SANDY LAKE DEVELOPMENT IMPACT ASSESSMENT FINAL REPORT

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ABSTRACT

This report, created by senior Environmental Engineering students from Dalhousie University in 2001-02, involves the examination of Sandy Lake and surrounding area, in Bedford, Nova Scotia. Due to developmental pressures in the area from the major metropolitan area of Halifax Regional Municipality (HRM), Sandy Lake is of concern regarding its relatively undeveloped shoreline. The initiating factor of this report is a beach and park project to be developed by HRM, which started construction in 2001 and will be completed over the following few years.

This report involves the creation of baseline data including dissolved oxygen, pH, total suspended solids, a bathymetric map of the lake, total and fecal coliform, as well as other water quality parameters. This data can be used in the future for comparison purposes to determine the degree of environmental alteration resulting from any future development.

Along with this baseline data, recommendations were developed for the Sandy Lake area through computer modelling, established equations, and best industry practices. Although these recommendations were developed regarding the beach and park project, they can be applied to any future development in the area, which may be considered to be accompanied by adverse effects on the lake and surrounding watershed.

This report was intended to be retained for the purpose of maintaining a historic record of Sandy Lake and its surrounding area as well as to outline environmentally responsible practices regarding any future development.

ACKNOWLEDEMENTS

We would like to thank Dr. William Hart, Dr. Jack Burney, and Dr. A. Ghaly, Professors of Biological Engineering for their contribution and advice, and for their patience during the term of our design project. We are also grateful of Rick Scott for the methodology techniques, John Pyke for the help in the lab, Dave Haley for advice in the field, Betsy van Helvoort, Catherine Mott and Derek Sarty from the Sandy Lake Area Residents Association for providing us with valuable information. We would also like to thank Kevin Conley for his help in providing us with information that HRM had on the development.

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1. INTRODUCTION

The site of study for this report is the Sandy Lake watershed. Sandy Lake is the major body of water in the watershed, with a total surface area of 74-ha (Figure 1.1). The site is within the boundaries of the Halifax Regional Municipality, the major metropolitan center of Nova Scotia (Figure 1.2), in the Bedford area (Figure 1.3). Sandy Lake is a relatively undeveloped region near a highly developed metropolitan area.

The lake has a number of summer cottages along its shore, with some permanent residences as well. The area is considered one of the development hot spots for the city, an area where the pressures of development are very high. There are a number of developments occurring near the area, and certain projects are proposed to take place within the watershed boundaries. Many of the residents are concerned about the environmental implications of the proposed developments, and these implications have been investigated. It is the desire of the residents that any developments taking place around the lake follow environmentally friendly techniques.

The major project investigated in this report involves the construction of an artificial beach and picnic area. This development will increase traffic to the Sandy Lake area, as well as increased use of nature trails near the lake. The report looks at the effects of the proposed beach development.

Figure 1.1 – Aerial photograph of Sandy Lake (1992)

Figure 1.2 – Map of Nova Scotia (www.expedia.ca)

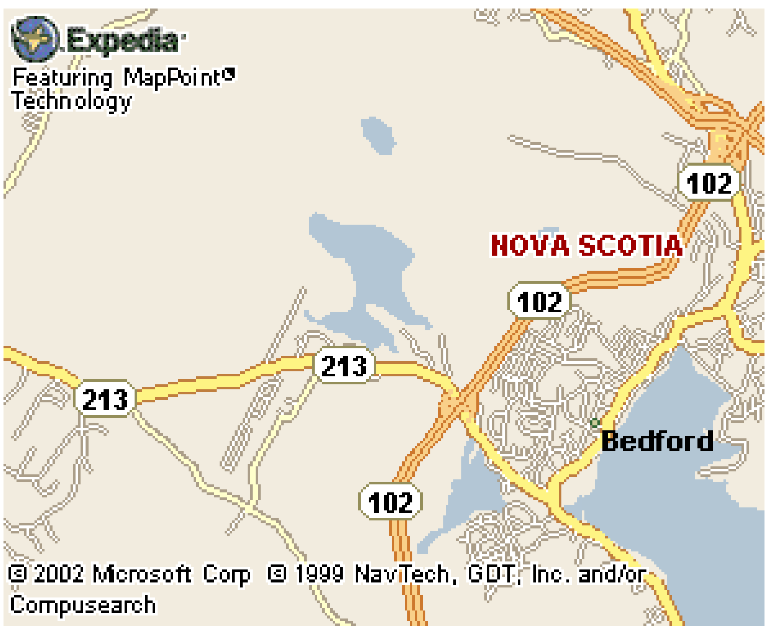

Figure 1.3 – Map of Sandy Lake and Bedford area **(www.expedia.ca)**

2. OBJECTIVES

The main objective of this project is to examine the water quality and quantity of Sandy Lake and to propose methods to protect the watershed from future environmental impacts. A study has been pursued on this area to look at the impact of current activities and to analyze the impacts of possible developments. Phase I of the park development has already been completed, while the proposal for developing a beach area (Figure 2.1), land preparation for a service center and trail system is currently going through approval procedures. This would be considered Phase II of the project, starting in mid to late May, 2002.

2.1 Specific Objectives

Specific objectives of this project are:

1) To examine the impact of Phase I (the construction of the gated road (Figures 2.2 & 2.3) and parking lot (Figures 2.4 & 2.5) for one hundred cars)
2) To examine the impact of developing a beach area with a capacity for 450 people
    a. Impact on the aquatic life
    b. Impact of the shoreline disruption.
3) To examine the impact on bio-diversity
4) To examine the impact on the water quality of the lake
5) To complete the bathymetric map, using data collected from first term
6) To establish baseline data for future reference
7) Computer modeling to determine the effects of increased residential development
8) Model runoff based on the universal soil loss equation

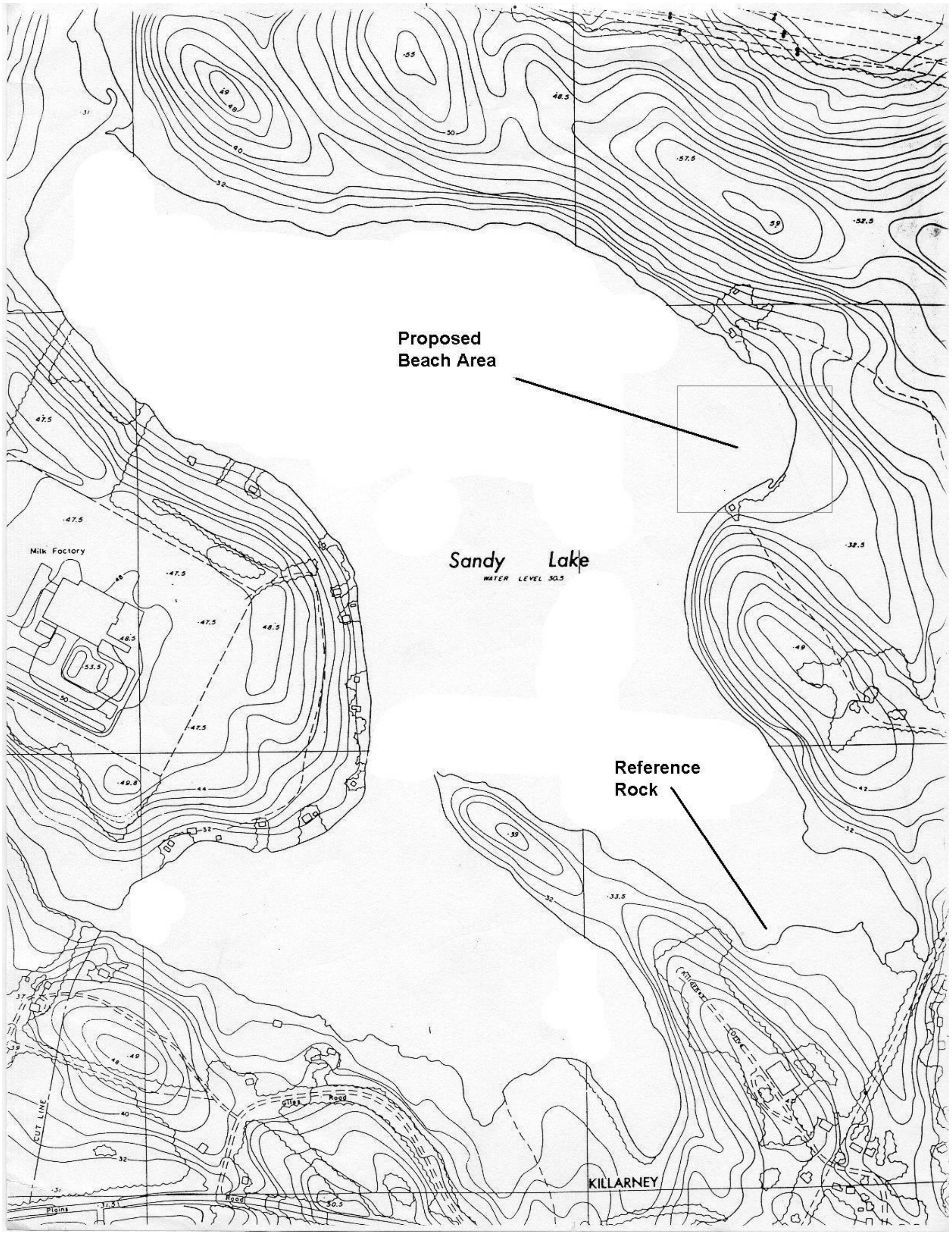

Figure 2.1 – Proposed Beach Area

Figure 2.2 – Main gate on beach access road

Figure 2.3 – Access road to beach (looking up to the gate)

Figure 2.4 – Beach parking lot (west side)

Figure 2.5 – Beach parking lot (east side)

3. COSTS FOR THE PROJECT

The costs of the project will be covered be HRM through the residents association. Costs will include purchasing maps and aerial photographs, as well as developing film of pictures taken of the site. The QEII Environmental Services Laboratory performed lab tests, and these tests included fecal and total coliform tests, as well as RCAP metal scans. A cost sheet for tests performed by the QEII Laboratory can be found in Appendix A. An outboard engine was rented, and mileage was taken into account in the sample acquiring stage. Also, the costs for generating the report are covered in this budget. For a breakdown of the various costs, refer to Table 3.1.

Table 3.1 - Project Budget

Item	Cost
Maps	$21
Aerial Photographs	$12
Lab Tests	$730
Boat Engine	$40
Mileage	$103
Photo Developing	$30
Report Production	$30
Total Cost	$966

4. METHODOLOGY

4.1 Water Testing

Sampling sites were chosen from a map according to their importance to the project, located while on the lake, and referenced to a specific point on shore based on position and distance. Using the reference point on shore, the same site could be located during each sampling period with some degree of accuracy. Once the site was located, a stationary position was maintained using an anchor at the site and the boat (Figure 4.1) was pointed into the wind to prevent drift while testing.

Once the boat was stabilized, a weighted line was dropped to determine the depth of water at each site. This depth determined the number of samples taken at each site – i.e. the number of samples taken at different depths at one, three, five, eight, and ten meters in most cases. Sampling bottles were obtained from CWRS and the QEII Environmental Services Laboratory. Samples were placed in these bottles, and then recorded for bottle number and depth and the bottles themselves were then labelled according to site, depth, and quality desired (this step was taken before hand as the bottle labels are difficult to write on after they are wet).

The collection of the water samples was done from the front (so as not to collect water disturbed by the action of the boat and/or oars/engine) of the boat and collected in appropriate bottles. The bottles were then sealed and refrigerated at 4°C until the samples could be examined, making special note of water temperature for each sample at the time they were collected (important for testing dissolved oxygen).

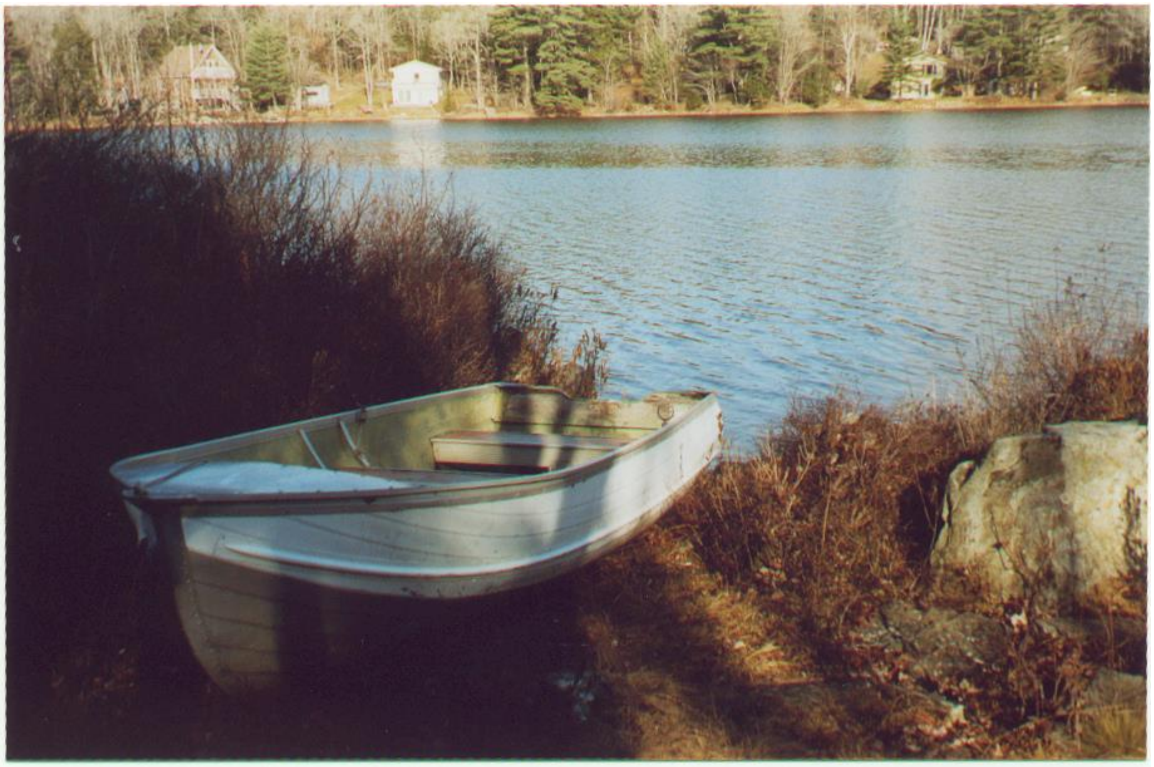

Figure 4.1 – The projects research vessel

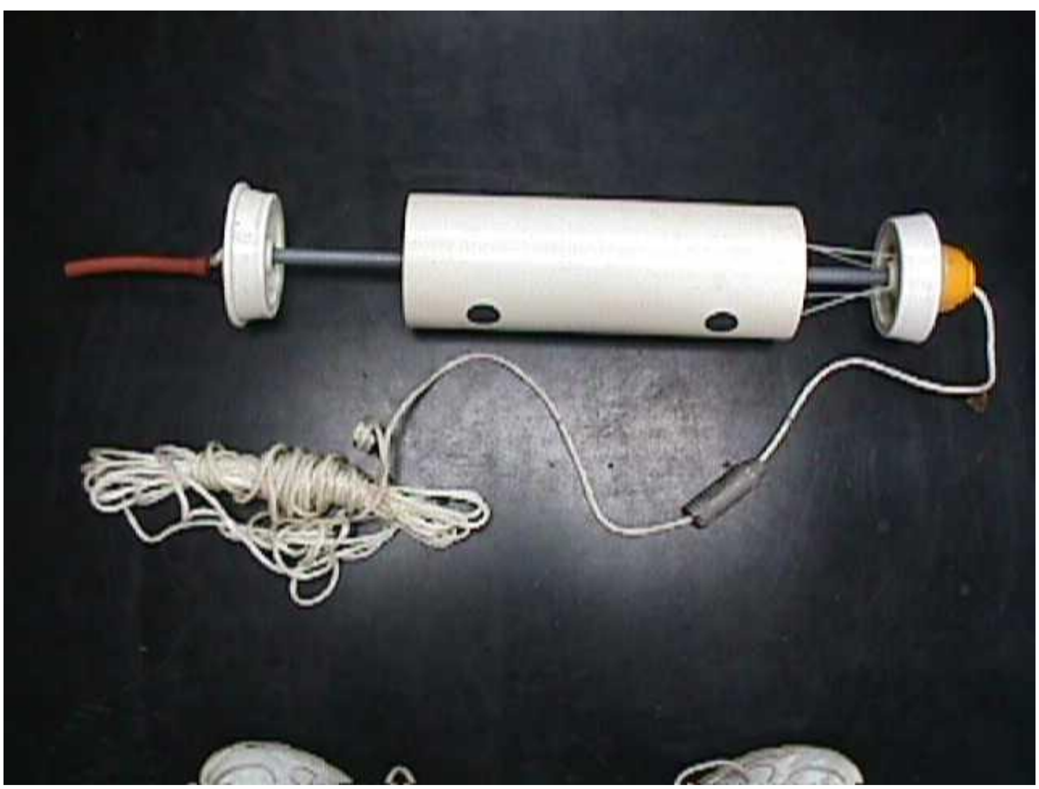

Figure 4.2 – Kemmerer – a device to take samples at depth

The surface samples were taken by hand, taking care not to contaminate the sample by placing nothing other than clean hands in the water while collecting the sample. The samples at depth were collected using a Kemmerer sampler (Figure 4.2), consisting of a hollow tube with valves at either end, which is attached to a rope with the depth in meters marked off on it. The tube with both valves open is lowered to the desired depth using the rope marks and a weight is dropped down the rope, which impacts the top of the tube, closing both valves. Only the water at this depth is collected, as the tube is open during the descent where water flows through it until the desired depth is reached. The tube then is pulled up and the water is retrieved from the tube via a small valve on the lower tube valve.

After the samples were collected and taken from the field, they were tested for their individual water qualities and parameters, both by project members and the QEII Water Testing Lab as soon as reasonably possible as some water qualities degrade over time (the reason why care was taken to refrigerate samples immediately after collection). The water qualities and parameters in question were suspended solids (SS), fecal coliform, total coliform, pH, dissolved oxygen (DO), and a metal scan (RCAP).

4.2 Bathymetric Mapping

The bathymetric map (Figure 4.3) was constructed by running transects at equal intervals across the lake and measuring water depth along each transect. Transects were determined by selecting noticeable landmarks and then transferring these to a map from one point along a straight line across the lake to another point. For this project, sixteen transects were determined in order to properly cover the entire area of the lake surface.

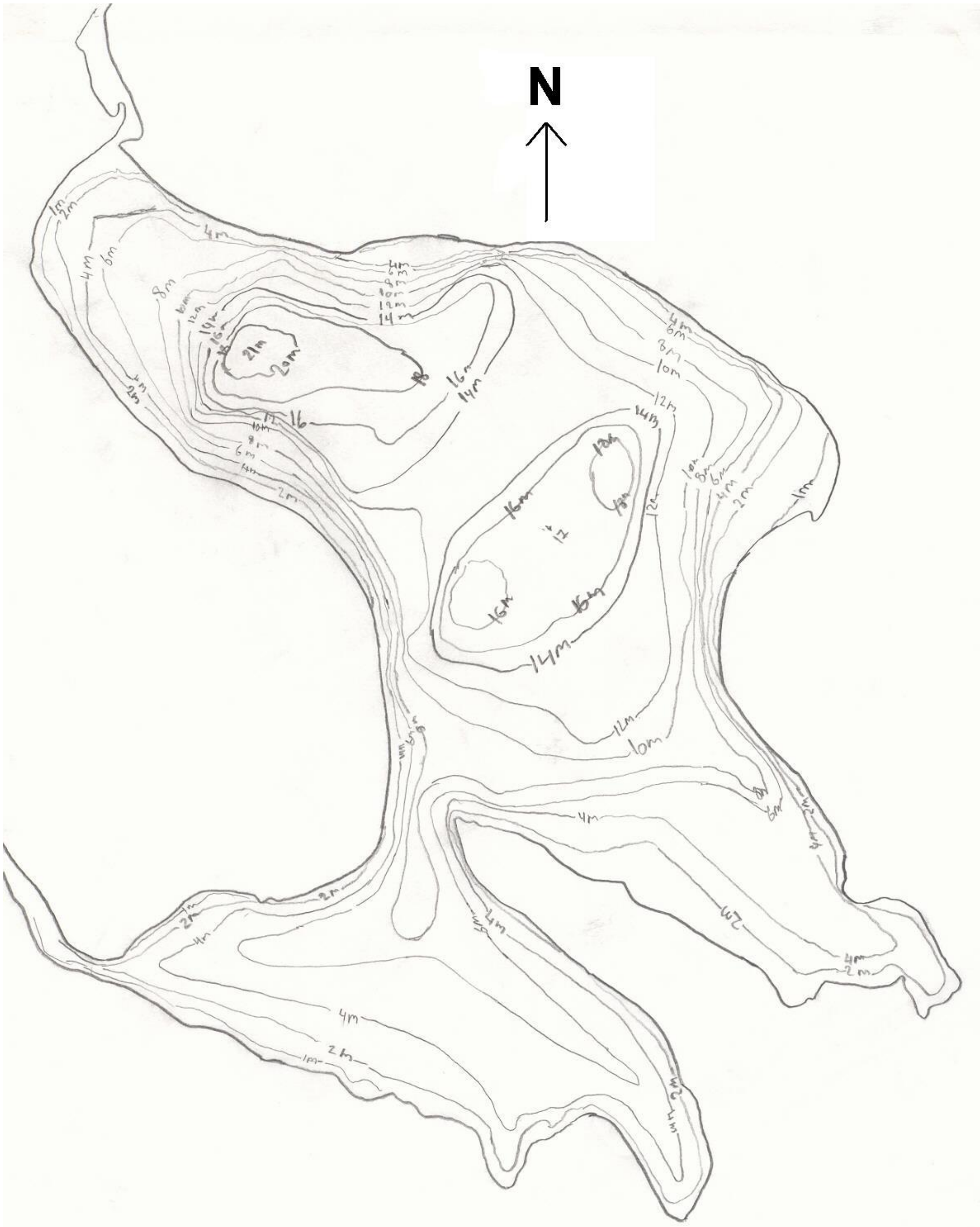

Figure 4.3 – Bathymetric map of Sandy Lake

Once on site, the points of each transect start and finish were identified on land as a point of reference, starting and stopping as close to shore as the boat and engine displacement allowed. Control of the boat was predetermined before each transect path to compensate for wind, current, and obstacles so as to keep a straight course across the transect.

Mapping was done on the lake with an acoustical recording depth sounder (Figure 4.4) and an aluminum boat (aluminum because the original testing boat was wooden, and the acoustic signal does not pass through wood as aluminum) and a 2hp outboard motor. The motor was needed as a constant speed was necessary in the operation of the depth sounder, and being 2hp it was small enough to give a relatively low full throttle speed (the full throttle position provided a simple, repeatable way to achieve a consistent speed across the transect – about 10 km/h).

Each transect was initiated at shore with a change to full throttle of the motor, accompanied by the starting of the depth sounder. As the transect progressed, one team member (the driver) maintained the heading appropriate to reach the preordained point on the other side of the lake while another group member, the operator, ensured proper and accurate operation of the depth sounder by altering the scale of the trace created by the sensor to ensure that the trace did not exceed the span of the paper recording. During each transect, the operator made note of each scale change, transect number, and direction traveled on the trace while the third member, the navigator, watched for obstacles, determined course, and made notes of activities.

At the end of each transect, the navigator signaled the driver to perform a full throttle turn as close to shore as possible to maintain proper speed to the very end of the transect, at which time the operator marked the end of the transect on the trace and turned off the sensor. This process was then repeated sixteen times.

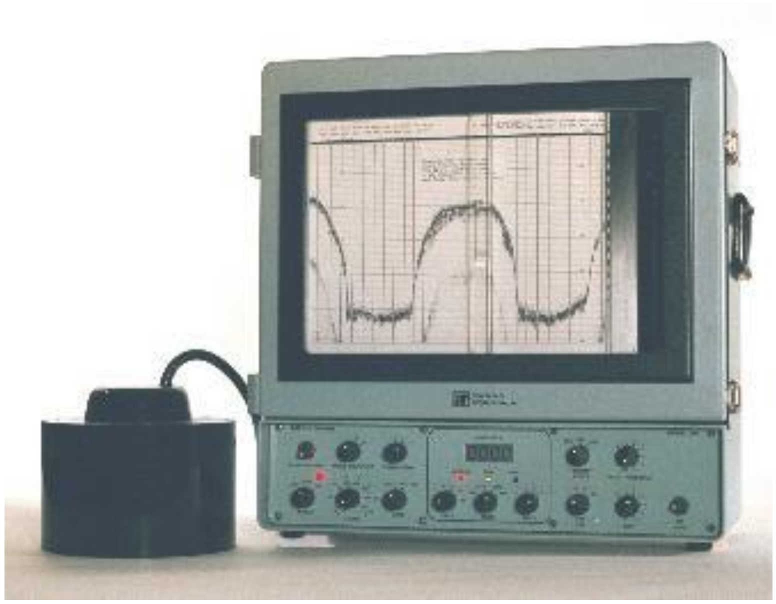

Figure 4.4 – Typical acoustic depth sounder (Innerspace, 2001)

Figure 4.5 – Rock used for water depth reference at the time of mapping

Before leaving the field, the lake was searched for a recognizable landmark in the water (a permanent dock or rock – a rock in this case) to use as a point of reference to allow compensation for any change in water depth from season to season and year to year. A rock (Figure 4.5) was chosen which was large enough to be not moved around by the winter ice and was recognizable for future studies. The location of this rock can be found on the map in Figure 2.1. This rock had a vertically flat face, which made its peak easy to measure above the water line. This distance was measured, recorded, and the rock was referenced to a point on land, described, and several pictures were taken to ease locating this point in future depth profiles. At the time of depth sounding, the reference rock was 90cm above the water level.

After the sixteen transects were completed, the trace marked for each transect, and the actual depth was calculated according to the scale on the depth sounder for each point along the line. A scale map was then used to draw in the transects at the specific points, noting the direction of travel for each. A proportional divider was then used to transfer the depth at specific intervals along the trace to the appropriate point along the transect on the map. Once all of the transects were marked for each depth, contour lines were drawn in, connecting the common depths across the lake. The bathymetric map is completed when the specific point of reference, in this case the reference rock, and its height above the current water line, is marked and described on the map itself, so that future maps would have some form of comparison.

The final copy of the bathymetric map was done by tracing over the rough coping using a light table. The intervals for the bathymetric map ranged from 2 to 21 meters, and the deepest point was found to be 21 meters.

4.3 Chemical Analysis

4.3.1 Suspended Solids Test

Solids refer to matter suspended or dissolved in water or wastewater. Solids may affect water or effluent quality in a number of ways. Water with high dissolved solids is generally of inferior palatability and may induce unfavorable physiological response (intestinal distress) in people who drink the water. High suspended solids content can also be detrimental to aquatic plants and animals by limiting light and deteriorating habitat.

Total suspended solids include all solids present in a sample that remain on a 1.2 µm filter. Suspended solids are determined by filtering a known volume of sample and placing the filter and filter container in a 105 ^{o}C oven for 24 hours to evaporate the water, leaving only the solids on the filter paper.

Fresh filter papers are dried in an oven for 24 hours to remove all moisture, and then are weighed individually. The papers are then weighed with their own weighing dish, which are labelled for reference. The filter papers are then placed into a vacuum filtration apparatus and wetted down with distilled water. The vacuum is started, a known volume of sample is then filtered, about 1000 ml, until dry, and then the filter papers, in their respective dishes, are placed in the 105 ^{o}C oven for 24 hours. The filter papers and dishes are then allowed to cool to room temperature in a desiccator. Each filter paper with dish is then weighed with the retained solids and recorded. The suspended solids calculation is as follows:

$$TSS\,(mg/L) = \frac{(A-B)\times 1000\,{}^{mL}\!/_{L}}{sample\ volume(mL)}$$

where A = dry filter dish and solids weight (mg)

B = dried weight of filter and dish (mg)

4.3.2 Dissolved Oxygen

Dissolved Oxygen (DO) is important to the health of aquatic ecosystems. All aquatic animals need oxygen to survive. Natural waters with consistently high dissolved oxygen levels are most likely healthy and stable environments, and are capable of supporting a diversity of aquatic organisms. Natural and human-induced changes to the aquatic environment can affect the availability of dissolved oxygen.

Dissolved Oxygen percent saturation is an important measurement of water quality. Cold water can hold more dissolved oxygen than warm water. For example, water at 28 degrees Celsius (°C) will be 100% saturated with 8 mg/L dissolved oxygen. However, water at 8 °C can hold up to 12 mg/L of oxygen before it is 100% saturated. High levels of bacteria from sewage pollution or large amounts of rotting plants can cause the percent saturation to decrease. This can cause large fluctuations in dissolved oxygen levels throughout the day, which can affect the ability of plants and animals to thrive. Generally a dissolved oxygen level of 9-10 mg/L is considered very good. At levels of 4 mg/L or less, some fish and macro invertebrate populations (i.e. bass, trout, mayfly nymphs, stonefly nymphs, and caddis fly larvae) will begin to decline. Other organisms are more capable of surviving in water with low dissolved oxygen levels (i.e. sludge worms, leeches).

The main factor contributing to changes in dissolved oxygen levels is the build- up of organic wastes. Organic wastes consist of anything that was once part of a living plant or animal, including food, leaves, feces, etc. Organic waste can enter rivers and lakes in many ways, such as in sewage, urban and agricultural runoff, or in the discharge of food processing plants, meat packinghouses, dairies, and other industrial sources.

A significant ingredient in urban and agricultural runoff is fertilizer that stimulates the growth of algae and other aquatic plants. As plants die, aerobic bacteria consume oxygen in the process of decomposition. Many kinds of bacteria also consume oxygen while decomposing sewage and other organic material in the river.

Samples for the DO test are collected in the field using a glass bottle with a tight fitting glass stopper. The samples are sealed in these bottles with no trapped air bubbles under the stopper. The samples then are refrigerated immediately as the storage temperature affects the results of the test. The water temperature at the time of sampling at each site is also noted, as this value is important for the calculation at time of testing.

The results for dissolved oxygen (DO) are achieved through the use of a dissolved oxygen meter. The meter must be properly calibrated according to the manufacturer's instructions, and each sample is tested for the amount of dissolved oxygen in mg/L.

4.3.3 pH

The pH of most natural bodies of water ranges between 5 and 10. In recent years, because of acid rain and other pollution problems, the pH of many natural water bodies has fallen below these values. Especially in danger are lakes and streams near large developed areas or near industrial centers, which burn fossil fuels. The atmospheric fallout in these areas is typically very acidic. Acid rain occurs in many areas and is especially prevalent in Eastern Canada (i.e. Nova Scotia). This acid rain may lower pH levels in the water bodies of Nova Scotia. As mentioned earlier, there is a region of slate found in the northwest corner of the watershed, and runoff from this slate enters the lake through the northern inlet. Runoff from this slate, when exposed to the surface, is sometimes very acidic, adding to the effect of acid rain.

Hydrogen ion concentration (pH) changes are influenced by many factors including acid rain, man-made modifications, pollution, and $C0_2$ from the atmosphere. The decay of organic matter and oxidation of compounds in bottom sediments also alter pH in water bodies. In ponds, phytoplankton and other aquatic plants use up $C0_2$ during photosynthesis, so the pH of a water body rises during the day and drops at night, so therefore, pH measurements should be done during the same times of day over the sampling periods to maintain a consistency of results.

For the most part, pH is most important as it relates to fish and invertebrates, which make up the food chain of the fluvial system. In general, fish are tolerant to pH ranges of 5 to 9, although this range varies from species to species. In many fish species the pH levels can affect different life stages of fish. Sometimes problems due to pH can go unnoticed until the adults in the ecosystem begin to die off.

As in the case of the DO measurements, pH is measured away from the field as soon as possible (pH results have a tendency to change over time) with the aid of a pH meter, properly calibrated to the meter specs.

4.3.4 RCAP Testing

The samples and results of the RCAP were obtained in the same way as the above coliform tests for the QEII Environmental Services. The results obtained through the RCAP test, and the various parameters involved in the RCAP test are found in detail in the results section and the discussion section.

4.4 Phosphorus Loading Model

A Phosphorus Loading Model (Hart, W.C, Scott, R.S., Ogden III, J.G, 1978) was used to give an indication of the effects of increased residential development on the lake. The model uses the land use of a watershed to determine the amount of phosphorus (P) that will potentially enter a lake or water body. Land use is divided into four categories: forest, forest + clear, agricultural + recreational, and urban. For each of these categories a

P Load is assigned, measured in $mg/m^2/yr$. Also, the contribution from septic systems within 300m of the lake being studied is considered.

Phosphorus and Nitrogen are a major concern for the trophic status of the lake. Nitrogen is a concern in salt water environment whereas Phosphorus is the limiting nutrient in fresh water.

"Nutrient inputs may be natural or anthropogenic. Natural sources are bedrock, soils, dust or other particulates, which are carried to lakes by the groundwater flow, surface runoff, wind action or precipitation. Anthropogenic sources are septic tank drainage, sewage or industrial outfalls, fertilizers, and particulates generated by industrial or agricultural processes. Nutrients from these sources are also incorporated into hydrologic system or are wind transported." (Hart ,W.C, Scott ,R.S., Ogden III, J.G, 1978)

The major concern with increased phosphorus loading to a lake is eutrophication. Eutrophication is the increase of nutrients to a lake, associated with human activity, which leads to high plant productivity.

The results were based on the following estimated values (calculations in Appendix B):

- Lake and watershed area obtained using a topographic map and a planimeter
- Lake volume was obtained using a bathymetric map, and summing the volumes in 2 m sections
- Mean depth by dividing volume of lake by surface area
- Dwellings on site obtained from Sandy Lake Area Residents Association
- Areas of land use were estimated from the topographic map
- Mean Q, runoff volume, flush rate, water load, retention coefficient, response time, P-runoff, P-upstream, P-precipitation, P-persons, P-dwell, and P-point source were all calculated from the model to obtain the total P-load.

4.5 Runoff model

The Universal Soil Loss Equation (USLE) (Schwab, G, et al, 1992) is very useful in determining soil loss due to water runoff from the land. In this application, this equation is being used to compare the original forested state to the conditions after the beach construction. This equation is as follows-:

$$A = RKLSCP$$

Where;

A= average annual soil loss per year in Mg/ ha

R= rainfall and runoff erosivity index for geographic location

K=soil erodibility factor

L= slope length factor

S= slope steepness factor

C= cover management factor

P= conversation practice factor

The equation provides a numerical comparison for the possible change in sedimentation as a result of beach construction, and the result is given in mega grams per hectare-year.

The results were based on the following values (calculations in Appendix C):

- R value based on geographic location – Halifax
- K value estimated from Figure 4.6, using 25% gravel, 35% sand, 40% silt and clay, 3% organic matter, fine granular structure, and slow permeability (MacDougall & Cann, 1963)
- L value using a slope length factor of 45m, and field slope steepness of 1.7
- S value using a slopes longer than 4m and a field slope percentage less than 9%
- C value based on ground cover resulting from project
- P value based on common practice

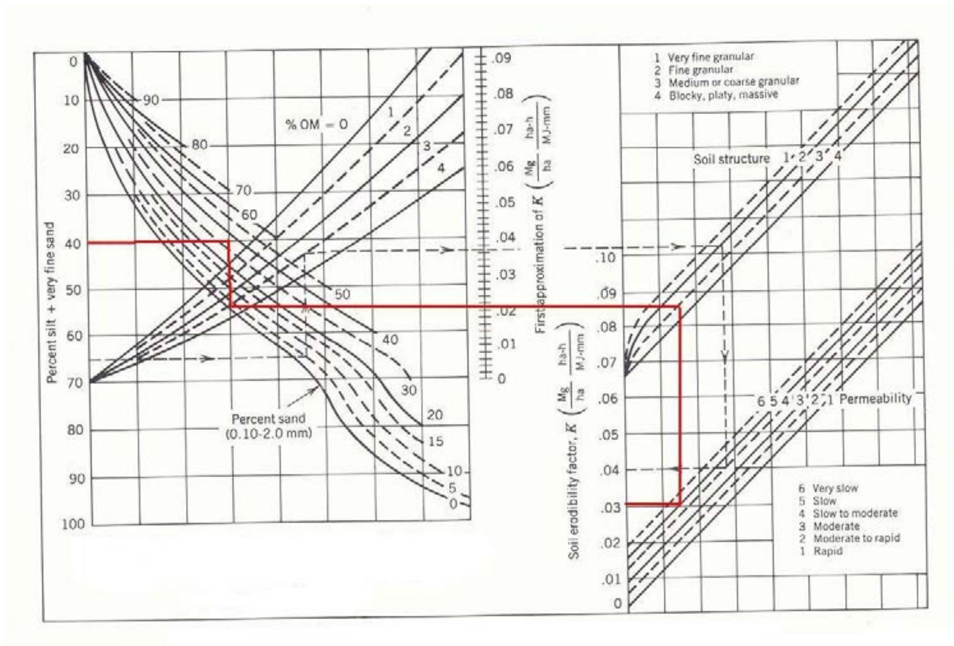

Figure 4.6 – Process for determining the K value in the USLE equation (Schwab, G, et al. 1993)

5. RESULTS

5.1 Suspended Solids Data

In an attempt to obtain data on the amount of sedimentation in the lake, suspended solids were tested in the lab, and the results are listed below in table 5.1. Based on suspended solids data, and estimate may be made on the amount of settling of solids in the lake.

Table 5.1 - Total suspended solids data

Bottle #	weight (g) of filter paper	weight (g) of Filter paper+dish	volume of Sample used (ml)	weight (g) of filter Paper+dish+solids	total suspended solids (mg/L)
10	0.3504	1.3577	1019	1.3588	0.0011
31	0.3518	1.3659	1029	1.3672	0.0013
100	0.3543	1.3717	1030	1.376	0.0042
121	0.3393	1.3488	1027	1.3534	0.0045
162	0.3478	1.3659	1031	1.3702	0.0042
186	0.3294	1.3419	1025	1.3501	0.0080

5.2 Dissolved Oxygen and pH

Two important parameters for life in aquatic systems are dissolved oxygen levels and pH, as they impact growth and health of aquatic life. The results from tests of both of these parameters are listed in tables 5.2 and 5.3.

Table 5.2 - DO and pH data

Site #	Bottle #	Depth (m)	DO (mg/L)	Temp Site (C)	Temp Test (C)	pH	Site Description
			14-Oct-01				
1	557	0	9.5	14	8.5	5.1	Boat Launch
	307	3	9.6	15	7	5.5	
2	451	0.5	9.9	15	4	5.02	Northern Outlet
3	436	0	9.7	14	4.5	5.1	Middle of Lake
	333	5	9.8	14	7.7	5.28	
	578	10	9.6	14	7	5.09	
4	321	0	9.4	15	10	5.22	Steep Slope
	411	3	9.5	14	7	5.12	
5	556	0	9.3	15	11	5.12	Sewage Spill
6	521	0	9.5	14	6	5.05	Narrows
	413	5	9.5	14	7.5	5.07	
7	363	0	9.6	14	3	5.15	Southern Outlet
				4-Nov- 01			
1	436	0	10.4	6.5	10.4		Boat Launch
2	411	0	10.3	6.9	8.8		Northern Outlet
3	333	0	10.5	6.4	8		Middle of Lake
4	578	0	10	6	10.1		Steep Slope
5	557	0	10.6	5.9	10.4		Sewage Spill
6	521	0	10.8	6.1	8		Narrows
7	307	0	10	5.8	11		Southern Outlet

Table 5.3 - pH data

25-Nov-01		
Site	pH	DO (mg/L)
Southern Outlet	5.15	
Northern Outlet	5.25	
Northern Inlet	3.38	11.8
Beach	5.85	

5.3 Fecal and Total Coliform

The results of fecal and total coliform counts were achieved through sampling at many sites across the lake, and accompanied by testing at the QEII Environmental Services Laboratory. The results for fecal coliform were zero at all sites, but the test for total coliform resulted in counts at all sites (Appendix D)

5.4 RCAP

The RCAP test covers various water parameters, which may either directly or indirectly indicate some form of contamination of concern to biological life. The results of the RCAP tests follow in Table 5.4 and the description of each parameter follows in the next section. For a copy of the official lab results, see Appendix E

Table 5.4 - RCAP Results from Sandy Lake (November 25)

Water Quality Parameters	Unit	Beach result	Lake Center result	Farmers inlet result	Northern Outlet result	Aesthetic Objectives
Sodium	mg/L	20.8	21.1	20.1	21.2	≤ 200
Potassium	mg/L	0.7	0.8	0.8	0.9	-
Calcium	mg/L	4.2	4.3	5.6	4.3	-
Magnesium	mg/L	1.0	1.0	1.3	1.0	-
Hardness	mg/L	14.6	14.8	19.3	14.8	-
Alkalinity	mg/L	2.8	2.0	4.0	2.8	-
Carbonate	mg/L	0.00	0.00	0.00	0.00	-
Bicarbonate	mg/L	2.80	2.0	4.0	2.80	-
Sulfate	mg/L	10.2	9.9	14.2	9.7	≤ 500
Chloride	mg/L	34.0	35.0	32.0	35.0	≤ 250
Silica	mg/L	2.7	2.7	4.5	2.7	-
Ortho Phosphorus	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	-
Nitrate+Nitrite	mg/L	< 0.05	< 0.05	0.05	< 0.05	-
Ammonia	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	-
Iron	mg/L	0.31	0.36	0.35	0.35	≤ 0.3
Manganese	mg/L	0.170	0.180	0.200	0.180	≤ 0.05
Copper	mg/L	< 0.002	< 0.002	0.002	0.002	≤ 1.0
Zinc	mg/L	0.006	0.006	0.007	0.008	≤ 5.0
Color	TCU	25.9	29.0	27.7	24.6	≤ 15
Turbidity	NTU	1.46	1.56	1.26	1.59	≤ 5
Conductivity	µmho/cm	149	152	157	152	
pH	unit	6.3	6.3	6.3	6.3	6.5 - 8.5
Total Org. Carbon	mg/L	4.7	4.7	5.4	4.6	
Cation Sum	-	1.22	1.24	1.28	1.24	
Anion Sum	-	1.23	1.23	1.28	1.24	
% Difference	-	0.49	0.11	0.02	0.09	
Std. Deviation	-	0.13	0.13	0.13	0.13	
Ion Sum	-	75.3	76.0	81.1	46.5	
Theo. Conductivity	-	151	153	158	154	

5.5 Phosphorus Model Results

The output from the phosphorus model can be found in Appendix E. The total phosphorus load based on current conditions in the watershed is 213.0 kg/yr. This value is below the total permissible phosphorus load of 237.0 kg/yr. The value of 237.0 kg/yr is based on the desired trophic status of oligo-mesotrophic[1].

5.6 Universal Soil Loss Equation Results

Based on the calculations from the USLE equation, it is estimated that the current soil loss from the proposed beach and picnic area is 1590 kg/year. After the proposed construction phase, the new estimated soil loss from the area will be 2550 kg/year.

[1] Oligo-mesotrophic is a state in which the lake has sufficient nutrients to maintain organisms, but not enough to have damaging plant growth.

6. DISCUSSION

6.1 Site Description

The Sandy Lake watershed has an approximate area of 1820 ha. Within the watershed there is a variety of development, ranging from large industrial facilities to single family homes and summer cottages. A trailer park is located on Lucasville Road, which is in the northwest corner of the watershed. Farmers Dairy, one of the large industrial facilities, treats its waste in a man-made lagoon. The waste from the residents on the lakeshore gets treated in septic tanks located on their property. Drinking water for the residents comes from wells, some hand dug, while others are drilled. There may be some concerns regarding the lake water affecting the quality of well water since many wells are close to the lake, with a possibility of infiltration.

Sandy Lake is fed by two main inputs, the first being a small stream (termed the Northern Inlet (Figure 6.1) entering the lake from the north, the second being a small river entering the lake from the south through the southern inlet. The lake is drained through the outlet on the north end (Figure 6.2), just east of the Northern Inlet. We suspect that much of the flow from the Northern Inlet "short-circuits" the lake by flowing directly across to the northern outlet and leaves the lake, with relatively low impact.

The lake is made up of two smaller basins separated by a narrow, relatively shallow shelf (Figure 6.3), which divides the lake into a northern basin (Figure 6.4) (deeper and larger, and a southern basin (more shallow and smaller).

Figure 6.1 – Northern Inlet

Figure 6.2 – Northern outlet

Figure 6.3 – Narrows of Sandy Lake

Figure 6.4 – Looking north on Sandy Lake

6.1.1 Geological Information

A geological profile of the watershed can be viewed in Figure 6.5. The northwestern region of the watershed is underlain with slate. This slate has the possibility of releasing amounts of acid if exposed to the surface, which will accumulate in the runoff and be carried to low lying bodies of water. Possible evidence that acid may be created in this area is the fact that the northern inlet (see Figure 6.1) to Sandy Lake is extremely acidic, with a pH of 3.38. The origin of the stream is at the edge of this slate.

The rest of the region is composed of Quartzite Till, Lawrencetown Till, drumlin facies, and exposed bedrock. These geological formations are interspersed throughout the watershed.

Acid drainage results when pyrite-bearing rock is exposed, and reacts with air and water, creating sulphuric acid and dissolved iron (http://geology.er.usgs.gov/eastern/environment/drainage.html). This type of exposure usually occurs during mining and construction activities. Sometimes pyritic rock is left uncovered after construction activity is finished, resulting in continuous drainage of acid. A region found in the northwest region of the Sandy Lake Watershed is underlain with slate, and some of this slate has been exposed. A small brook that originates near this exposed slate, and empties into Sandy Lake, has a pH of approximately 3.4, and leads to suspicions that the exposed slate may be pyritic.

The reaction describing the weathering of this slate is

$$4\,FeS_2 + 15\,O_2 + 14\,H_2O \rightarrow 4\,Fe\,(OH)_3\downarrow + 16\,H^+ + 8\,SO_4^{+2}$$

The ferrous sulphide deposits are attacked by Thiobacillus ferrooxidans to generate sulphuric acid, which lowers the pH. From the above reaction, this acidity can be seen in the form of the 16 H^+.

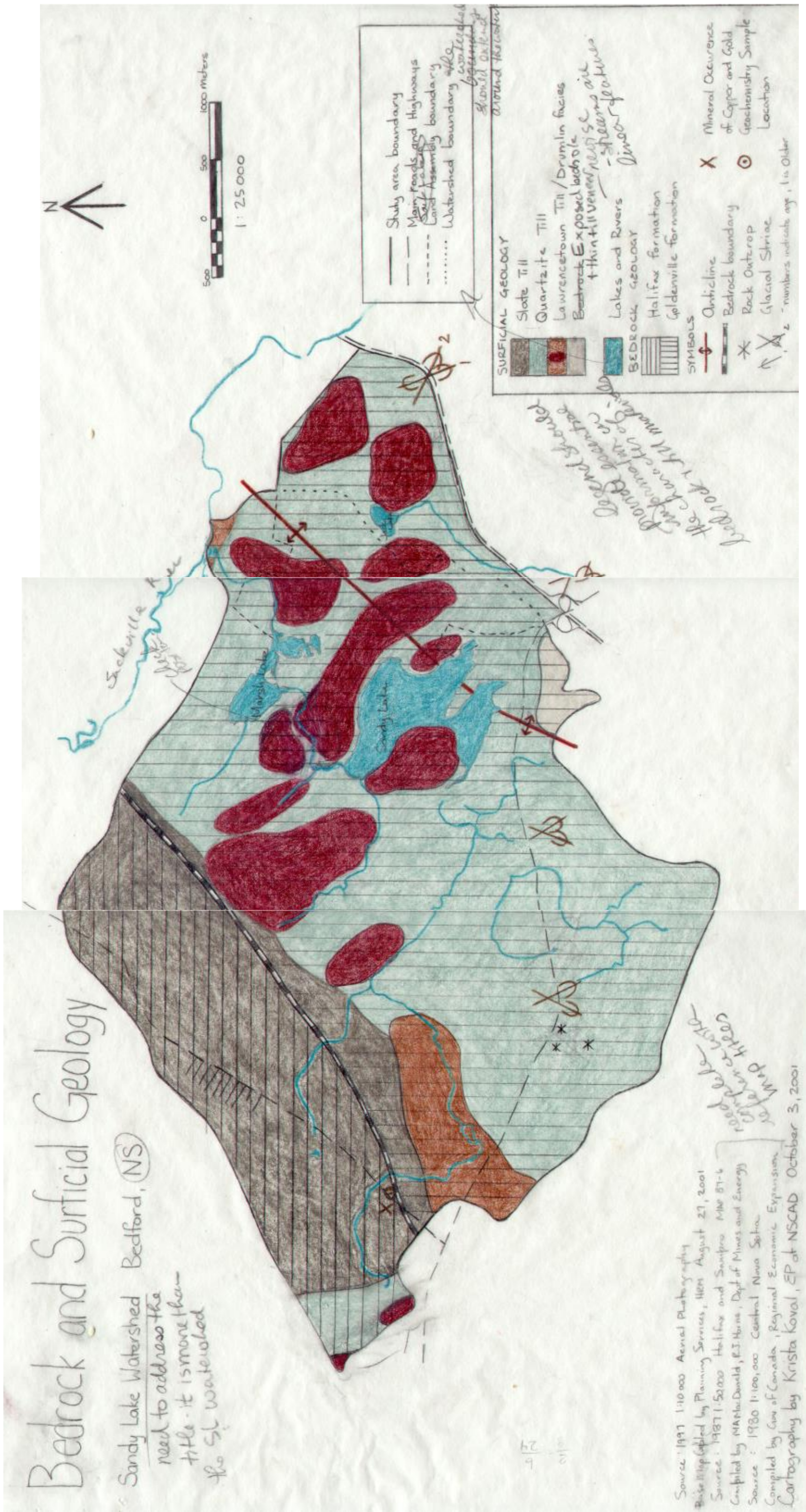

Figure 6.5 – Geological survey of Sandy Lake watershed (Koval, Krista, 2001)

6.1.2 Soils

The region around the lake is comprised of mostly Halifax soil, which is a sandy loam type of soil (Figure 6.6). Aspotogan soil surrounds the southern inlet, the inlet by Farmers Dairy. The area where the northern outlet from Sandy Lake enters Marsh Lake is comprised of peat. Overlying the slate region in the northwest corner, two other soil types are found, Bridgewater and Riverport.

6.1.3 Slope

The slope profile of the lake can be found in Figure 6.7. The slope around the lake is of serious concern, and varies to a great extent near the shore. Most of the proposed beach zone is found in the 0-5% range. To the northwest and south of the beach the slope increases sharply to the 5-15% range, turning into a 15-25% slope farther north along the shore. For the rest of the lakeshore, the slope ranges from 0-25%.

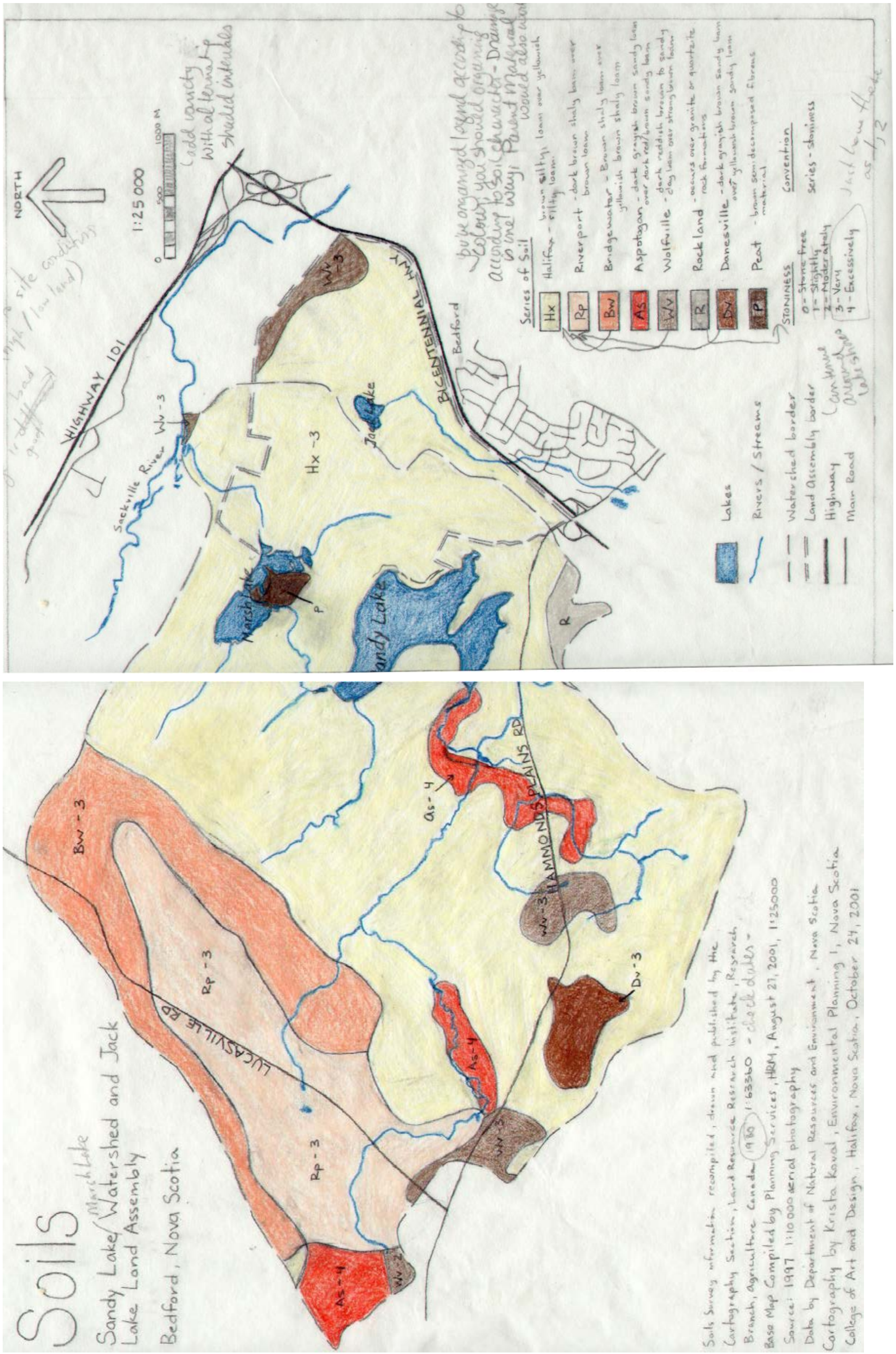

Figure 6.6 – Soils type in Sandy Lake area (Koval, Krista, 2001)

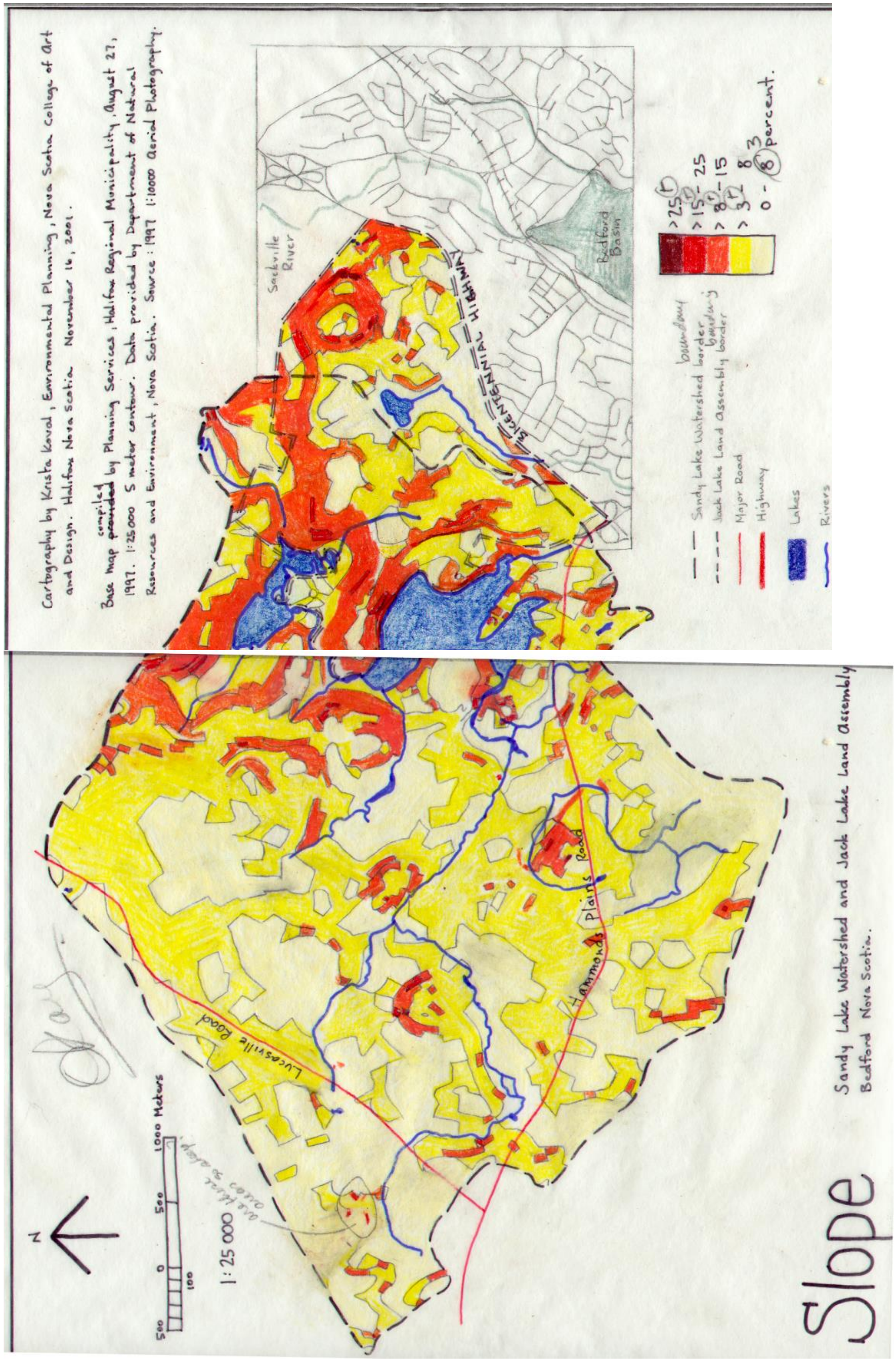

Figure 6.7 – Slope description of Sandy Lake watershed (Koval, Krista, 2001)

6.1.4 Vegetation Survey

In 1995 an extensive vegetation survey for Sandy Lake Park was conducted to determine the vegetation composition and to identify the possibility of designing a trail system. Nova Scotia Department of Environment is currently reviewing this survey for development the trail system and the proposed beach area (EDM, 2001).

The study showed that the general area is typical of the Acadian Forest Region consisting of Maple, Yellow Birch, Beech and spruce and Eastern Hemlock in well-drained areas and Black spruce, Balsam Fir, White Pine and Larch in poor soils (Figures 6.8 & 6.9).

The parking lot area has already been constructed and the vegetation study had shown that this area was a disturbed site in the state of secondary succession (apparently after a small scale logging operation some time ago) with mostly Alder with only a scattering of large tress.

6.1.5 Constructed Parking Lot

A parking lot has already been constructed, which is suitable for approximately 100 cars. No drainage system, such as tile drainage was put in place for this parking lot, even though there will probably be some contamination from leakage of oil and gas from the vehicles using the parking lot. This contamination was not considered to be of major concern by HRM and the developers since the parking lot is located at a fair distance from the lake.

Figure 6.8 – Mixed forest of Sandy Lake area

Figure 6.9 - Mixed forest of Sandy Lake

6.2 Beach Development

A section of the lake is being proposed as a site for beach development. A gated access road and parking lot have already been constructed in preparation for the development of the beach. A kayak and boat launch is also proposed at the edge of the beach. Access paths will be constructed on preexisting trails through wooded areas. A pedestrian bridge will be built over an existing stream that is currently crossed by the trail. The construction of a service center is also planned for the site. A lifeguard platform is also proposed for installation in the center of the beach. Utility poles (Figure 6.10) that are currently in the middle of the proposed development will be relocated to a new site behind the beach.

6.2.1 Beach Area Details

The beach is proposed for construction on land with a slope in the 0-5% range. There is a region of natural beach (Figure 6.11) approximately 1 meter wide, depending on water level, from the water edge to the riparian zone (Figure 6.12). The riparian zone is made up of a combination of hardwood and softwood trees, such as fir, birch, and pine. Also, growing in the shallow waters next to the shore is a large amount of vegetation (Figure 6.13). This region has been described as a low energy site (low fertility) in the lake that is an important component of the fish habitat (Hamilton, 2000).

Figure 6.10 – Power poles in the riparian zone of the beach location

Figure 6.11 – Natural beach zone at proposed site

Figure 6.12 – Riparian Zone on Sandy Lake

Figure 6.13 – Vegetation in the area of the beach project

6.2.2 Beach Construction

Before any construction takes place along the shore, silt fencing will be put in place to reduce the amount of silt entering the lake. This fence will be placed along the edge of the high water mark. A silt fence, seen in Figure 6.14, is currently in place along the access road to the parking lot. Another form of silt control is achieved through the use of hay bales (Figure 6.15) across small streams to control the movement of silt but allow the passage of water; however the effectiveness of this control is in question (Schwab et al, 1993).

Figure 6.14 – A silt fence in use off the beach access road

Figure 6.15 – Hay bales (middle) in use off of beach access road in a small stream

No construction is allowed to take place below the high water mark (HWM). A stone retaining wall, similar to the one in Figure 6.16, is to be constructed above the HWM that will separate the deposited sand at the beach from the natural beach. The wall is to extend 18 inches below the finished grade. At the base of the wall a 4-inch diameter sock filter (Figure 6.17) will be put in place. The imported sand will be deposited behind this wall. Under the deposited sand will be a geotextile fabric liner (Figure 6.18) to prevent sediment transport to the natural beach.

The shallow region rich in vegetative growth will be left relatively untouched. The proposal is to clear two access pathways through this vegetative zone allowing people to reach the swimming area. The two paths will be hand cleared, with one having a width of 3m and the other being 5m in width. Since this region is an important fish habitat of the lake, it is difficult to predict the effects that this will have. It would also be important to determine just how effective these paths will be. It is a concern that with the high number of people proposed to access the beach using these paths, some may stray from the paths.

A kayak and boat launch will be built at the edge of the beach, and this development does not appear to have any major effects to be concerned with.

There are certain areas that are considered to be sensitive and, therefore, a permanent fence will be installed to inhibit access to certain areas. Near this fence area will be the construction of a boardwalk with interpretive signs describing the ecosystem. From here, park users will be able to overlook the sensitive ecological area.

After construction is complete, exposed soils will be covered with non-erodable aggregate or grass cover. Also, a number of trees will be planted around the site on the graded area.

Figure 6.16 – A common stone retaining wall (http://www.paveloc.com/largecreta.html)

Figure 6.17 – A typical sock filter (Armtec Ltd. 2001)

Figure 6.18 – A common geotextile fabric liner used in construction

The area of construction for the artificial beach and picnic area will be levelled and graded to a 3% slope. This slope will extend to the edge of the currently existing natural beach.

6.3 Current Pollution Problems

During numerous visits to the Sandy Lake area, common litter problem have been noticed. A wide variety of garbage, such as tires (Figure 6.19), rusted metals, car parts (Figure 6.20), and oil traces were found in and around the lake. A major concern with higher numbers of visitors to the region is the possible increase of garbage left in the area, often associated with human traffic.

Figure 6.19 – Tires and various car parts found in southeast section of Sandy Lake

Figure 6.20 – Truck hood found on shore in southeast region of Sandy Lake

6.4 Hydrologic Cycle

There are five major processes that make up the hydrologic cycle: condensation, precipitation, infiltration, runoff, and evapotranspiration. Figure 6.21 shows the stages of the hydrologic cycle.

Condensation is the process of water vapour transforming into a liquid. Warm air rises, and this air carries water vapor with it. When this air cools, the ability to hold this water is decreased and the water vapour becomes a liquid. Clouds are formed by the condensation of water.

Precipitation occurs when the water that has condensed as clouds is released. The reason for the release of this precipitation is that the water has become too heavy to remain in the atmosphere, so it must come out in the form of precipitation. This precipitation reaches the earth's surface to continue the cycle.

Infiltration occurs when the water that lands on the earth's surface penetrates the soil and becomes groundwater. Groundwater is often used for drinking water, and many people dig wells to obtain this water. Vegetation, soil and rock type, and the water saturation level of the soil already, are major factors in determining how much water infiltrates the surface.

Runoff is what becomes of the remaining precipitation that doesn't infiltrate the soil. Runoff water will always flow to the lowest point possible. Precipitation that lands within a watershed will tend to flow in a certain direction. All water that falls in the watershed will have an effect on what is happening with the water quality within the watershed boundaries. This is why it is important to look at the watershed as a whole, not just a single area of the watershed.

Evapotranspiration involves the evaporation of water from the land, as well as the transpiration of water from plants. These two methods outline how water returns to the atmosphere. Evapotranspiration results when water is heated, causing molecules to become active and enter into the atmosphere as vapor (Campbell, 1993)

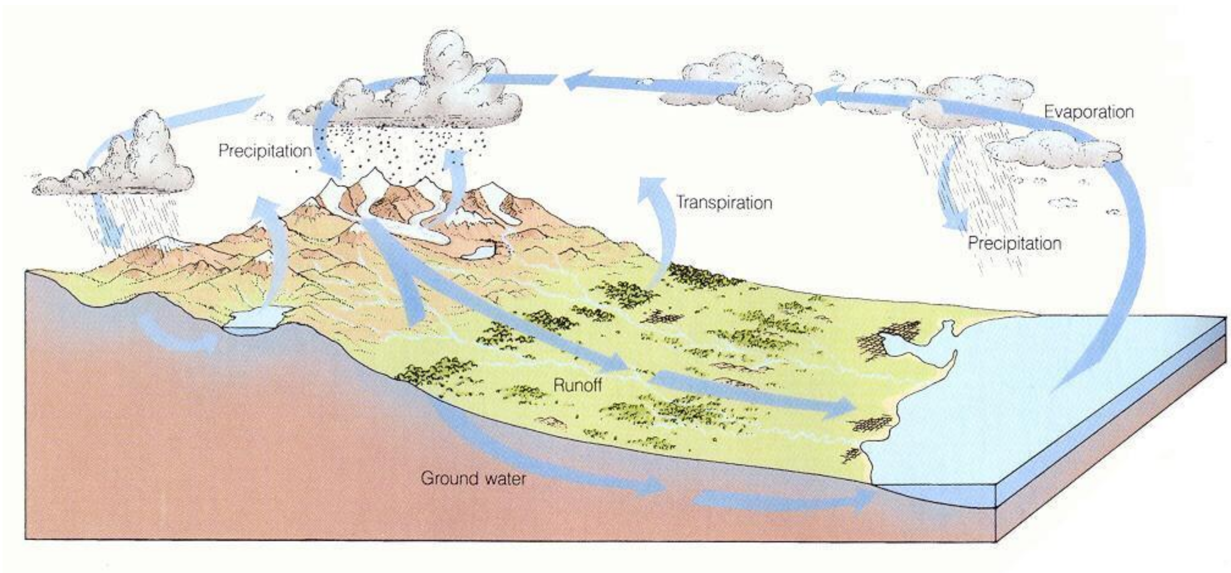

Figure 6.21 – The Hydrologic Cycle (Hamblin, Kenneth W., 1992)

6.5 Coliform Bacteria

Total coliform bacteria are a collection of relatively harmless microorganisms that live in large numbers in the intestines of man and warm- and cold-blooded animals. A specific subgroup of this collection is the fecal coliform bacteria, the most common member being *Escherichia coli*. These organisms may be separated from the total coliform group by their ability to grow at elevated temperatures and are associated only with the fecal material of warm-blooded animals.

The presence of fecal coliform bacteria in aquatic environments indicates that the water has been contaminated with the fecal material of humans or animals. If coliforms are found, there is an indication that the source water may have been contaminated by pathogens or disease producing bacteria or viruses which can also exist in fecal material.

Some waterborne pathogenic diseases include typhoid fever, viral and bacterial gastroenteritis and hepatitis A. The presence of fecal contamination is an indicator that a potential health risk exists for individuals exposed to this water. Fecal coliform bacteria may occur in water as a result of the overflow of domestic sewage or non-point sources of human and animal waste.

Regulations regarding recreational use of lakes have set a limit for a maximum coliform count of 200 and 10 for total and fecal coliform respectively, and 10 and zero respectively for drinking water purposes. The results from this study on Sandy Lake have found total coliform counts to range from 92 to 142 coliform/100ml. The results from the fecal coliform tests show counts of 0 fecal coliform/100ml for all test sites. Both of these parameters are found to be within the limits for recreational use, but the total coliform count places this water above the acceptable limit for drinking water.

6.6 Suspended Solids

The suspended solids data ranged from 0.0011 to 0.0080 mg/L. This information was collected for the purpose of creating baseline data before the major construction commences for the beach project, as an indication of the increase in sedimentation during and after the construction period.

An increase in sedimentation would result in the decrease in depth of the water at the point of sedimentation (in this case at the beach and surrounding area), reduce the quality of water for drinking as well as for aquatic life, disruption of shoreline regarding aquatic plants (creating a muddy shoreline), and reducing the aesthetics of the water for recreational use.

6.7 Dissolved Oxygen

With an increase in trophic level to a eutrophic level, there will be increases in organisms. This will increase the amount of decaying material at the lake bottom, which would in turn increase the population of decomposers and increase the amount of oxygen consumed. Bacteria are the main decomposers and they consume a large amount of oxygen through the breakdown of the organic material at the lake bottom (Cole, 1994).

6.8 pH

Since most organisms require a specific range of pH to survive and reproduce successfully, any change in pH, even small amounts, will reduce the organism's chance of survival.

Levels of pH within the lake were within normal tolerance levels for most aquatic organisms, it was found that the Northern Inlet had a pH of 3.38. At this level of pH it is unlikely that any aquatic organisms, either micro or macro, would survive.

6.9 RCAP Parameters

The following concentration parameters are obtained from the recommendations by Health Canada (1996).

6.9.1 Sodium

Sodium is the most important cation in living organisms – it regulates acid-base equilibrium, maintains the osmotic pressure of body fluids, and preserves the normal function of muscle and permeability of cells.

Due to the importance of this substance, the human body is very adept at controlling the levels of sodium in the body and, therefore, sodium is not generally considered a toxic substance in water. Sodium is a factor which is more involved in the aesthetics of water rather than its harmful effects on the human body – excess levels of sodium are easily detected by taste, making sodium concentrations of 175 to 185 mg/L offensive to the palette. However, at extremely high doses, toxic effects include muscle twitching, cerebral and pulmonary oedema and death.

However, in the case of people suffering from hypertension or congestive heart failure with a sodium-restricted diet (about 500 mg/d), the intake of sodium from drinking water could become significant. If the sodium intake from drinking water makes up 10% of these sodium-restricted diets, then it is recommended that concentrations of sodium in drinking water be less than 20 mg/L. The AO (aesthetic objective) for sodium in drinking water is recommended to be ≤ 200 mg/L. The results from the RCAP test have shown that the sodium levels across the samples range from 20.1 to 21.2 mg/L, which is below the aesthetic objective but not suitable for people on sodium-reduced diets (i.e. heart patients).

6.9.2 Potassium

Like many other of the parameters, potassium is an element necessary for life, and therefore is well regulated by the body and therefore is generally not a concern in drinking water.

6.9.3 Calcium

Having many natural sources from rocks like limestone, calcium is an abundant natural element, entering groundwater through the weathering of these rocks. Also, various forms of calcium emanate from various industries. For instance, calcium oxide (lime) is used extensively in mortar, stucco and plaster in the building industry, in pulp and paper production, sugar refining, petroleum refining and tanning and as a wastewater treatment chemical. However, these sources of calcium are not applicable in this part of the province, and would have little effect on the Sandy Lake watershed.

Calcium is associated with hardness in drinking water, with hardness ranging from ≤ 175 mg/L as calcium carbonate (soft water) to ≥ 300 mg/L (hard water).

As in the case of sodium, the human body efficiently regulates internal concentrations of calcium, and therefore adverse effects are usually only associated with intake of large quantities of calcium, making a maximum allowable concentration (MAC) of calcium in drinking water not necessary.

Outside of what might be received from drinking ground water, high levels of calcium in the body can adversely affect the bioavailability of other minerals in the diet. Conversely, calcium can slow the onset of osteoporosis, prevent colon cancer and act as an anti-hypertensive agent. Hard drinking water has also been associated with a lower incidence of cardiovascular disease.

Results have shown that calcium in the samples range from 4.2 to 5.6 mg/L, meaning that the water in Sandy Lake qualifies as soft water.

6.9.4 Magnesium

Magnesium deficiencies are associated with cardiovascular, neuromuscular and renal disorders, making it essential in human metabolism. Similar to calcium, magnesium also contributes to water hardness and a decrease in cardiovascular disease with its presence in drinking water.

Undesirable effects include a poor taste, when magnesium exists at higher concentrations usually found in Canadian drinking water, and may indirectly result in a laxative effect when magnesium is associated with the sulphate ion.

Due to the lack of direct evidence that magnesium adversely affects human health, no recommendations have been made about concentrations of this element in drinking water.

6.9.5 Hardness

As stated before, hardness is most affected by calcium and magnesium, resulting in a classification of hard or soft water, related to the equivalent quantity of calcium carbonate.

Although not generally a concern regarding human health, hardness is associated more with a “nuisance factor” hard water leads to incrustation of water systems (and scale formation with heat) and excessive soap consumption related to washing, and soft water leads to corrosion of water pipes.

When taking into account interactions of hardness with other factors such as pH and alkalinity, hardness levels between 80 and 100 mg/L (as calcium carbonate) are acceptable balances the actions of corrosion and incrustation.

Due to the apparent absence of adverse health effects, hardness is not considered a factor that necessitates a suggested maximum acceptable limit, outside of the nuisance factor.

As mentioned before, the water samples have shown that the water in Sandy Lake is soft water.

6.9.6 Alkalinity, Carbonate, and Bicarbonate

Alkalinity is the capacity of water to neutralize acids. This capacity is caused by the water's content of carbonate, bicarbonate, hydroxide and occasionally borate, silicate, and phosphate. Alkalinity is expressed in milligrams per liter of equivalent calcium carbonate. Alkalinity is a measure of how much acid can be added to a liquid without causing a great change in pH.

Because this parameter is generally not of concern in regard to adverse health effects, there is no suggested maximum concentration in drinking water.

6.9.7 Sulphate

Occurring naturally in various minerals, sulfates are used in a variety of industries in different uses - in the manufacture of chemicals, dyes and fertilizers, in the mining and pulping industries, in sewage treatment and in wood preservation. Outside of these sources, atmospheric sulphur dioxide and acid rain may also contribute to the sulphate content of surface waters

Sulphate is one of the least toxic anions, although adverse effects resulting from the ingestion of large quantities of sulphate include gastrointestinal irritation, which increases in severity when the sulfates are associated with magnesium. Ingestion of water containing magnesium sulphate at concentrations in excess of 600 mg/L can cause diarrhoea in children, and in excess of 1000 mg/L in adults.

Sulphate in drinking water can result in a noticeable taste at or above 500 mg/L for most people, although some may find the taste of sulphate in water offensive at lower concentrations. Due to the adverse effects of sulphate in drinking water, the AO for sulphate is ≤ 500 mg/L.

Results have shown that samples contained 9.7 to 10.2 mg/L which is well below the aesthetic objectives for this parameter.

6.9.8 Chloride

Originating naturally from salt deposits and anthropogenically from chemical industries and, significant in this province, road salt application, chloride is generally present in ground water at low levels of concentration.

Chloride is the most abundant anion in the human body. Like sodium, chloride levels in the body are efficiently regulated through the nervous and hormonal systems. Again, aside from the taste, no evidence has been found that ingestion of chloride is harmful to humans. The AO for chloride in drinking water is ≤ 250 mg/L a value that is much higher than is usually found in Canadian drinking water.

Results from this project have ranged from 32.0 to 35.0 mg/L for chloride, which is well below the AO for drinking water.

6.9.9 Ortho Phosphorus

Phosphorus is an important nutrient found in many forms. Ortho-phosphates are the most reactive (biologically accessible) form of this nutrient. The higher the level of orthophosphates in water, the more food substrate that is readily available for immediate use by algae. While some small amount of phosphorus is vital to sustain plant growth, too much phosphorus can lead to eutrophication, the increase in the nutrient levels of a lake or other body of water causing an increase in the growth of aquatic animal and plant life, possibly leading to the depletion of dissolved oxygen in the water. Although this parameter is very important in the health of a body of water, generally there are no ill effects of it in drinking water, unless in high enough concentrations to result in a state of eutrophication and a reduction in the aesthetics of the water.

6.9.10 Nitrate/nitrite

Naturally occurring ions in the environment (from decaying plant and animal material), nitrites and nitrates also enter the environment from different sources - nitrates generally come from inorganic fertilizers, manure and domestic sewage, whereas nitrites are used mainly as food preservatives and may result from excess ammonia in drinking water distribution systems that use chloramines as a disinfectant. Due the nitrate ion's relative stability as compared to the nitrite ion, most nitrogenous materials tend to convert to nitrates.

Due to the high solubility of nitrate salts, nitrate is highly mobile in soil and migrates to the water table when present in excess where, under anaerobic conditions, nitrate may be degraded to nitrite or denitrified. Nitrate levels in Canadian municipal water supplies are generally less than 5 mg/L, whereas levels in well water are often higher. This is due to the treatment that municipal water supplies undergo, as opposed to raw well water.

There is some concern about an increased risk of cancer in humans because of the fact that nitrites derived from nitrates may react with certain foods in the body to form carcinogenic compounds.

A more important side effect associated with the ingestion of nitrate or nitrite in drinking water is methaemoglobinaemia or "Blue Baby Syndrome" (the bonding of a nitrogenous compound to the iron center of blood and resulting blue colored blotches on the surface), with infants less than three months of age at the greatest risk.

Based on this, a MAC for nitrate in drinking water of 45 mg/L has been recommended, this being equal to 10 mg/L as nitrate-nitrogen - though not applicable to both infants and adults, only infants.

Nitrite is more of a concern as it is directly toxic and is converted within the body from nitrate. Nitrite has been found to have toxicity 10 times greater than that of nitrate and, through a few uncertainty calculations, a maximum of 3.2 mg nitrite/L has been recommended in cases where nitrite and nitrate are measured separately.

In this case, results were less than 0.01 mg/L and, therefore, are not of any concern regarding drinking water.

6.9.11 Ammonia

Ammonia is used in the manufacture of fertilizers, explosives, nitric acid, plastics and in refrigeration plants and petroleum refineries. It occurs naturally as a result of the biological breakdown of organic matter. Ammonia and ammonium compounds also are used to lower trihalomethane production in municipal water supplies. Ammonia and ammonium compounds react with chlorine to form chloramines, instead of the carcinogenic trihalomethane compounds.

The ingestion of large doses of ammonium chloride by human adults results in headache, nausea, diarrhoea and a reduction in glucose tolerance. Most drinking water contains low levels of these compounds and, therefore, there is no need to establish a maximum suggested concentration.

6.9.12 Iron

An abundant element in the earth's crust and an essential element in human nutrition, iron in Canada is used mainly for the manufacturing of steel products. Toxic effects can arise from the ingestion of large quantities of iron, but such large quantities rarely exist in drinking water.

At concentrations above 0.3 mg/L, iron can stain laundry and plumbing fixtures, causes an undesirable taste and color, and promotes the growth of microorganisms.

The AO for iron in drinking water is ≤ 0.3 mg/L, at which only a small number of people may detect the taste in water. Results from the RCAP have shown that samples ranged from 0.31 to 0.36 mg/L, which is close to the AO of 0.3 mg/L, possibly resulting in staining of fixtures and an undesirable taste in drinking water of more sensitive consumers.

6.10 Phosphorous Loading Model

The model determined how much phosphorous could enter the lake to maintain a mesotrophic level and, based on this, the maximum number of houses allowable was found to be 19 without surpassing the mesotrophic level. This calculation, as well as others required for this model, can be found in Appendix B. A significant increase in houses could lead to eutrophic conditions, which may be detrimental to the lake.

An increase in the trophic level from mesotrophic to eutrophic would result in algal blooms, increase in plant growth and other biotic organisms, as well as a drop in dissolved oxygen, reducing the aesthetic value of the water in regards to recreational and drinking water use.

6.11 Universal Soil Loss Equation

The USLE was used to predict upland erosion and was used both for current land state and for future proposed beach project for the purpose of comparing soil loss before and after the construction.

For the present conditions (pre-construction), it was found that the soil loss was estimated to be 1590 kg per year, and for the future conditions (post-construction), the soil loss per year was 2550 kg. These estimated values, when compared, represent a significant increase in soil loss after the construction of the beach and park and, therefore, soil control is of major concern for this beach project.

7. OUTSIDE INTERACTION

Interaction outside of the university environment plays a major role in the field of environmental engineering. This important interaction broadens the information base available to researchers and project groups.

7.1 Inter-departmental Interaction

Over the course of this project, spanning 7 months, engineers and environmental planners had been working together on the Sandy Lake project. This kind of interaction was beneficial for both groups since each of these groups are looking at the project from a different angle, however they are seeking the same target of having a safe and clean watershed for many years to come. The environmental engineering students mainly concentrated on the chemical analysis of the water and how this ties in with the future developments. The engineers created models based on the physical and chemical characteristics, while the planners concentrated more on how development will affect the physical layout of the land.

As the project progressed, we became more involved with the planners, as they provided important detailed information in the form of maps of slope, soil type, and geological profile of the land. The planners changed their outlook on the project this semester, as they began looking at the social and economic impacts of development in the area. Information exchanged between the two groups was an asset, providing a broader outlook on the project scope.

7.2 Public Interaction

Throughout the course of the project the group had numerous meetings with Betsy van Helvoort and Derek Sarty of the Sandy Lake Area Residents Association, as well as various members of the community. We received valuable information from these people, since they have extensive experience with the lake being residents, in some cases for several generations. Also, this past semester the group presented the findings from the first semester to the residents at a public meeting, and will be presenting the final recommendations at an undetermined date to the public.

7.3 Professional Interaction

The group consulted with members of the professional community, and received helpful guidance from these sources. Dave Haley provided information regarding tests to perform on the water, due to his experience on the lake. John Underwood provided as much information as he could, however he hadn't had any experience on the lake for about 30 years. Steve Thompson, a former engineer with Farmers Dairy also provided some helpful information regarding their waste treatment system. The group also met with Kevin Conley of HRM Parks and Recreation to obtain information on HRM's approach to the project.

Overall, the group found that invaluable practical experience was gained in the interaction with people of various backgrounds. This experience will better prepare us for the transition from academia to industry.

8. EXPERIENCE GAINED

The group has gained knowledge in a variety of practical field techniques. New techniques had to be acquired each time field tests needed to be performed. Methods for obtaining samples from the lake were explained to the group by Rick Scott prior to field visits. The group also learned how to create a bathymetric map of the lake. Laboratory techniques were put into practice while testing pH, suspended solids and dissolved oxygen.

This project has provided valuable experience that could not be learnt in a classroom setting. The project helps to expand on the theory taught in the academic curriculum.

9. RECOMMENDATIONS

At the conclusion of this project, it is felt that the following recommendations should be considered for future development in the Sandy Lake area.

During the construction, efforts should be made to control soil loss during the disruption of the current vegetative cover. This would involve the use of silt fences as a direct barrier to soil movement into the lake and assuring that no construction takes place in or around the stream to the south of the beach development. Disturbance of the soil should also be avoided during rainy periods to reduce the amount of runoff into the lake. A plan should be developed to carry out highly disruptive activities on dry days only, using rainy days for less disruptive activities.

Avoiding the usage of mechanical equipment in the lake itself is recommended. Also proper maintenance of the equipment to ensure that contamination of the lake water by petroleum products will be avoided, and this maintenance should occur away from the lake for the same reason.

During construction of the picnic park, it is recommended that areas planned to be kept natural are disturbed as little as possible. Leaving natural vegetation in place can do this. Not only is leaving natural vegetation untouched a good environmental practice, but it will also maximize privacy for picnickers. When the area is to be disturbed, it is recommended that sod be placed in the disturbed area as soon as possible to reduce the amount of soil loss from the bare areas.

Preparation of the service center site will be performed this year, but Phase III of the project, which includes the actual construction of the service center building, will not commence until the following year. During the time between the two phases, it is recommended that the cleared site for the building be covered to control soil loss. One possibility of cover for this purpose would be geotextile fabric, which would minimize the amount of runoff and avoid weed growth.

Fertilizer will be applied to the newly sodded areas to encourage growth, and because fertilizer contains a high phosphorous percentage, its application should be controlled. Initial fertilizer application should be done mid summer to avoid heavy rain periods and therefore avoiding runoff. Fertilizer should also be in the form of pellets to ensure a controlled release and to avoid spraying a powder or liquid in an uncontrolled manner.

Washroom facilities should not include flush toilets as this greatly increases the amount of disturbance in the area. These disturbances would include the connection of a sewer line to the municipal system approximately one kilometer away, the construction of a septic system on site in the form of a septic field or holding tank. It is recommended that an extensive study of the impacts of different types of washroom facilities be performed, to determine which type would have a minimum impact on the lake.

Control is needed in the swimming area to avoid damage to the natural vegetation in the lake. The beach project currently includes paths to be created from the shore out to the deeper water for swimming, but at this point there is no defined plan for what this might entail. A recommendation might be to create a roped off area out from shore along these paths along with a lifeguard to ensure that swimmers do not violate the natural areas of the lake. Swimming activities should not be carried out during spawning and nursing periods to protect fish populations.

In regards to access to the beach park itself, access should be restricted to daylight hours only with the main gate being locked from dusk till dawn. This would control vehicular access to the parking lot and beach area.

Increases in traffic are expected to result from the beach project, as people will come to the area for recreational purposes. Traffic pattern studies should be performed to determine the effect this will have on Smiths Road and its intersection with Hammonds Plains Road. If necessary, upgrades to Smiths Road and the intersection should be carried out to support the extra traffic to the area. An upgrade that should be looked at for the intersection would be a set of lights. As of now, plans are to monitor the situation and make changes as they become necessary.

Based on the Phosphorus Loading Model, it was determined that 19 more permanent residences may be built within 300m of the lake before the levels of phosphorus begin to allow increased aquatic growth in the lake. Above this number this number of houses, high nutrient loads will begin entering the lake and this may result in damaging the lake ecosystem. Care should be taken to prevent overloading of nutrients to the lake from residential development. With increased use of the lake, awareness of such an attractive living area will increase the demand for development.

Before future developments are carried out, more detailed environmental impact assessments (EIA's) should be performed. Aside from these impact assessments, monitoring programs should be put in place to determine the impacts from development. Baseline data collected in this report can be used as a comparison for future monitoring, to determine these impacts. HRM has committed to setting up a monitoring program for the lake. Coliform levels must be continuously monitored to ensure that water quality is suitable for recreational use. Of major concern are the two sewer breaks that have occurred in the past year. If these breaks had gone unnoticed, serious health hazards could have resulted in sickness to swimmers and residents in the area.

10. CONCLUSION

Based on the findings of this project, it is felt that more in depth studies concerning environmental components of development should be carried out. Further development near Sandy Lake should take into consideration the recommendations made in this report. Future development now has baseline data to compare with, provided in this report.

The project proposed by HRM to develop the beach and picnic area follows best industry practices today. As long as these plans are followed, the impact of this development will be minimized. Any future projects should also be researched to find best industry practices, as is the case with this project.

Sandy Lake is near a rapidly developing area of Halifax Regional Municipality, and therefore is likely to come under increased development pressure. Any future developments should be done with great care, taking into careful consideration the environment and water quality of Sandy Lake, both for residents and recreational users. Development plans in the future should be looked at on a larger scope rather than individual activities and projects. Small projects may often seem to have small effects on an area. With a large number of these developments, the cumulative effects may prove to be very harmful. The cumulative and future effects should be considered at the outset of these smaller projects.

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http://www.tarleton.edu/~dekeith/Kemmerer.jpg

www.expedia.ca

(http://geology.er.usgs.gov/eastern/environment/drainage.html**)**

APPENDIX A

Fill in sample information on page 1.

PACKAGES REQUIRES BOTH BLACK AND WHITE CAP BOTTLES

Package	Turn around time	Cost
☐ ***Budget Home Owner Package*** Coliforms (P/A) Arsenic Uranium	(Turn around time 2-4 working days) (Savings $5.00)	Cost $ 47.15
☐ ***Ultimate Home Ownership Package*** Sodium,Calcium,Magnesium,Hardness,Alkalinity,Sulfate,Chloride,Nitrate Ammonia,Iron,Manganese,pH,Lead-HGA,Arsenic,Uranium,Coliform (P/A)	(Turn around time 7-10 working days) (Savings $51.00)	Cost $ 138.00
☐ ***Extensive Home Ownership Package*** Coliforms (P/A) Uranium Arsenic RCAP	(Turn around time 7-10 working days) (Savings $128.00)	Cost $ 161.00
☐ ***Registered Water Supply Package 1 Includes: (Recommended by NSDOE)*** Aluminum, Antimony, Arsenic, Barium, Boron, Cadmium, Chromium, Copper, Iron, Lead, Manganese, Selenium, Uranium, Zinc, Color, Turbidity, Conductivity, pH, Sodium, Potassium, Calcium, Magnesium, Hardness, Sulfate, Chloride, Nitrate, Ammonia, Total Organic Carbon,Fluoride, Total Dissolved Solids	(Saving $102.00)	$264.50
☐ ***Registered Water Supply Package 2 (Recommended by NSDOE)*** Includes Registered Water Supply Package 1 + Coliforms (P/A)	(Savings $106.00)	Cost $ 276.00
☐ ***RCAP Analysis Includes:*** Sodium,Potassium,,Calcium,Magnesium,Hardness,Alkalinity,Sulfate,Chloride,Silica,ortho Phosphorus(regular) Nitrate,Ammonia,Iron,Manganese,Copper,Zinc,Color,Turbidity,Conductivity,pH,Total Organic Carbon	(Turn around time 7--10 working days) (Savings $ 102.00)	$ 138.00
☐ ***Inductively Coupled Plasma (ICP) Metals Package*** Calcium,Magnesium,Aluminum,Boron,Barium,Berillium,Cadmium,Cobalt,Chromium,Copper Iron,Manganese,Nickel,Lead-HGA,Antimony,Selenium,Tin,Vanadium,Zinc	(Turn around time 7-10 working days) (Individual Charge $13.80)	Cost $115.00
☐ ***General Analyses*** Sodium, Potassium, Calcium, Magnesium, Hardness, Alkalinity, Sulphate, Chloride,Fluoride, Silica Ortho Phosphorus (regular), Nitrate, Ammonia, Arsenic, Iron, Manganese, Lead-HGA, Copper, Zinc Suspended Solids, Color, Turbidity, Conductivity, pH, Total Organic Carbon	(Turn around time 7-10 working days) (Savings $ 108.00)	Cost $184.00
☐ ***Basic Analyses*** Calcium, Magnesium, Hardness, Alkalinity, Sulphate, Chloride, Nitrate, Ammonia, Iron, Manganese, pH	(Turn around time 7-10 working days) (Savings $ 33.00)	Cost $80.50

Individual Tests: ***REQUIRES BLACK CAP BOTTLE ONLY***

Test	Cost	Test	Cost	Test	Cost	Test	Cost	Test	Cost
☐ Sodium	$ 13.80	☐ Nitrate/Nitrite	$ 11.50	☐ Iron	$ 13.80	☐ Colbalt	$ 13.80	☐ pH	$ 5.75
☐ Potassium	$ 13.80	☐ Ammonia	$ 11.50	☐ Manganes	$ 13.80	☐ Chromium	$ 13.80	☐ Conductivity	$ 5.75
☐ Calcium	$ 13.80	☐ ortho-Phosphorus	$ 11.50	☐ Lead	$ 13.80	☐ Nickel	$ 13.80	☐ Color	$ 9.20
☐ Magnesium	$ 13.80	☐ Total Phosphorus	$ 23.00	☐ Copper	$ 13.80	☐ Antimony	$ 13.80	☐ Turbidity	$ 9.20
☐ Hardness	$ 27.60	☐ Kjeld.Nitrogen	$ 23.00	☐ Zinc	$ 13.80	☐ Selenium	$ 13.80	☐ Solids, Total	$ 13.80
☐ Alkalinity	$ 11.50	☐ Total Nitrogen	$ 23.00	☐ Aluminum	$ 13.80	☐ Tin	$ 13.80	☐ Solids, Total Diss.	$ 13.80
☐ Chloride	$ 11.50	☐ Sulfate	$ 11.50	☐ Boron	$ 13.80	☐ Chlorophyll a		☐ Solids, Suspended	$ 13.80
☐ Silica	$ 11.50	☐ Arsenic	$ 13.80	☐ Barium	$ 13.80	☐ field filtered	$ 28.75	☐ Solids, Vol. Susp.	$ 13.80
☐ Acidity	$ 13.80	☐ Uranium	$ 23.00	☐ Beryllium	$ 13.80	☐ lab filtered	$ 46.00	☐ TOC	$ 23.00
☐ Fluoride	$ 11.50	☐ Mercury	$ 23.00	☐ Cadmium	$ 13.80	☐ Humic		☐ BOD	$ 28.75
☐ Phenol	***	☐		☐		☐ Substances	$ 23.00	☐ COD	$ 23.00
								☐ ODI	$ 23.00

*** by Arrangement

As a referring service, tests not offered at Environmental Services may be sent to an alternate facility.

Please sign to indicate acceptance of referral to alternate facility. ______________________

Other ____

____

See reverse side for additional information and sampling instructions.

APPENDIX B

Lake Volume Calculations

Depth (m)	Area at depth (m^2)
0	740000
2	644776
4	533750
6	431689
8	326870
10	266185
12	206190
14	126886
16	103440
18	26894
20	4137
21	0

To calculate the volume, the lake can be looked at as a series of 2m vertical slices from the surface to the deepest point.

$Volume_{0m-2m}$ = ((Area at 0m * Area at 2m)/2)*Total depth change
= ((740000m * 644776m)/2)*2m
= 1384776m

Vertical Slice	Volume (m^3)
0m – 2m	1384776
2m – 4m	1178526
4m – 6m	965439
6m –8m	758559
8m – 10m	593055
10m – 12m	472375
12m – 14m	333076
14m – 16m	230326
16m – 18m	130334
18m – 20m	31031
20m – 21m	2069
Total Volume	6079566

Maximum number of houses allowed above current level based on trophic status-:

Permissible houses = (Permissible P – current P) / contribution per house within 300m
= (237-213) / 1.26 = 19 homes

APPENDIX C

USLE Calculations

R = 2000

K = 0.032

s = filed slope in percent = 3

θ = field slope steepness in degrees = $\tan^{-1}(s/100) = 1.7$

m = dimensionless exponent = $\sin\theta / (\sin\theta + 0.269(\sin\theta)^{0.8} + 0.05)$

l = slope length in meters = 45m

$L = (l/22)^m = 1.25$

For slopes longer than 4m and s < 9 percent, $S = 10.8\sin\theta + 0.03 = 0.35$

C = 0.25

P = 1

A = 7.08 Mg/ha

Based on the beach project area of 0.225ha, this results in an annual soil loss of 1.59 Mg

APPENDIX D

Queen Elizabeth II Health Sciences Centre
Environmental Services
Environmental Chemistry, Water Bacteriology
5788 UNIVERSITY AVENUE, HALIFAX, N. S. B3H 1V8
PHONE 473-8466

Report To:
Conrad, Damon
443 Lockview Rd.
Fall River NS
B2T 1J1

Bill To:
Conrad, Damon
443 Lockview Rd.
Fall River NS
B2T 1J1

Sample Number : **246749**
Sample Name :**Damon Conrad**
Sample Location:**Outlet**

Client's Phone Number.. 861-3309
Collection Date········ Nov 12/01
Source················· Water

DETERMINATION	RESULT	UNIT	ACCEPTABLE LIMIT
Total Coliforms	100	/100 ml	

Date Received: Nov 13, 2001
Date Issued : Nov 15, 2001

Verified By:

James W. Halliday
Technologist II
Environmental Services

Paid $ 23.00
Payment Received

Queen Elizabeth II Health Sciences Centre
Environmental Services
Environmental Chemistry, Water Bacteriology
5788 UNIVERSITY AVENUE, HALIFAX, N. S. B3H 1V8
PHONE 473-8466

Report To:
Conrad, Damon
443 Lockview Rd.
Fall River NS
B2T 1J1

Bill To:
Conrad, Damon
443 Lockview Rd.
Fall River NS
B2T 1J1

Sample Number : **246748**
Sample Name :**Damon Conrad**
Sample Location:**Beach**

Client's Phone Number.. 861-3309
Collection Date········ Nov 12/01
Source················· Water

DETERMINATION	RESULT	UNIT	ACCEPTABLE LIMIT
Total Coliforms	92	/100 ml	

Date Received: Nov 13, 2001
Date Issued : Nov 15, 2001

Verified By:

James W. Halliday
Technologist II
Environmental Services

Paid $ 23.00
Payment Received

Queen Elizabeth II Health Sciences Centre
Environmental Services
Environmental Chemistry, Water Bacteriology
5788 UNIVERSITY AVENUE, HALIFAX, N. S. B3H 1V8
PHONE 473-8466

Report To:
Conrad, Damon
443 Lockview Rd.
Fall River NS
B2T 1J1

Bill To:
Conrad, Damon
443 Lockview Rd.
Fall River NS
B2T 1J1

Sample Number : **246746**
Sample Name : **Damon Conrad**
Sample Location: **Site #2**

Client's Phone Number.. 861-3309
Collection Date········ Nov 12/01
Source················· Water

DETERMINATION	RESULT	UNIT	ACCEPTABLE LIMIT
Total Coliforms	142	/100 ml	

Date Received: Nov 13, 2001
Date Issued : Nov 15, 2001

Verified By:

James W. Halliday
Technologist II
Environmental Services

Paid $ 23.00
Payment Received

Queen Elizabeth II Health Sciences Centre
Environmental Services
Environmental Chemistry, Water Bacteriology
5788 UNIVERSITY AVENUE, HALIFAX, N. S. B3H 1V8
PHONE 473-8466

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Conrad, Damon
443 Lockview Rd.
Fall River NS
B2T 1J1

Bill To:
Conrad, Damon
443 Lockview Rd.
Fall River NS
B2T 1J1

Sample Number : **246747**
Sample Name : **Damon Conrad**
Sample Location: **Rocky**

Client's Phone Number.. 861-3309
Collection Date········ Nov 12/01
Source················· Water

DETERMINATION	RESULT	UNIT	ACCEPTABLE LIMIT
Total Coliforms	94	/100 ml	

Date Received: Nov 13, 2001
Date Issued : Nov 15, 2001

Verified By:

James W. Halliday
Technologist II
Environmental Services

Paid $ 23.00
Payment Received

APPENDIX E

ENVIRONMENTAL CHEMISTRY
DIVISION OF CLINICAL CHEMISTRY
VICTORIA GENERAL HOSPITAL
5788 UNIVERSITY AVENUE, HALIFAX, N. S. B3H 1V8
PHONE 428-3466

Copy To:
Damon Conley
443 Lockview Rd.
Fall River NS
B2T 1J1

Report To:
Halifax Regional Municipality
Kevin Conley
PO Box 1749
Halifax, NS
B3J 3A5

Sample Number : **247659**
Sample Name : **HRM Kevin Conley / Damon Conrod**
Sample Location: 111

Client's Phone Number.. 902-490-6193
Collection Date········ Nov 25/01
Collector·············· Damon Conrod
Source················· Water

DETERMINATION		RESULT	UNIT	meq/L
Sodium		21.2	mg/L	0.922
Potassium		0.9	mg/L	0.023
Calcium	(R)	4.3	mg/L	0.214
Magnesium	(R)	1.0	mg/L	0.082
Hardness		14.8	mg/L	
Alkalinity (CaCO3)		2.8	mg/L	0.056
Carbonate (CaCO3)		0.00	mg/L	
Bicarbonate (CaCO3)		2.80	mg/L	
Sulfate		9.7	mg/L	0.201
Chloride		35.0	mg/L	0.987
Silica		2.7	mg/L	
Ortho Phosphorus (P)		< 0.01	mg/L	
Nitrate+Nitrite (N)		< 0.05	mg/L	0.000
Ammonia (N)		< 0.05	mg/L	0.000
Iron	(R)	0.35	mg/L	
Manganese	(R)	0.180	mg/L	
Copper	(R)	0.002	mg/L	0.000
Zinc	(R)	0.008	mg/L	0.000
Color		24.6	TCU	
Turbidity		1.59	NTU	
Conductivity		152	μmho/cm	
pH		6.3	units	
Total Organic Carbon		4.6	mg/L	

Cation Sum	1.24	Theo. Conductivity	154
Anion Sum	1.24	Saturation pH 5°C.	10.7
%Difference	0.09	Langelier Index 5°C.	-4.4
Std. Deviation	0.13	Langelier Index 20°C.	-4.1
Ion Sum	76.5	Langelier Index 50°C.	-3.5

(R) Indicates parameter referred out to an accredited laboratory.

Date Received: Nov 26, 2001
Date Issued : Dec 17, 2001

Verified By:

James W. Halliday

Technologist II
Environmental Services

Cost $ 138.00
Invoice to follow

Continued.....

ENVIRONMENTAL CHEMISTRY
DIVISION OF CLINICAL CHEMISTRY
VICTORIA GENERAL HOSPITAL
5788 UNIVERSITY AVENUE, HALIFAX, N. S. B3H 1V8
PHONE 428-3466

Copy To:
Damon Conley
443 Lockview Rd.
Fall River NS
B2T 1J1

Report To:
Halifax Regional Municipality
Kevin Conley
PO Box 1749
Halifax, NS
B3J 3A5

Sample Number : **247660**
Sample Name : **HRM Kevin Conley / Damon Conrod**
Sample Location: **Farmer's Inlet**

Client's Phone Number.. 902-490-6193
Collection Date........ Nov 25/01
Collector.............. Damon Conrod
Source................. Water

DETERMINATION			RESULT	UNIT	meq/L
Sodium			20.1	mg/L	0.874
Potassium			0.8	mg/L	0.020
Calcium	(R)		5.6	mg/L	0.279
Magnesium	(R)		1.3	mg/L	0.106
Hardness			19.3	mg/L	
Alkalinity (CaCO3)			4.0	mg/L	0.080
Carbonate (CaCO3)			0.00	mg/L	
Bicarbonate (CaCO3)			4.0	mg/L	
Sulfate			14.2	mg/L	0.295
Chloride			32.0	mg/L	0.902
Silica			4.5	mg/L	
Ortho Phosphorus (P)		<	0.01	mg/L	
Nitrate+Nitrite (N)			0.05	mg/L	0.003
Ammonia (N)		<	0.05	mg/L	0.000
Iron	(R)		0.35	mg/L	
Manganese	(R)		0.200	mg/L	
Copper	(R)	<	0.002	mg/L	0.000
Zinc	(R)		0.007	mg/L	0.000
Color			27.7	TCU	
Turbidity			1.26	NTU	
Conductivity			157	µmho/cm	
pH			6.3	units	
Total Organic Carbon			5.4	mg/L	

Cation Sum	1.28	Theo. Conductivity	158
Anion Sum	1.28	Saturation pH 5°C.	10.5
%Difference	0.02	Langelier Index 5°C.	-4.2
Std. Deviation	0.13	Langelier Index 20°C.	-3.8
Ion Sum	81.1	Langelier Index 50°C.	-3.3

(R) Indicates parameter referred out to an accredited laboratory.

Date Received: Nov 26, 2001
Date Issued : Dec 17, 2001

Verified By:

James W. Halliday
Technologist II
Environmental Services

Cost $ 138.00
Invoice to follow

Continued.....

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5788 UNIVERSITY AVENUE, HALIFAX, N. S. B3H 1V8
PHONE 428-3466

Copy To:
Damon Conley
443 Lockview Rd.
Fall River NS
B2T 1J1

Report To:
Halifax Regional Municipality
Kevin Conley
PO Box 1749
Halifax, NS
B3J 3A5

Sample Number : **247661**
Sample Name : **HRM Kevin Conley / Damon Conrod**
Sample Location: **Lake Center**

Client's Phone Number.. 902-490-6193
Collection Date........ Nov 25/01
Collector.............. Damon Conrod
Source................. Water

DETERMINATION		RESULT	UNIT	meq/L
Sodium		21.1	mg/L	0.917
Potassium		0.8	mg/L	0.020
Calcium	(R)	4.3	mg/L	0.214
Magnesium	(R)	1.0	mg/L	0.082
Hardness		14.8	mg/L	
Alkalinity (CaCO3)		2.0	mg/L	0.040
Carbonate (CaCO3)		0.00	mg/L	
Bicarbonate (CaCO3)		2.0	mg/L	
Sulfate		9.9	mg/L	0.205
Chloride		35.0	mg/L	0.987
Silica		2.7	mg/L	
Ortho Phosphorus (P)		< 0.01	mg/L	
Nitrate+Nitrite (N)		< 0.05	mg/L	0.000
Ammonia (N)		< 0.05	mg/L	0.000
Iron	(R)	0.36	mg/L	
Manganese	(R)	0.180	mg/L	
Copper	(R)	< 0.002	mg/L	0.000
Zinc	(R)	0.006	mg/L	0.000
Color		29.0	TCU	
Turbidity		1.56	NTU	
Conductivity		152	µmho/cm	
pH		6.3	units	
Total Organic Carbon		4.7	mg/L	

Cation Sum	1.24	Theo. Conductivity	153
Anion Sum	1.23	Saturation pH 5°C.	10.9
%Difference	0.11	Langelier Index 5°C.	-4.6
Std. Deviation	0.13	Langelier Index 20°C.	-4.2
Ion Sum	76.0	Langelier Index 50°C.	-3.6

(R) Indicates parameter referred out to an accredited laboratory.

Date Received: Nov 26, 2001
Date Issued : Dec 17, 2001

Verified By:

James W. Halliday
Technologist II
Environmental Services

Cost $ 138.00
Invoice to follow

Continued.....

ENVIRONMENTAL CHEMISTRY
DIVISION OF CLINICAL CHEMISTRY
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PHONE 428-3466

Copy To:
Damon Conley
443 Lockview Rd.
Fall River NS
B2T 1J1

Report To:
Halifax Regional Municipality
Kevin Conley
PO Box 1749
Halifax, NS
B3J 3A5

Sample Number : **247662**
Sample Name : **HRM Kevin Conley / Damon Conrod**
Sample Location: **Beach**

Client's Phone Number.. 902-490-6193
Collection Date........ Nov 25/01
Collector.............. Damon Conrod
Source................. Water

DETERMINATION			RESULT	UNIT	meq/L
Sodium			20.8	mg/L	0.904
Potassium			0.7	mg/L	0.017
Calcium	(R)		4.2	mg/L	0.209
Magnesium	(R)		1.0	mg/L	0.082
Hardness			14.6	mg/L	
Alkalinity (CaCO3)			2.8	mg/L	0.056
Carbonate (CaCO3)			0.00	mg/L	
Bicarbonate (CaCO3)			2.80	mg/L	
Sulfate			10.2	mg/L	0.212
Chloride			34.0	mg/L	0.958
Silica			2.7	mg/L	
Ortho Phosphorus (P)		<	0.01	mg/L	
Nitrate+Nitrite (N)		<	0.05	mg/L	0.000
Ammonia (N)		<	0.05	mg/L	0.000
Iron	(R)		0.31	mg/L	
Manganese	(R)		0.170	mg/L	
Copper	(R)	<	0.002	mg/L	0.000
Zinc	(R)		0.006	mg/L	0.000
Color			25.9	TCU	
Turbidity			1.46	NTU	
Conductivity			149	µmho/cm	
pH			6.3	units	
Total Organic Carbon			4.7	mg/L	

Cation Sum	1.22	Theo. Conductivity	151
Anion Sum	1.23	Saturation pH 5°C.	10.7
%Difference	0.49	Langelier Index 5°C.	-4.4
Std. Deviation	0.13	Langelier Index 20°C.	-4.1
Ion Sum	75.3	Langelier Index 50°C.	-3.5

(R) Indicates parameter referred out to an accredited laboratory.

Date Received: Nov 26, 2001
Date Issued : Dec 17, 2001

Verified By:

James W. Halliday
Technologist II
Environmental Services

Cost $ 138.00
Invoice to follow

Continued.....

APPENDIX F

SANDY LAKE WATERSHED - PHOSPHORUS LOADING MODEL
****
(calculations based on Hart et al, 1978, Tech Report No. 2,
Shubenacadie- Stewiacke River Basin Board)
****
P Loading Constants
****

Maximum Spring P corresponding to
given Tropic Status
****

Status	Status No	Max. Conc.
		mg/m^2
OLIGOTROPHIC	1	3.5
OLIGO-MESOTROPIC	2	7
MESO-EUTROPHIC	3	20

****

UNIT P LOAD- MG/M^2/YR
****

PRECIP.	25
FOREST	5.4
+CLEARED	7.8
AG./REC.	10.4
URBAN	22

****

CONTRIBUTION FROM HOUSES WITHIN 300 M OF LAKE

Loading- KG/YR	1.26	This number is based on 0.4 kg P/capita/year (average family size=3.15)
Fraction of Year Cottage Occupied	0.5	

INDIVIDALS SERVED BY STP

Loading- KG/CAP/YR	1.5

LOADING
MODEL
****
VARIABLE
****
Sandy Lake (Bedford)
****

LAKE NUMBER 1
TRIBUTARY LAKES
"
"

LAKE AREA- M^2	740000
WATERSHED AREA- M^2	18200000
Subwatershed area m^2	0
LAKE VOL.- M^3	6079566
MEAN DEPTH- M	8.20
MEAN Q- M/YR	0.98
PERSONS- STP	0
DWELLINGS- ON-SITE	20
AREAS IN M^2	
-FOREST	10556000
-FOREST+CLEAR	3640000
-AGRIC/RECREATION	364000
-URBAN	3640000
RUNOFF VOL.- M^3/YR	1.9E+07
FLUSH.RATE- TIMES/YR	3.05
WATER LOAD- M/YR	25.08
RETENTION COEFF.	0.45
RESPONSE TIME- YR.	0.16

P IN RUNOFF- KG/YR	169.3
P UPSTREAM- KG/YR	0.0
P FROM PRECIP- KG/YR	18.5
P PERSONS-STP- KG/YR	0
P DWELL-O.S.- KG/YR	25.2
P POINT SOURCES	*
TOTAL P LOAD- KG/YR	213.0

DESIRED TROPHIC STATUS	
- 1 to 3 (see table)	2
- Max. SPRING P	7
PERMISSIBLE P- KG/YR	237.0