B.C. Volunteer Lake Monitoring Program
NALTESBY (BOBTAIL) LAKE
2001 - 2002

The Importance of Naltesby Lake & its Watershed

British Columbians want lakes to provide good water quality, aesthetics and recreational opportunity. When the public is unable to see these features in our local lakes, we want to know why. What changes are taking place that are affecting water quality? What uses can be made of the lake today? And, what conditions will result from more changes within the watershed?

The Ministry of Environment's Volunteer Lake Monitoring Program (VLMP), in collaboration with the non-profit B.C. Lake Stewardship Society, is designed to help answer these questions. Through regular water sample collections, we can come to understand a lake's current water quality, identify the most sensitive uses for a given lake, and monitor water quality changes.

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. Naltesby Lake's watershed is 208 km^2 and is shown on the next page.

Watersheds are where much of the ongoing hydrological cycle takes place and play a crucial role in the purification of water. The quality of the water resource is largely determined by a watershed's capacity to buffer impacts and absorb pollution. This buffering capacity can be decreased by changing land use activities.

Through regular status reports, the VLMP 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 as land development activity is seen to be a contributor to water quality degradation. Finally, the VLMP allows government to use its limited resources efficiently thanks to the help of area volunteers and the B.C. Lake Stewardship Society.

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 down stream environment.

Naltesby Lake's VLMP program began in 2001 and has been conducted by a group of volunteer residents who have interest in the lake. This status report summarizes information derived from this program. Quality of the data has been found to be acceptable. Data quality information is available on request.

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. outfalls, spills, etc.). Undisturbed watersheds have the ability to purify water and repair small amounts of damage from pollution and alteration. However, modifications to the landscape and increased levels of pollution impair this ability.

Naltesby Lake is located in the Omineca-Peace region near Highway 16, approximately 100 km west of Prince George, B.C. The lake is roughly 10 km long with maximum and mean depths of 20.1 m and 10.8 m, respectively. It has a surface area of 8.4 km^2 and a shoreline perimeter of 29 km. The map below shows the Naltesby Lake watershed and associated forestry activities (the predominant land use activity). There are many small drainages entering the lake that pass through harvested areas, which all have the potential to impact lake water quality. Many of these small tributaries do pass through small wetlands and ponds prior to entering the lake, which are expected to help buffer some of the anticipated forestry impact. In addition, Naltesby Lake likely benefits from a relatively fast flushing rate with a lake retention time of approximately 3.4 years.

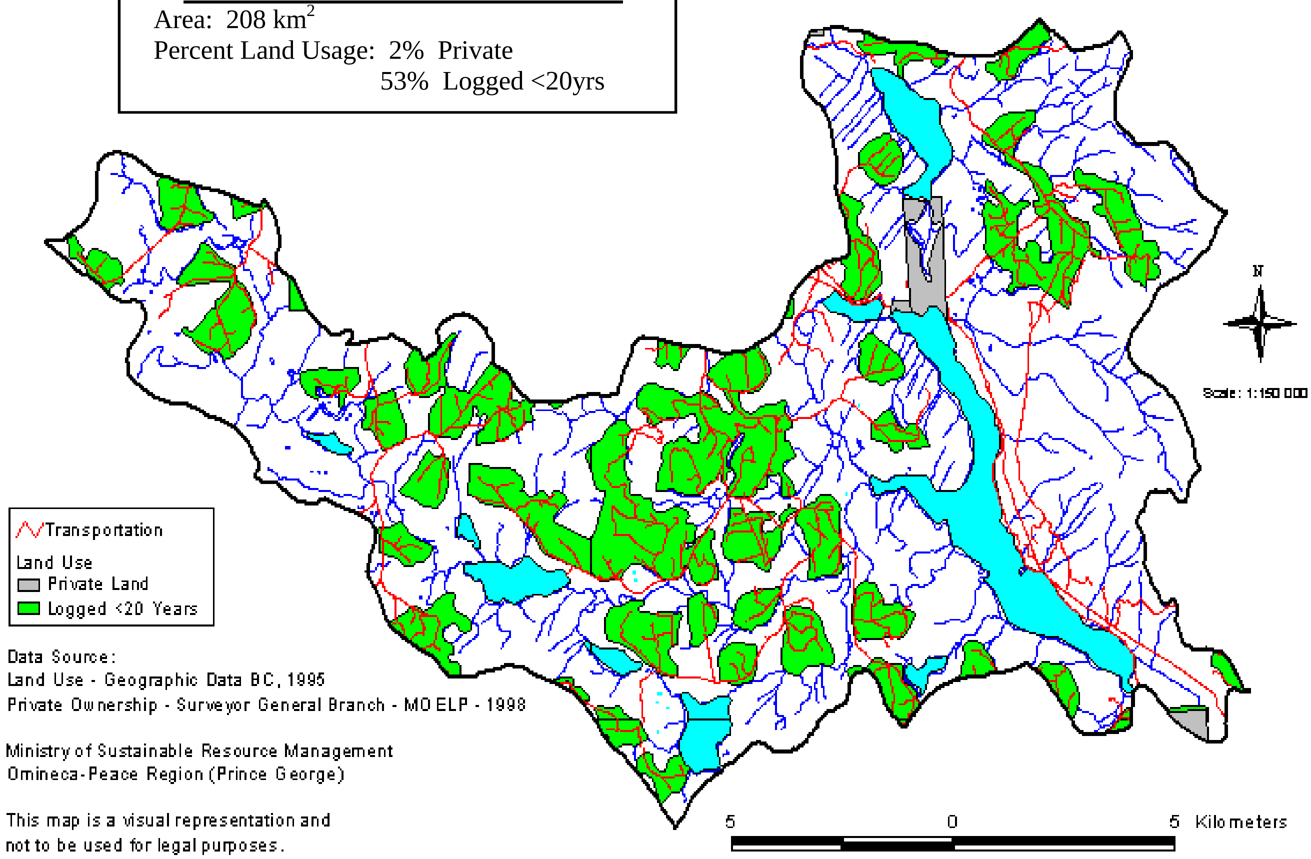
Naltesby Lake contains the following sport fish: burbot (*Lota lota*), mountain whitefish (*Prosopium williamsoni*), rainbow trout (*Oncorhynchus mykiss*), and kokanee (*Oncorhynchus nerka)*. The lake was last stocked with approximately 10,000 rainbow trout in 2004.

Land use within the watershed includes lakeshore development (~50 residences) and forestry. The lake has multiple forest recreation sites, a public boat launch and numerous hiking trails. The greatest challenge to lake management is likely the control of phosphorus (nutrient) loading. This loading may promote summer algal blooms and the spread of aquatic plants. More specifically, there was a large algal bloom in July of 2000, when *Oscillatoria tenuis* and *Lyngbya limnetica* (blue-green algae/cyanobacteria) flourished, causing turbid, brown lake water. Although lake residents filed complaints with MOE in July of 2000 suggesting the brown colour in the lake was due to forestry activities, water samples collected by MOE found the brown coloured water contained only organic particles. Sediment entering the lake from surrounding forest activities would probably have a large inorganic content. This suggests the brown colour in July 2000 was probably attributable to the cyanobacterial bloom. This bloom resulted in a minor fish kill of approximately 50-100 peamouth chub, with MOE field staff suggesting starvation as the cause. Fisheries staff believe the intensity of the bloom might have prevented these chub from effectively feeding on prey, rather than succumbing to dissolved oxygen sags or the creation of cyanotoxins.

MOE samples collected in 1995 also indicated the presence of *Oscillatoria tenuis* and *Lyngbya limnetica*, which were collected after lake residents complained. So, although these blooms don't appear to occur every year, they have occurred more than once. These blooms likely resulted from ideal weather conditions. Certain cyanobacterial species, particularly *Oscillatoria tenuis*, are known to take advantage of warm, light-limited water columns, possibly influenced by heavy precipitation. By using their gas vacuole to move to the top of the water column where light is most intense, cyanobacteria can out-compete other phytoplankton and algal species. A sediment core was collected in 2001 from Naltesby Lake that helps infer historical lake conditions (refer to page 6) and past algal activity. Algal pigment analysis done on this core suggests no significant shifts in cyanobacterial abundance during the past 200 years, and that any major shifts that did occur were random, with no particular pattern. These algal blooms have been occurring during the life of the lake, with some of the most intense blooms occurring around 1850, prior to large scale forest harvesting.

Naltesby Lake Watershed and Land Use Map

WATERSHED CHARACTERISTICS
Area: 208 km^2
Percent Land Usage: 2% Private
53% Logged <20yrs



Non-Point Source Pollution and Naltesby 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.

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 may 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

Lawn and garden fertilizer, sediment eroded from modified shorelines or infill projects, oil and fuel leaks from vehicles and boats, road salt, and litter can all be washed by rain and snowmelt from properties and streets into watercourses. Phosphorus and sediment are of greatest concern, providing nutrients and/or rooting medium for aquatic plants and algae. Pavement prevents water infiltration to soils, collects hydrocarbon contaminants during dry weather and increases direct runoff of these contaminants to lakes during storm events.

Tree Harvesting

Harvesting can include clear cutting, road building and land disturbances, which may alter water flow and increase sediment and phosphorus inputs to water bodies.

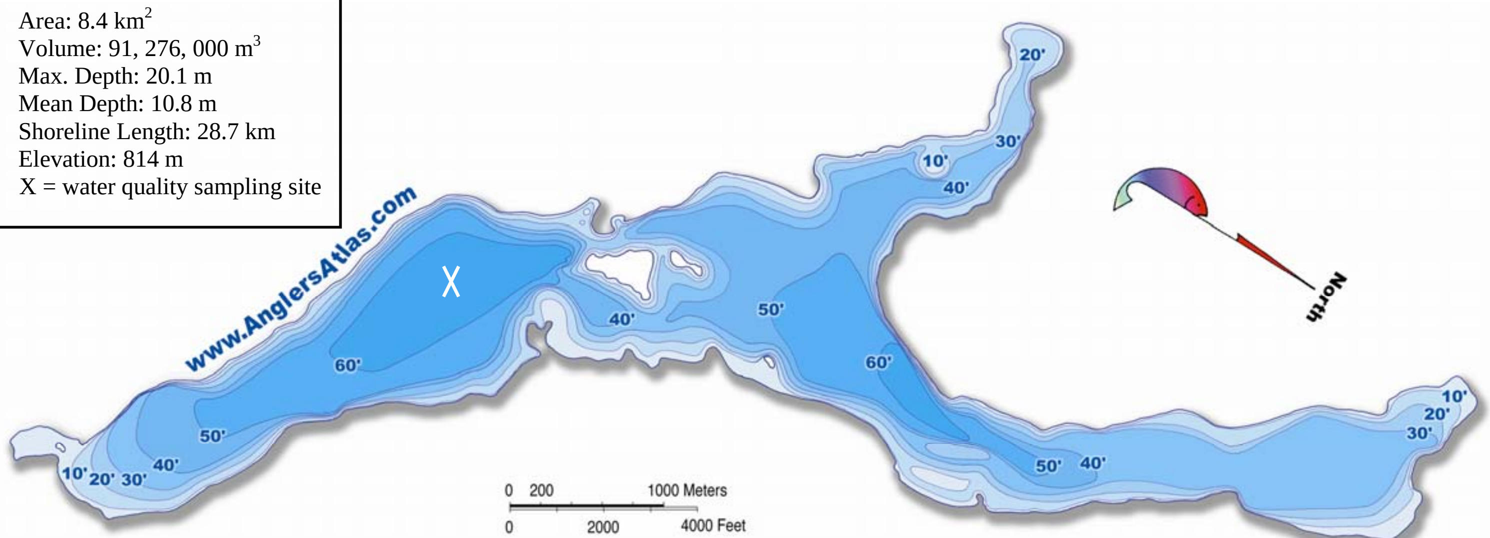
Boating

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

Naltesby Lake Contour Map

LAKE CHARACTERISTICS

Area: 8.4 km^2
Volume: 91, 276, 000 m^3
Max. Depth: 20.1 m
Mean Depth: 10.8 m
Shoreline Length: 28.7 km
Elevation: 814 m
X = water quality sampling site



NALTESBY LAKE TROPHIC CHARACTERISTICS

	2001	2002
Max. Surface Temp (°C):	18	16
Min. Near-bottom Oxygen (mg/L):	0.5	0.0
Spring Overturn TP (µg/L):	59	30
Avg. Chlorophyll a (µg/L):	10.4	21.9
Avg. Secchi Depth (m):	1.6	1.1

What's Going on Inside Naltesby Lake?

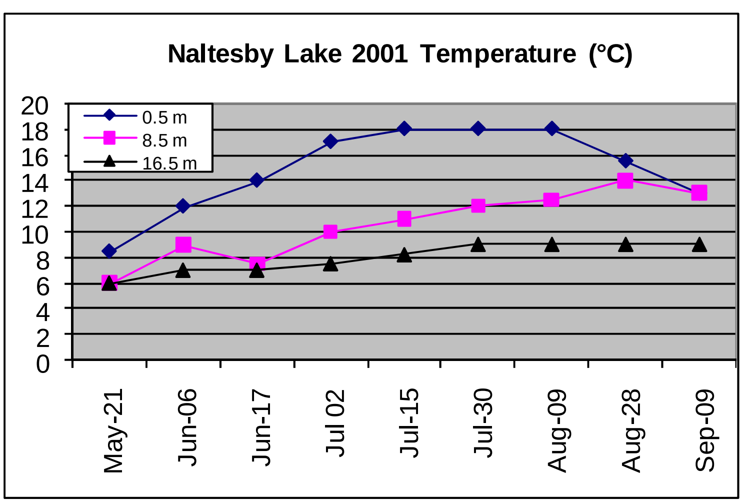
Temperature

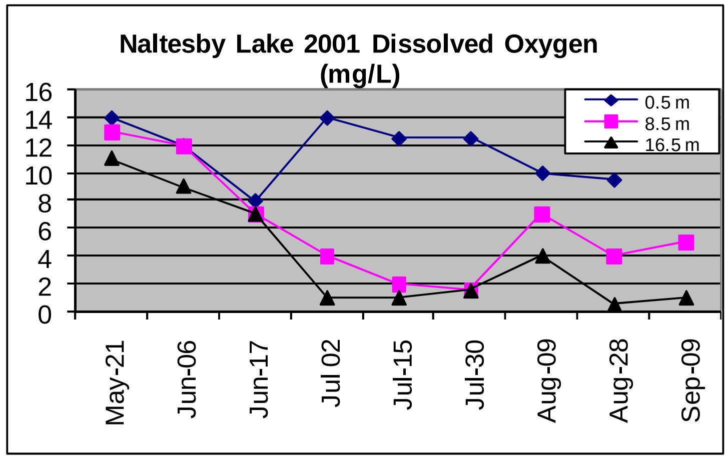
Lakes show a variety of annual temperature patterns based on each lake's location and depth. Most interior lakes form layers (stratify), with the coldest summer water near the bottom. Because cold water is more dense, it resists mixing into the warmer, upper layer for much of the summer. In spring and 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 ice with the most dense water (4°C) near the bottom.

Lakes of only a few metres depth tend to mix throughout the summer or layer only temporarily, depending on wind conditions. In winter, the temperature pattern of these lakes is similar to that of deeper lakes.

Temperature stratification patterns are very important to lake water quality. They determine much of the seasonal oxygen, phosphorus and algal conditions. When abundant, algae can create problems for most lake users.

Temperature was measured in the south basin of Naltesby Lake in 2001 and 2002. The figure below illustrates Naltesby Lake water temperatures for 2001. This figure is similar to the data collected in 2002; however, water temperatures at all depths were slightly higher in 2001 compared to 2002. Maximum water temperatures varied by 2 °C between the two years, as indicated on page 3. According to the graph below, the lake appears to stratify in early May and holds this stratification throughout the summer (due to the presence of a strong temperature gradient that resists vertical mixing). Because the lake holds this stratification during the summer, and experiences two turnover events (one in the spring and one in the fall), it is termed a dimictic lake. Shorter days and cooling air temperatures through September contribute to the de-stratification of the water column, leaving the water temperature nearly uniform with depth, followed by decreasing water temperatures throughout the fall.





Dissolved Oxygen

Oxygen is essential to life in lakes. It enters lake water from the air by wind action and plant photosynthesis. Oxygen is consumed by respiration of animals and plants, including the decomposition of dead organisms by bacteria. A great deal can be learned about the health of a lake by studying oxygen patterns and levels.

Lakes that are unproductive (oligotrophic) will have sufficient oxygen to support life at all depths through the year. But as lakes become more productive (eutrophic), and increasing quantities of plants and animals respire and decay, more oxygen consumption occurs, especially near the bottom where dead organisms accumulate.

In productive lakes oxygen in the isolated bottom layer may deplete rapidly (often to anoxia), forcing fish to move into the upper layer (fish are stressed when oxygen falls below about 20% saturation). Fish kills can occur when decomposing or respiring algae use up the oxygen. In summer, this can happen on calm nights after an algal bloom, but most fish kills occur during late winter or at initial spring mixing.

The figure above shows the oxygen patterns for Naltesby Lake in 2001. Surface water oxygen remained near saturation for most of the summer, not dropping below 8 mg/L. The south basin displayed declines in mid-depth and bottom oxygen to 1.5 and 0.5 mg/L, respectively. This bottom depletion existed during July and August, influenced by the strong temperature gradient and the lack of mixing with surface water. The bottom waters, with less than 4 mg/L oxygen, would not have supported fish for a period of roughly two months. This duration of bottom anoxia suggests that internal phosphorus loading would have occurred for over two months (refer to page 5 for a more in-depth look at internal phosphorus loading). Vertical mixing and the aeration of bottom waters probably occurred with the onset of cooler fall temperatures in mid-September (data was not collected past September 9th, 2001). The 2002 dissolved oxygen data showed similar results to 2001, with low oxygen levels in the middle and bottom depths during most of the summer. However, unlike 2001, when surface oxygen remained above 8 mg/L, there was a decline in dissolved oxygen during September, when levels dropped to around 2 mg/L. This low level dissolved oxygen reading occurred around the same time as fall turnover, which suggests as the lake was mixing and low level bottom dissolved oxygen was being circulated throughout the lake, the surface dissolved oxygen dropped.

What's Going on Inside Naltesby Lake?

Trophic Status and Phosphorus

The term "trophic status" is used to describe a lake's level of productivity and depends on the amount of nutrient available for plant growth, including tiny floating algae called phytoplankton. Algae are important to the overall ecology of lakes because they are food for zooplankton, which in turn are 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, phosphorus accelerates growth and may artificially age a lake. As mentioned earlier (page 3), total phosphorus (TP) in a lake can be greatly influenced by human activities.

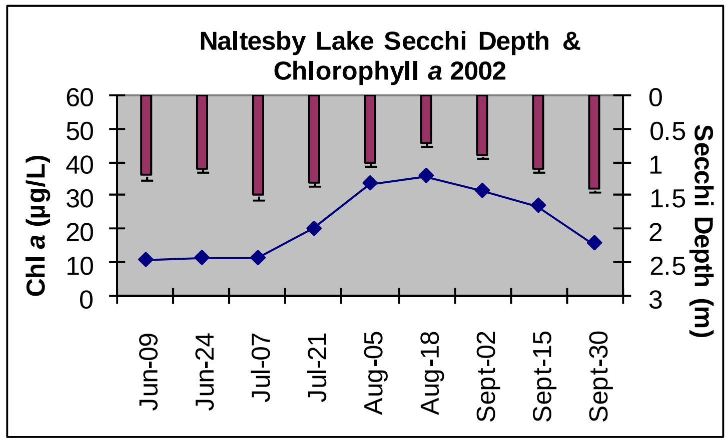
The trophic status of a lake can be determined by measuring productivity. The more productive a lake is the higher the algal growth and therefore the less clear the water becomes. Water clarity is measured using a ***Secchi disc***. Productivity is also determined by measuring nutrient levels and ***chlorophyll a*** (the green photosynthetic pigment of algae). Phosphorus concentrations measured during spring overturn can be used to predict summer algae productivity.

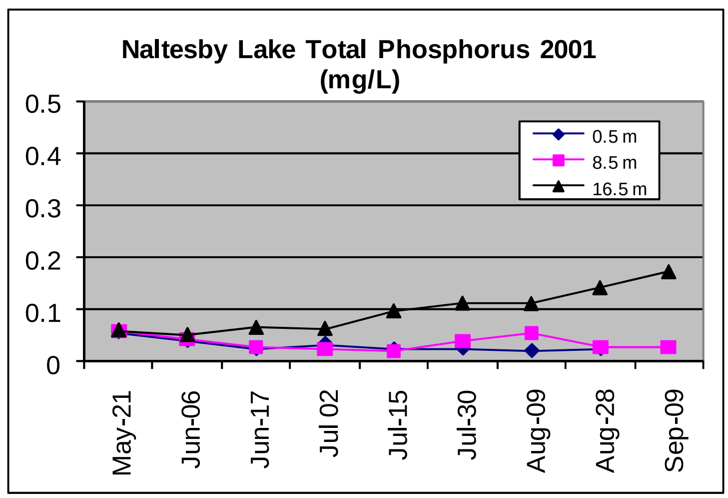
Lakes of low productivity are referred to as ***oligotrophic***, meaning they are typically clear water lakes with low nutrient levels (1-10 µg/L TP), sparse plant life (0-2 µg/L Chl. *a*), and low fish production. Lakes of high productivity are ***eutrophic***. They have abundant plant life (>7 µg/L Chl. *a*), including algae, because of higher nutrient levels (>30 µg/L TP). Lakes with an intermediate productivity are called ***mesotrophic*** (10-30 µg/L TP and 2-7 µg/L Chl. *a*) and generally combine the qualities of oligotrophic and eutrophic lakes.

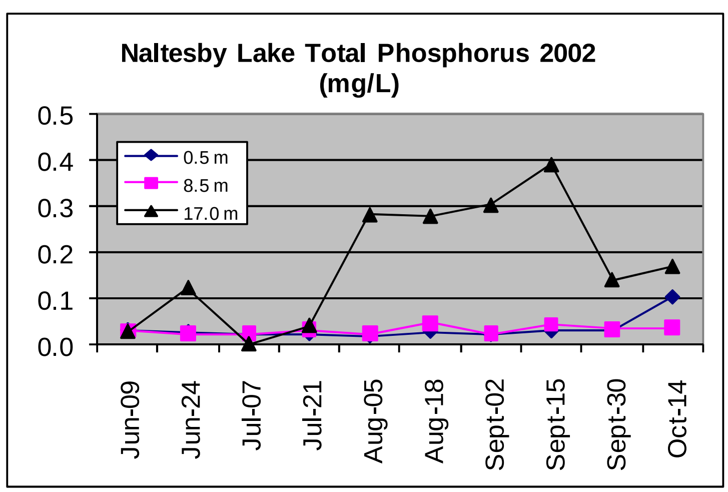
Lake sediments can themselves be a major source of phosphorus. If deep-water oxygen becomes depleted, a chemical shift occurs in bottom sediments. This shift causes sediment to release phosphorus to overlying waters. This "internal loading" of phosphorus can be natural, but is often a pollution sign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

Naltesby Lake spring TP levels (page 3) had a spring overturn average greater than 30 µg/L (0.030 mg/L) in both 2001 and 2002, implying eutrophic conditions. As indicated on the TP graph for 2001, surface and mid-depth concentrations remained relatively stable throughout the summer, while bottom depth concentrations increased from May until September. This increase can be attributed to different factors, with the main factor probably being internal phosphorus loading. As previously discussed, this internal loading begins when oxygen levels decline to low levels at the sediment/water interface on the lake bottom. Other factors possibly influencing the increased bottom TP include settling of surface organic material (such as plankton) and phosphorus bound sediments. It is also of note that lake bottom TP concentrations were much higher in 2002 than in 2001. Between the two years, maximum bottom TP concentrations had a range of 0.200-0.400 mg/L. This increased chlorophyll *a* may be due to several factors, such as water temperature, light levels and available nutrients, which can all influence algal production. Although not shown in the graphs, fall overturn likely occurred in mid-September or early October, and would have mixed the lake to show similar phosphorus concentrations with depth.

Because historical chlorophyll and Secchi data are lacking, it is hard to determine which year, 2001 or 2002, is more 'normal'. More specifically, there was large variability between the two years of study (almost 100% difference). For this reason, it is generally preferred that programs last at least three years or longer to attain more confidence in data. The following figure displays Naltesby Lake chlorophyll *a* concentrations and Secchi discvisibility. As shown, Secchi depth was a good indicator of chlorophyll *a* in both 2001 and 2002. Chlorophyll averaged 10.4 µg/L in 2001 and 21.9 µg/L in 2002, both concentrations suggesting eutrophy.







Historical Look at Naltesby Lake

Lake Coring; What does it Mean?

The Naltesby Lake VLMP was initiated well after local land development and possible impacts to the lake began. So, although this monitoring program can accurately document current lake quality, it cannot reveal historical "baseline" conditions or long term water quality trends. Here lies the value in coring lake sediments. Past changes in water quality can be inferred by studying the annual deposition of algal cells (in this case diatoms) on the lake bottom.

Naltesby Lake's south basin was cored and sectioned by BC Environment in 2001. The 38.5 cm core, which represents sedimentation over the last 200 years, was analysed by Dr. Brian Cumming of Queen's University. His report is available on request.

Historical changes in relative diatom abundance were measured directly by microscopy. By knowing the age of various core sections (using a lead 210 profile) and the phosphorus preference of the specific diatom in each section, historical changes in lake phosphorus concentrations, chlorophyll, and water clarity can be inferred. Furthermore, sedimentation rates of both organic and inorganic material were determined.

Diatoms are a type of phytoplankton commonly found in lake environments. Their glass-like shell (known as a frustule) is composed of silicon and is their primary characteristic. There are two main types of diatoms, the Centrales which have radial symmetry (e.g. *Cyclotella stelligera* seen in the left photo) and the Pennales which have bilateral symmetry (e.g. *Navicula miniscula* seen in the right photo).

Dating processes suggest the Naltesby Lake core was of good quality and would provide reliable records of environmental history over the past 200 years. One hundred and twenty three diatom species were found in the Naltesby core, with cluster analysis results suggesting three major shifts in diatom assemblage. Prior to 1900, the eutrophic taxon *Stephanodiscus minutulus* (TP preference 23.1 µg/L) was dominant, with the slightly less eutrophic taxon *Stephanodiscus parvus* (TP preference 20.1 µg/L) having the second highest abundance. After 1900, between approximately 1900 to 1970, *Stephanodiscus minutulus* decreased by 20% and was a codominant with *Stephanodiscus parvus*. After 1970 there appears to be another shift, with a large increase in the mesoeutrophic taxon *Fragilaria nanana* (TP preference 17 µg/L). Overall, the history attained from the diatom assemblage suggests meso-eutrophic to eutrophic conditions during the past 200 years (TP ranging from 15-20 µg/L). The highest TP concentrations coincided with the 1840-1865 period. According to Dr. Cumming, the variation in diatom species throughout the core, albeit a small range, indicates changes in TP conditions. Dr. Cumming also suggests that human activities during the last century have likely had little impact on the 'average' trophic status of the lake, as concentrations have actually decreased; however, this does not necessarily rule out small scale impacts along the lake shoreline, that were not large enough to be detected in the core.

Sedimentation rates were also determined from the core, which suggest that after 1940 rates slightly increased, followed by larger increases after 1980. However, confidence in this data is felt to be low, as multiple cores are generally used when doing sedimentation rate analysis, which give a better spatial representation.

The core also determined that there was a slight increase in percent organic matter between 1860 and 1900, and a gradual increase from 1900 to present day (~5% increase). Increases in organic matter can be attributable to many factors, some of which include increased in-lake production, increased inwash of organic matter, or decreases in the load of inorganic matter. Although an increase did occur, the increase was small.

SUMMARY

Recent VLMP water quality results suggest that Naltesby Lake is eutrophic. This somewhat agrees with the sediment core results, which indicated meso-eutrophic conditions during the past 200 years. The sediment core analyzed by Queen's University also suggests that nutrient conditions over the past 200 years have actually decreased as a whole. Additional VLMP data (including the addition of a north basin site) are recommended to help confirm the current nutrient status of the lake, and to better identify summer algal and TP concentrations. The data collected from 2001 and 2002 was variable; however, did provide some general information on lake trophic status. Regardless, all residents and land developers within the watershed are encouraged to practice good land management such that nutrient and/or sediment addition to the lake and its tributaries is minimized.

Household Tips to Keep Naltesby 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.
- Don't 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 and treat outgoing runoff 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.
- If livestock cross streams, provide gravelled 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 4 stroke engines, which are less polluting than 2 stroke engines, whenever possible. Use an electric motor where practical.
- Keep motors well maintained and tuned to prevent fuel and lubricant leaks.
- Use absorbent bilge pads to soak up minor oil and fuel leaks or spills.
- Recycle used lubricating oil and left over paints.
- 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

Public Feedback Welcomed

Ministry of Environment
Contact: Environmental Quality Section
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