, protected side of boat; under a sunshade; minimal waves or ripples. Sampling should be made as close to the same time and day as possible, each week, weather/water conditions permitting. Any departure from these conditions should be noted below.

Readings should be taken weekly. Sampling should begin one week after "ice-off" and end on Oct. 15.

Station:
Lake Name: ____
Sampling Site Location Description: ____________________________
Sampler name(s): ____

Date (YYMMDD)	Time (24 hour clock)	Secchi Depth (meters)	Water Temperature (°C)	Weather Conditions (sunny, overcast, windy, etc.)	Water Conditions (calm, rippled, wavy, etc.)