BC Lake Stewardship and Monitoring Program

Green Lake 2001 - 2004

A partnership between the BC Lake Stewardship Society and the Ministry of Water, Land, and Air Protection

The Importance of Green Lake & its Watershed

British Columbians want lakes to provide good water quality, aesthetics and recreational opportunities. When these features are not apparent in recreational lakes, questions arise. People begin to wonder if the water quality is getting worse, if the lake has been affected by land development, and what conditions will result from more development within the watershed.

The BC Lake Stewardship Society, in partnership with the Ministry of Water, Land, and Air Protection, has designed a program, entitled *The BC Lake Stewardship and Monitoring Program*, to help answer these questions. Through regular water sample collections, we can begin to understand a lake's current water quality, identify the preferred uses for a given lake, and monitor water quality changes resulting from land development within the lake's watershed. There are different levels of lake monitoring and assessment. The level appropriate for a particular lake depends on funding and human resources available. In some cases, data collected as part of a Level I or II program can point to the need for a more in-depth Level III program. This report gives the 2001-2004 results of a Level II program for Green Lake.

Through regular status reports, this program can provide communities with monitoring results specific to their local lake and with educational material on lake protection issues in general. This useful information can help communities play a more active role in the protection of the lake resource. Finally, this program allows government to use its limited resources efficiently thanks to the help of area volunteers and the BC Lake Stewardship Society.

The watershed area of Green Lake is over 708 km^2. A **watershed** is defined as the entire area of land that moves the water it receives to a common waterbody. The term watershed is misused when describing only the land immediately around a waterbody or the waterbody itself. The true definition represents a much larger area than most people normally consider.

Watersheds are where much of the ongoing hydrological cycle takes place and play a crucial role in the purification of water. Although no "new" water is ever made, it is continuously recycled as it moves through watersheds and other hydrologic compartments. The quality of the water resource is largely determined by a watershed's capacity to buffer impacts and absorb pollution.

Every component of a watershed (vegetation, soil, wildlife, etc.) has an important function in maintaining good water quality and a healthy aquatic environment. It is a common misconception that detrimental land use practices will not impact water quality if they are kept away from the area immediately surrounding a water body. Poor land-use practices anywhere in a watershed can eventually impact the water quality of the downstream environment.

Human activities that impact water bodies range from small but widespread and numerous *non-point* sources throughout the watershed to large *point* sources of concentrated pollution (e.g. waste discharge outfalls, spills, etc). Undisturbed watersheds have the ability to purify water and repair small amounts of damage from pollution and alterations. However, modifications to the landscape and increased levels of pollution impair this ability.

Green Lake is located approximately 16 km northeast of 70 Mile House. The lake is one of the largest water bodies in the southern part of the Cariboo Plateau and measures approximately 14 km long, with an average of 1.5 km in width, and a maximum depth of 36 m. Its surface area is 2307 hectares and the shoreline perimeter is 65 km. Green Lake contains Kokanee, Rainbow Trout, Lake Chub, Longnose Dace, and White and Bridgelip Sucker. The lake is restocked with Rainbow Trout annually.

Green Lake Watershed Characteristics

Land use around the lake is made up of residential/developed areas, open rangeland, and mixed forests of Aspen and Lodgepole Pine, with a provincial park encompassing 347 hectares of the watershed. Green Lake Provincial Park contains three campgrounds, which are spread out along separate shores of the lake. The lake is also surrounded with a variety of other resorts and dude ranches.

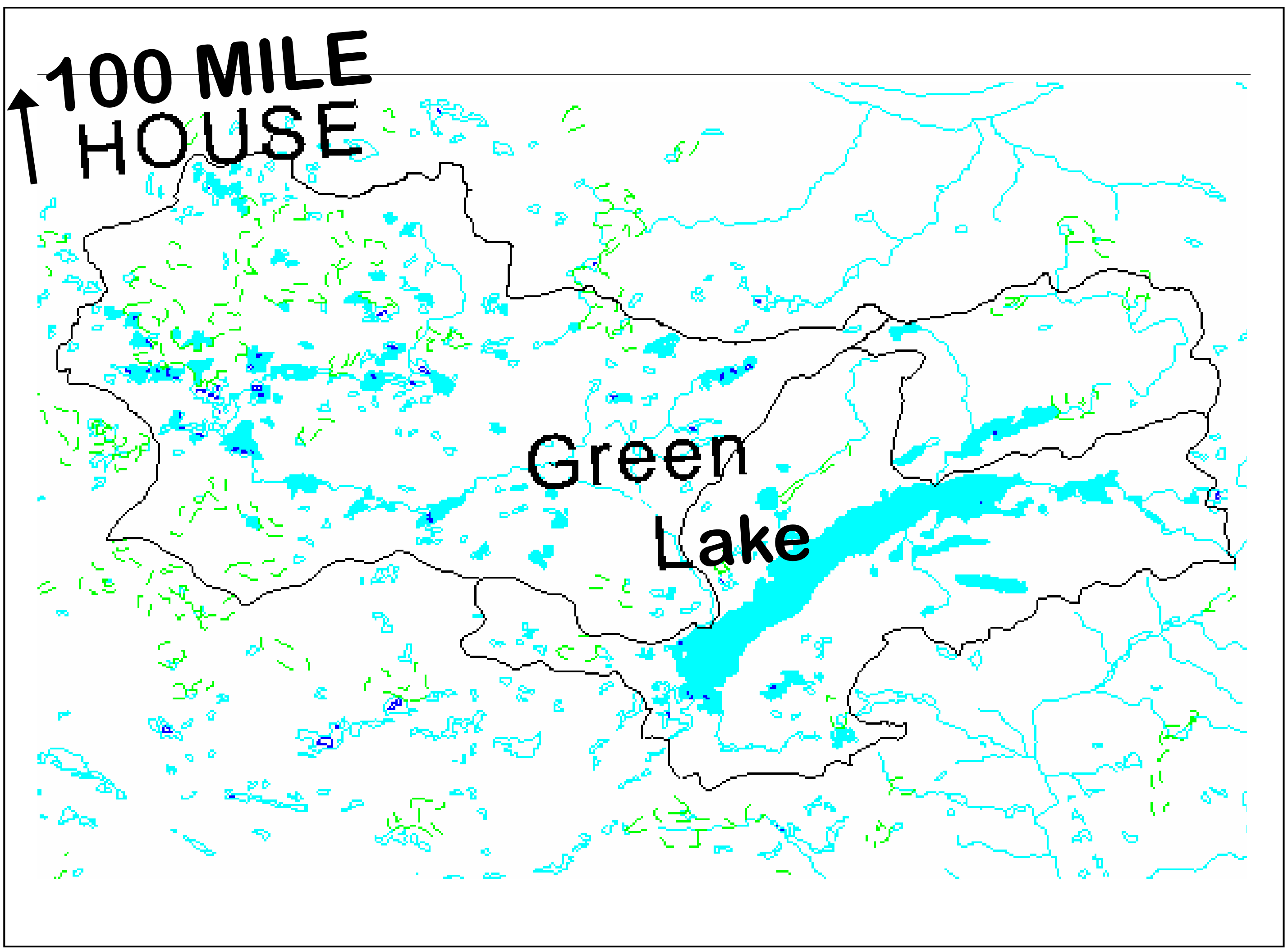
For the most part, Green Lake is quite shallow (mean depth 10.3 meters), making it ideal for recreational activities including: swimming, boating, fishing, waterskiing, and paddling. Some residents use lake water as a potable water supply.

The greatest challenge to the lake is phosphorus (nutrient) loading as well as high pH levels during periods of low lake levels. This loading may promote summer algal blooms and the spread of aquatic plants. Marl precipitation events in the early summer help to remove phosphorus into the lake sediments maintaining relatively high water clarity.

Green Lake Watershed Map

Watershed Area: 708.96 km^2

Land Use:
15% Residential/Developed
35% Agricultural
20% Forestry
30% Undisturbed



Non-Point Source Pollution and Green Lake

Point source pollution originates from municipal or industrial effluent outfalls. Other pollution sources exist over broader areas and may be hard to isolate as distinct effluents. These are referred to as non-point sources of pollution (NPS). Shoreline modification, urban stormwater runoff, onsite septic systems, agriculture, and forestry are common contributors to NPS pollution. One of the most detrimental effects of NPS pollution is phosphorus loading to water bodies. The amount of total phosphorus (TP) in a lake can be greatly influenced by human activities. If local soils and vegetation do not retain this phosphorus, it will enter watercourses where it will become available for algal production.

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Agriculture

Agriculture is economically and culturally important. When practices are improperly managed, however, there can be significant NPS impacts, such as nutrients and pathogens from manure and damage to shorelines from livestock access.

Onsite Septic Systems and Grey Water

Onsite septic systems effectively treat human waste water and wash water (grey water) as long as they are properly located, designed, installed, and maintained. When these systems fail, they become significant sources of nutrients and pathogens. Poorly maintained pit privies, used for the disposal of human waste and grey water, can also be significant contributors.

Stormwater Runoff

Over-fertilizing of lawns and gardens, oil and fuel leaks from vehicles , snowmobiles and boats, road salt, and litter are all washed by rain and snowmelt from our yards and streets. Pavement increases runoff of surface water and the amount of contaminants entering water bodies. Pavement collects contaminants during dry weather, and prevents water from soaking into the ground during storm events. Phosphorus and sediment are of greatest concern, providing nutrients and/or a rooting medium for aquatic plants and algae.

Forestry

Forestry, which includes clear cutting, road building and other land disturbances is essential to the economy, however it can increase sediment and phosphorus, and alter water flow.

Boating

Oil and fuel leaks are the main concerns of boat operation on small lakes. With larger boats, sewage and grey water discharges are issues. Other problems include the spread of aquatic plants and the dumping of litter. In shallow water operations, the churning up of bottom sediments and nutrients is a serious concern.

Green Lake Bathymetric Map

Map obtained from
www.fishwizard.com (2004)

What's Going on Inside Green Lake?

Temperature

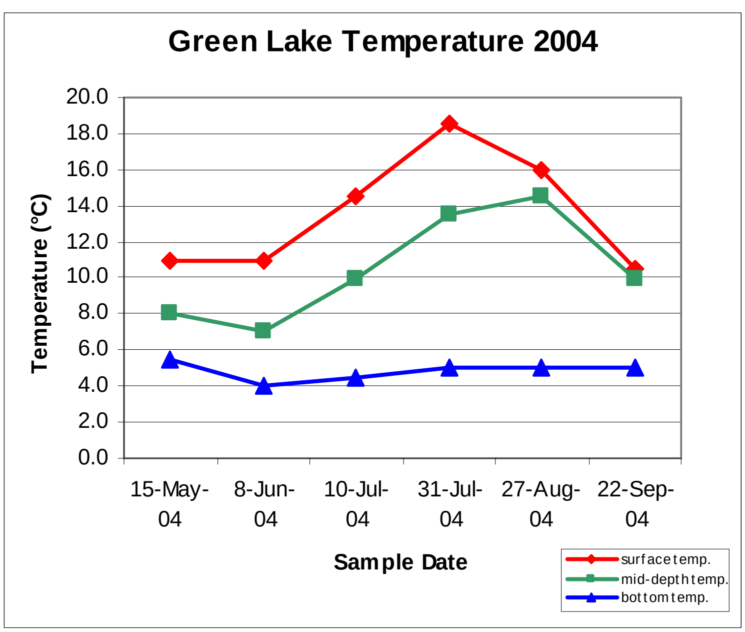
BC lakes can show a variety of annual temperature patterns based on their location and depth. Most interior lakes form layers (stratify), with the coldest water near the bottom. Because colder water is more dense, it resists mixing into the warmer, upper layer for much of the summer. When the warmer oxygen rich surface water distinctly separates from the cold oxygen poor water in the deeper parts of the lake, it is said to create a thermocline, a region of rapid temperature change between the two layers.

In spring and fall, these lakes usually mix from top to bottom (overturn) as wind energy overcomes the reduced temperature and density differences between surface and bottom waters. In the winter, lakes re-stratify under floating ice with the densest water (4°C) near the bottom. Because these types of lakes turn over twice per year, they are called dimictic lakes. These are the most common type of lake in British Columbia.

Coastal lakes in BC are more often termed warm monomictic lakes. These lakes turn over once per year. Warm monomictic lakes have temperatures that do not fall below 4°C in the winter and stratify in the summer.

The timing of freeze up and break up of BC lakes is important information for climate change research. BCLSS is interested in this information. If these dates have been recorded in the past, please send the information to BCLSS so that it can be incorporated into climate change studies.

Temperature stratification patterns are very important to lake water quality. They determine much of the seasonal oxygen, phosphorus, and algal conditions. Continuously monitored surface temperature can provide us with information not only on algal blooms, but also provide important data to climate change studies.



The preceding figure illustrates Green Lake's temperature patterns for 2004. The lake was stratified in early May and by October the upper and mid depth temperatures were decreasing and approaching the temperature of the bottom depth, indicating fall overturn would likely begin in the following weeks. The surface temperature reached a high of 18.5 °C, on July 31.

2001-2003 showed similar readings to those of 2004, with the highest reading at 21 °C taken on August 6, 2003. Sampling in 2001 started on May 3, which was early enough to take samples while the lake was still mixed following spring overturn. The subsequent sample date for that year was in late May and showed the lake had stratified. This agrees with data collected in 2002-2004, in which sampling did not begin until after overturn (in late may in 2002 and 2004, and in July in 2003).

Trophic Status

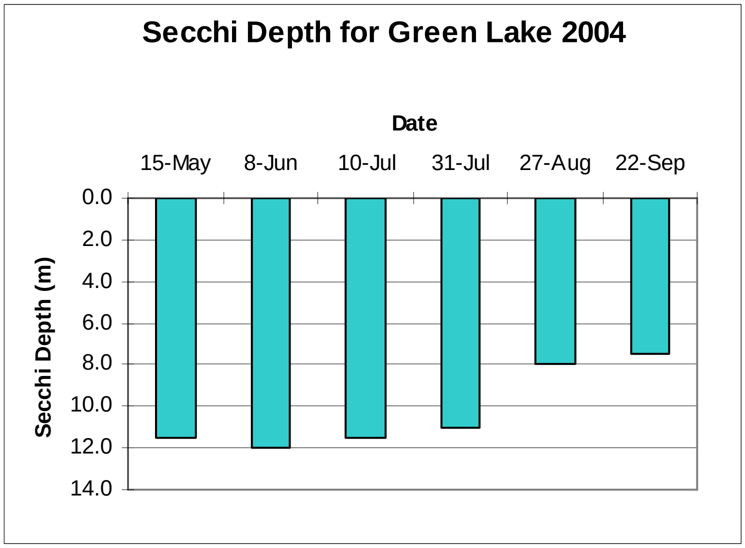
The term *trophic status* is used to describe a lake's level of productivity and depends on the amount of nutrients available for plant growth, including tiny floating algae called phytoplankton. Trophic status is often determined by measuring levels of phosphorus, algal chlorophyll A (the green photosynthetic pigment), and water clarity. Establishing the trophic condition of a lake allows inter-lake comparisons and general biological and chemical attributes of a lake to be estimated.

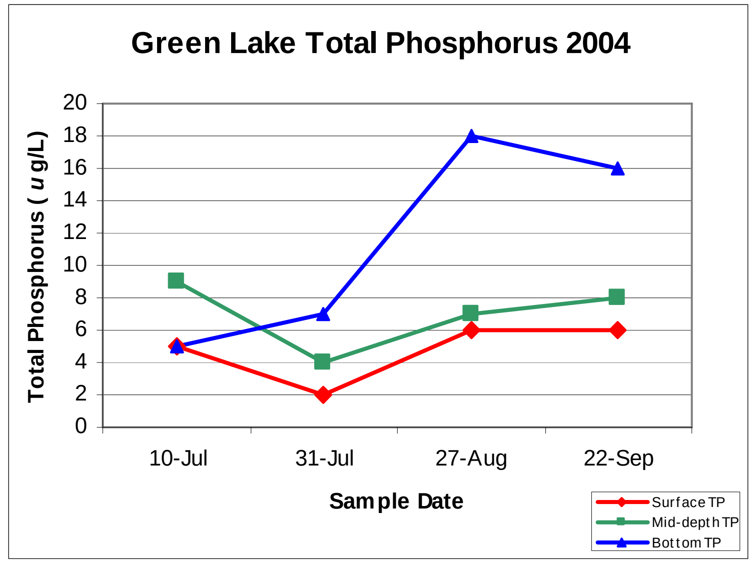
Lakes of low productivity are referred to as ***oligotrophic***, meaning they are typically clear water lakes with low nutrient levels (1-10 *u*g/L TP), sparse plant life and low fish production. Lakes of high productivity are ***eutrophic***. They have abundant plant life including algae, because of higher nutrient levels (>30 *u*g/L TP). Lakes with an intermediate productivity are called ***mesotrophic*** (10-30 *u*g/L TP) and generally combine the qualities of oligotrophic and eutrophic lakes.

Water Clarity

One method of determining productivity is by measuring water clarity. The more productive a lake is, the higher the algal growth, and, therefore, the less clear the water becomes. The clarity of the water can be evaluated by using a ***Secchi disk***, a black and white disk that measures the depth of light penetration. The greater the ***Secchi depth*** the greater the water clarity.

In 2004 Secchi depth measurements were above the minimum level of 6 meters for oligotrophic, or unproductive, lakes. Water clarity was good throughout the sampling period with the shallowest reading at 7.5 meters in the fall. The average summer Secchi depth for Green Lake ranged from 8.1 m to 10.3 m from 2001 to 2004, indicating that Green Lake is oligotrophic.





Phosphorus

As mentioned previously, productivity can also determined by measuring phosphorus levels. Phosphorus concentrations measured during spring overturn can be used to predict summer algal productivity. Productivity is dependant on the amount of nutrients (phosphorus and nitrogen) in a lake, which are essential for plant growth, including algae. Algae are important to the overall ecology of a lake because they are the food for zooplankton, which in turn are the food for other organisms, including fish. In most lakes phosphorus is the nutrient in shortest supply and thus acts to limit the production of aquatic life. When in excess, however, phosphorus accelerates growth and artificially ages a lake. Total phosphorus (TP) in a lake can be greatly influenced by human activities. Marl precipitation events (discussed on next page) in the early summer help move phosphorus into the lake sediments maintaining relatively high water clarity.

Lake sediments can themselves be a major source of phosphorus. If deep-water oxygen becomes depleted, a chemical shift occurs in bottom sediments. This shift causes sediment to release phosphorus to overlying waters. This *internal loading* of phosphorus can be natural but is often the result of phosphorus pollution. Lakes displaying internal loading have elevated algal levels and generally lack recreational appeal.

As seen in the following graph, Green Lake TP surface and mid-depth concentrations are between 2 ug/L and 9 ug/L, which falls within the range for an oligotrophic lake.

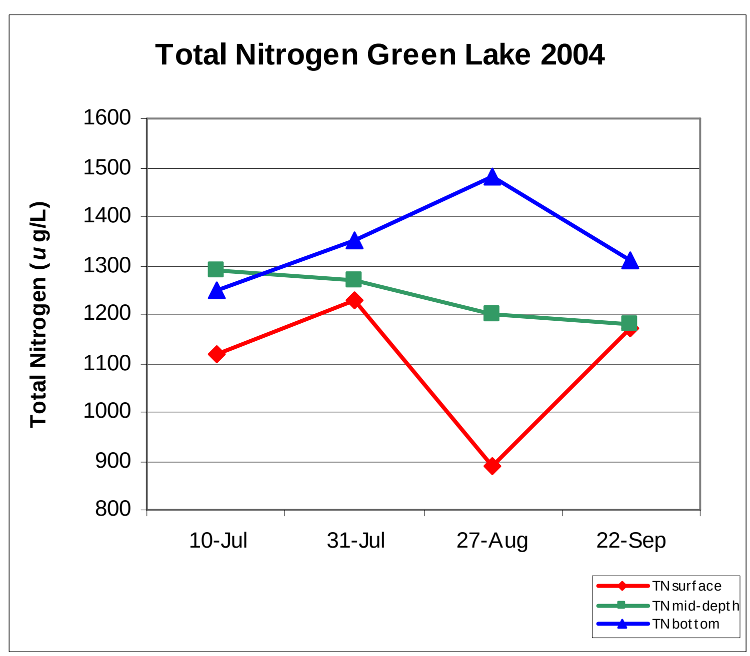
Trends in phosphorus concentrations throughout the water column were as expected. The higher levels of phosphorus in the bottom depths were likely due to decomposing algae, which take up phosphorus in surface waters, then sink and die. On the last sampling date, the phosphorus concentrations were still higher at the bottom than the surface and mid-depths, reflecting that fall turnover had not yet occurred.

The average summer surface TP was 4.8 *u*g/L, up from 2.5 *u*g/L in 2003. In 2002 and 2001, the averages were 6.4 *u*g/L and 4.6 *u*g/L, respectively. Taking into consideration that only four samples were collected in the 2004 and 2003 seasons, it appears that phosphorus levels have not changed significantly from 2001 to 2004.

Nitrogen

Nitrogen is the second most important nutrient involved in lake productivity. In BC lakes, nitrogen is rarely the limiting nutrient for algae growth (see phosphorus). In most lakes, the ratio of nitrogen to phosphorus is well over 15:1, meaning excess nitrogen is present. In lakes where the N:P is less than 5:1, nitrogen becomes limiting to algae growth and can have major impacts on the amount and species of algae present.

As shown in the following graph, total nitrogen (TN) concentrations were relatively constant and similar at all depths over most of the sampling period, with the exception of the sample



taken on August 27. The peak in nitrogen at the bottom depth could be due to the isolation of the deeper water as a result of thermal stratification. The sharp decline in nitrogen at the surface on that date is likely due to sampling error..

Not considering the surface TN value from August 27, the surface and mid-depth TN concentrations ranged from 1120 - 1290 *u*g/L. Bottom TN values ranged from 1250 - 1480 *u*g/L.

The N:P ratio is approximately 232:1, which means the lake is a phosphorus limited system. Although an increase in nitrogen should not increase algae biomass, it could result in a change to the species of algae present, possibly to a less desirable species.

The average summer surface TN in 2004 was 1103 *u*g/L. In 2003, 2002 and 2001, the average summer surface TN was 1115 *u*g/L, 1027 *u*g/L, and 1108 *u*g/L, respectively. This indicates that nitrogen concentrations have remained relatively stable since 2001.

Marl Lakes

The climate, hydrology, and basin geology within a watershed help to determine the chemistry of a lake. The chemical composition of the water helps to determine the types of species that can survive there and the water's recreational and drinking water value. Human activity within the watershed can also have an impact on the chemical composition of a lake. Some lakes, such as hardwater lakes, have a natural way of combating problems such as acidification.

Hardwater lakes have a high pH level, which causes calcium carbonate to precipitate and remove phosphorus from the water column by adsorption of phosphorus to the calcium carbonate. One type of hardwater lake is a marl lake. Marl lakes are generally saturated with calcium and carbonate ions. The sediment of these lakes consist of marl, a soft-textured mixture of clay, sand, and limestone. When the calcium carbonate in these lakes begins to precipitate, phosphorus is effectively removed as a co-precipitate. Therefore, these lakes can reduce the impact of phosphorus loading from sources such as septic systems, livestock, domestic gardening, car washing, and agriculture. In other words, marl lakes are more resistant to eutrophication.

But how do we decide if a lake is a marl lake or not? There are a few qualities that we can use to determine this. The first is a visible shift from dark blue/green to extreme turquoise colour during periods of warmer temperatures. Tiny particles remain suspended in the water, refracting light and causing the lake to turn a light aquamarine (lake whitening). Another quality of a marl lake is high calcium concentrations in the sediment, especially in the shallower areas. These sediments are often lighter in colour due to the increased amount of limestone (calcium carbonate).

Since phosphate precipitates with calcium, marl lakes generally have low phosphorus levels and good water clarity. Calcium carbonate precipitates can be observed on vegetation and along the lake's edge. The presence of *Chara* species also indicates the possibility of a marl lake. Charophytes are a type of large, structurally complex green algae that attach to substrates. The rhizoids that enable this attachment play an important role in the absorption of nutrients and extraction of calcium carbonate.

Many hardwater lakes in the interior dry belt of British Columbia can be classified as marl lakes, including Green Lake.

Should Further Monitoring Be Done on Green Lake?

The data collected on Green Lake indicates that the water quality has remained relatively stable in terms of Secchi depth and nitrogen and phosphorus concentrations over the last four years. As a marl lake, Green Lake has the ability to limit the amount of available phosphorus. This helps protect it against algal blooms and other problems associated with high levels of phosphorus. However, all residents and land developers within the watershed are advised to continue to practice good land management so that nutrient migration to the lake and its tributaries is minimized.

It would be worthwhile to continue monitoring Secchi, temperature, phosphorus and nitrogen with an effort to begin sampling earlier in the year to collect spring overturn data. Testing for dissolved oxygen at multiple depths is recommended. These measurements would provide additional information on lake trophic status and determine habitat availability for Kokanee and Rainbow Trout.

In addition to continued monitoring, ice-on and ice-off dates should be recorded for climate change studies.

Tips to Keep Green Lake Healthy

Yard Maintenance, Landscaping & Gardening

- Minimize the disturbance of shoreline areas by maintaining natural vegetation cover.
- Minimize high-maintenance grassed areas.
- Replant lakeside grassed areas with native vegetation.
- Do not import fine fill.
- Use paving stones instead of pavement.
- Stop or limit the use of fertilizers and pesticides.
- Do not use fertilizers in areas where the potential for water contamination is high, such as sandy soils, steep slopes, or compacted soils.
- Do not apply fertilizers or pesticides before or during rain due to the likelihood of runoff.
- Hand pull weeds rather than using herbicides.
- Use natural insecticides such as diatomaceous earth. Prune infested vegetation and use natural predators to keep pests in check. Pesticides can kill beneficial and desirable insects, such as lady bugs, as well as pests.
- Compost yard and kitchen waste and use it to boost your garden's health as an alternative to chemical fertilizers.

Agriculture

- Locate confined animal facilities away from waterbodies. Divert incoming water and treat outgoing effluent from these facilities.
- Limit the use of fertilizers and pesticides.
- Construct adequate manure storage facilities.
- Do not spread manure during wet weather, on frozen ground, in low-lying areas prone to flooding, within 3 m of ditches, 5 m of streams, 30 m of wells, or on land where runoff is likely to occur.
- Install barrier fencing to prevent livestock from grazing on streambanks and lakeshore.
- If livestock cross streams, provide graveled or hardened access points.
- Provide alternate watering systems, such as troughs, dugouts, or nose pumps for livestock.
- Maintain or create a buffer zone of vegetation along a streambank, river or lakeshore and avoid planting crops right up to the edge of a waterbody.

Onsite Sewage Systems

- Inspect your system yearly, and have the septic tank pumped every 2 to 5 years by a septic service company. Regular pumping is cheaper than having to rebuild a drain-field.
- Use phosphate-free soaps and detergents.
- Don't put toxic chemicals (paints, varnishes, thinners, waste oils, photographic solutions, or pesticides) down the drain because they can kill the bacteria at work in your onsite sewage system and can contaminate waterbodies.
- Conserve water: run the washing machine and dishwasher only when full and use only low-flow showerheads and toilets.

Auto Maintenance

- Use a drop cloth if you fix problems yourself.
- Recycle used motor oil, antifreeze, and batteries.
- Use phosphate-free biodegradable products to clean your car. Wash your car over gravel or grassy areas, but not over sewage systems.

Boating

- Do not throw trash overboard or use lakes or other waterbodies as toilets.
- Use biodegradable, phosphate-free cleaners instead of harmful chemicals.
- Conduct major maintenance chores on land.
- Use absorbent bilge pads to soak up minor leaks or spills.
- Check for and remove all aquatic plant fragments from boats and trailers before entering or leaving a lake.
- Do not use metal drums in dock construction. They rust, sink and become unwanted debris. Use Styrofoam or washed plastic barrel floats. All floats should be labeled with the owner's name, phone number and confirmation that barrels have been properly emptied and washed.

Who to Contact for More Information

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Acknowledgements

Volunteer Monitoring by:
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Data Compiling by:
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Brochure Produced by:
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Bathymetric Map:
FishWizard

Photo Credit:
Tom Voyt
www.shared-visions.com/explore/bc/Green Lake.html