BC Lake Stewardship and Monitoring Program

Lakelse Lake 2004-2005

A partnership between the BC Lake Stewardship Society and the Ministry of Environment

The Importance of Lakelse 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 Environment, 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 results of a Level II program for Lakelse Lake for the years 2004—2005.

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 volunteers and the BC Lake Stewardship Society.

The watershed area of Lakelse Lake is approximately 589 km². 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.

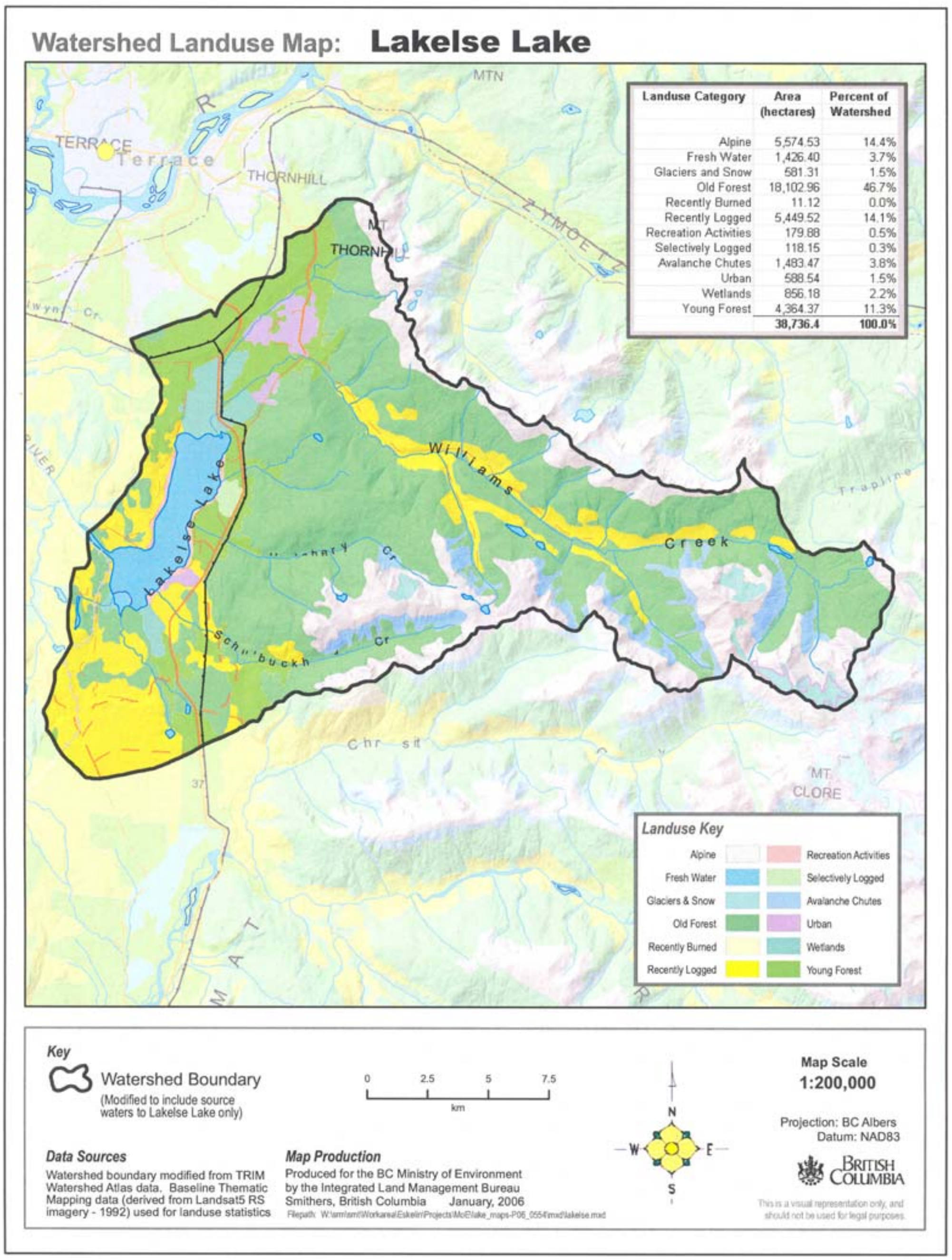
Lakelse Lake is located approximately 10 km south of Terrace on Highway #37 and lies at an elevation of 72 metres. The lake has a maximum depth of 31.7 m and a mean depth of 8.5 m. Its surface area is 1460 hectares and the shoreline perimeter is 26.8 km (see bathymetric map, pg. 3).

Lakelse Lake contains fish species such as aleutian sculpin, brook trout, dolly varden, longnose sucker, largescale sucker, nothern pikeminnow, mountain whitefish, prickly sculpin, rainbow trout, redside shiner, river lamprey, threespine stickleback, western brook lamprey, steelhead and chinook, chum, coho, pink, and sockeye salmon. The Lakelse watershed is one of the more important salmon rearing and migration areas in the province.

The flushing rate of Lakelse Lake is estimated to be five to six times per year. The flushing rate is a measure of time that inflow replaces the lake water volume. It is important because the longer the retention time, the less the lake has the ability to assimilate additional nutrients, and therefore avoid unnatural eutrophication. The high flushing rate of Lakelse Lake is caused by its large watershed and the high annual precipitation for the area. A large percentage of the precipitation occurs during the winter as snow, causing maximum water input during the spring and summer months. (McKean, 1986). There are approximately 13 tributaries feeding Lakelse Lake. The largest inflow is Williams Creek which drains a 25 km long valley into the north end of the lake (Kokelj, 2003); the outlet of Lakelse Lake is the Lakelse River, which flows into the Skeena River.

The map below shows the Lakelse Lake watershed and its associated land uses. It has been noted that previous forestry practices in the Lakelse watershed have increased sediment delivery to Lakelse Lake, as has shoreline development (Kokelj, 2003). Information on non point source pollution is provided; sources of concern for Lakelse Lake are onsite septic systems and stormwater runoff.

Lakelse Lake Watershed Map



Non-Point Source Pollution and Lakelse 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 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.

Properly located and maintained septic tanks do not pose a threat to the environment, however, mismanaged or poorly located tanks can result in a health hazard and/or excessive nutrients getting into the lake. Excessive nutrients such as phosphorus can cause a variety of problems including increased plant growth and algal blooms.

Stormwater Runoff

Lawn and garden fertilizer, sediment eroded from modified shorelines or infill projects, oil and fuel leaks from vehicles, snowmobiles 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 a 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.

Forestry

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

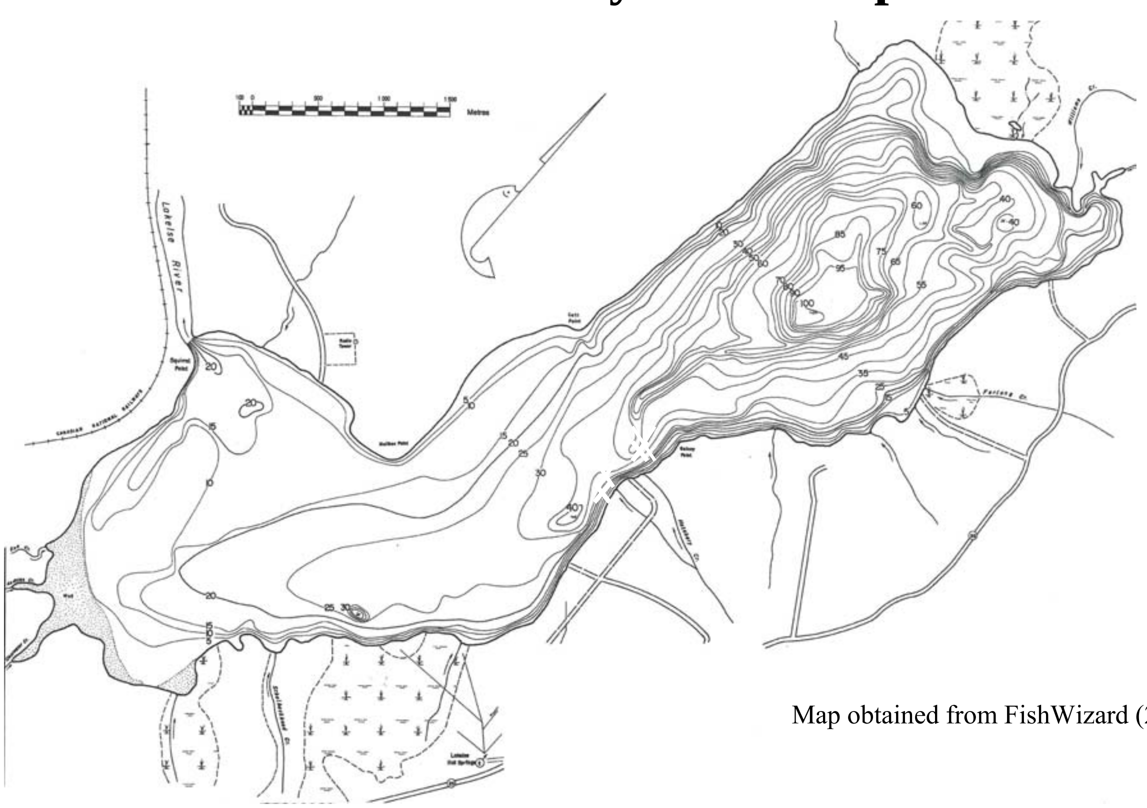
Boating

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.

Agriculture

Agriculture including grains, livestock, and mixed farming, can alter water flow and increase sediment and chemical/bacterial/parasitic input into water bodies.

Lakelse Lake Bathymetric Map



Map obtained from FishWizard (2005)

What's Going on Inside Lakelse Lake?

Temperature

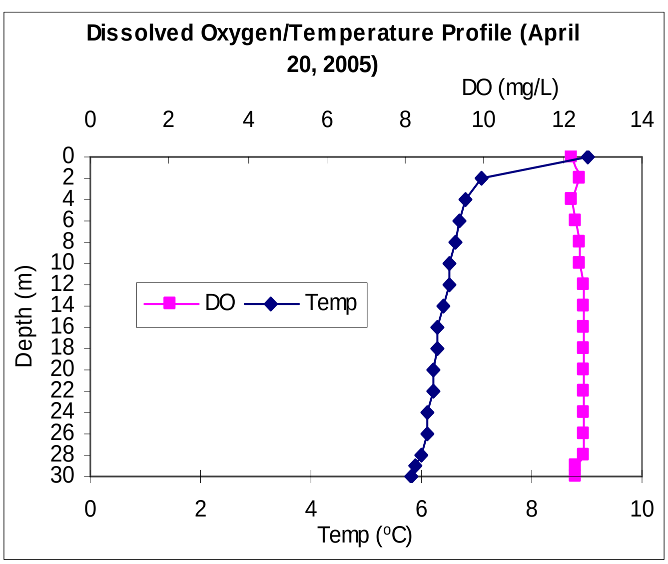
Lakes show a variety of annual temperature patterns based on their location and depth. Most interior lakes form layers (stratify), with the coldest water near the bottom. Because colder water is more dense, it resists mixing into the warmer, upper layer for much of the summer. When the warmer oxygen 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.

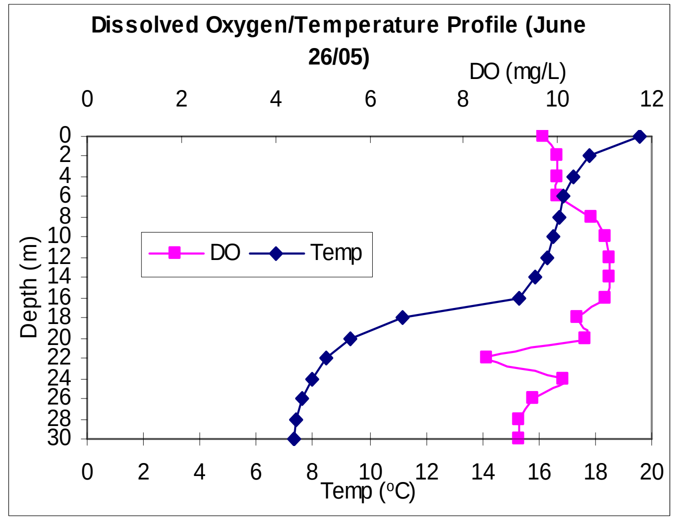
In spring and fall, these lakes usually mix from top to bottom (overturn) as wind energy overcomes the reduced temperature and density differences between surface and bottom waters. In the winter, lakes re-stratify under ice with the densest water (4°C) near the bottom. Because these types of lakes turn 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. These lakes generally do not freeze and circulate freely in the winter at or above 4°C and stratify in the summer.

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 lake users. Continuously monitored surface temperature can provide us with information not only on algal blooms, but also provide important data to climate change studies.

The following figure (below) illustrates Lakelse Lake's temperature and dissolved oxygen patterns at Spring overturn, 2005. Both the temperature and dissolved oxygen are relatively uniform throughout the depth profile. The profile for June 26, 2005 (above right) shows Lakelse Lake weakly stratified. There is evidence of a thermocline starting at 16 m





depth. The thermal stratification of Lakelse Lake is considered weak in July and August due to the flushing rate and heavy winds which circulate the water (Kokelj, 2003).

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.

Dissolved Oxygen

Oxygen is essential to life in lakes. It enters lake water from the air by wind action and also through 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 less productive (oligotrophic) will have sufficient oxygen to support life at all depths throughout 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 (salmonids are stressed when oxygen levels fall below about 20% saturation) where temperatures may be too warm. Fish kills can occur when decomposing or respiring algae use up the oxygen. In the summer, this can happen on calm nights after an algal bloom, but most fish kills occur during late winter or at initial spring mixing.

While the dissolved oxygen in the above graph (June 26, 2005) is variable through the water column, the oxygen concentration at 30 m depth is at 75% saturation, indicating that during summer stratification dissolved oxygen does not deplete to anoxia. This can be partially attributed to the high flushing rate and subsequent mixing of the water column.

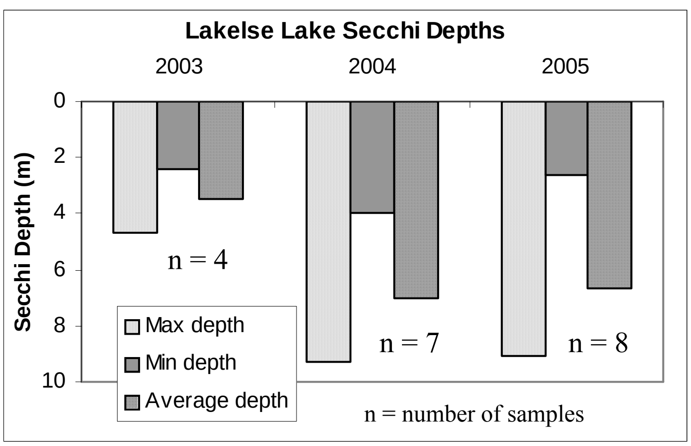
Trophic Status

The term *trophic status* is used to describe a lake's level of productivity which 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 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.

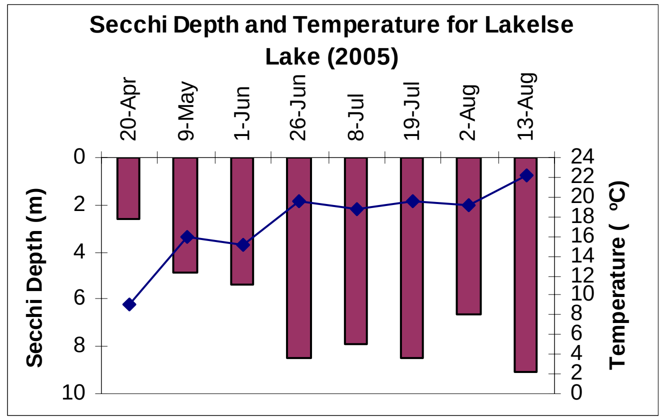
Water Clarity

As mentioned in the previous section, one method of determining productivity is 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 lake water can be evaluated by using a Secchi disk, a black and white disk that measures the depth of light penetration.



The average Secchi depths for Lakelse Lake 2003 to 2005 are shown in the graph above. The data can not accurately be compared year to year as there are too few sample dates and sampling is not always representative of the entire ice free season. Secchi depth for Lakelse Lake can also vary year to year based on inputs to the lake and the associated turbidity from suspended sediments (Kokelj, 2003). The average Secchi depths for 2004 and 2005 are in the oligotrophic range as they are 5 m or greater, while the data for 2003 would be classified as mesotrophic.

Natural variations and trends in Secchi depth and temperature not only occur between years, but also throughout one season. The Secchi depth and surface temperature for Lakelse Lake in 2005 are shown in the following graph. The pattern seen in this graph, of increasing Secchi depth with



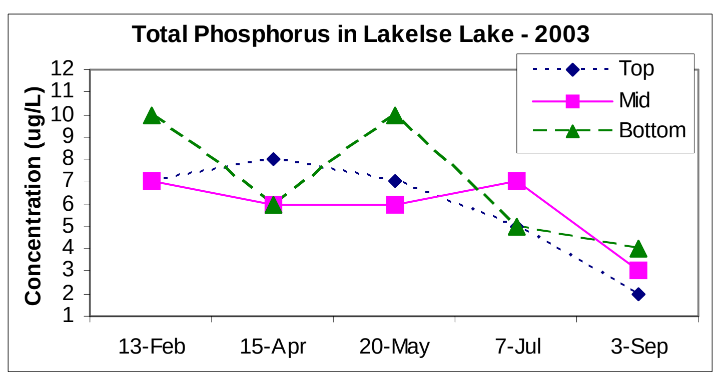
increasing temperature is not typical and while there is often a relationship between these parameters, it is not seen here.

Phosphorus

As mentioned previously, productivity can also be determined by measuring nutrient (i.e. phosphorus) levels. Phosphorus concentrations measured during spring overturn can be used to predict summer algal productivity. In most lakes, phosphorus accelerates algae growth and may artificially age a lake. Total phosphorus (TP) in a lake can be greatly influenced by human activities. In some lakes, marl precipitation events 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.

The following diagram displays 2003 phosphorus cycling in Lakelse Lake. Low TP levels were observed in all three sample depths throughout most of the year.



These TP values all fall within the oligotrophic classification, as does lake phosphorus data from other years.

Chlorophyll *a*

Chlorophyll *a* is the common green pigment found in almost all plants. In lakes, it occurs in plants ranging from algae (phytoplankton) to rooted aquatic forms (macrophytes). Chlorophyll captures the light energy that drives the process of photosynthesis. While several chlorophyll pigments exist, chlorophyll *a* is the most common. The concentration of chlorophyll *a* in lake water is an indicator of the density of algae present in that same water.

Chlorophyll *a* data from Lakelse Lake ranged from 0.68 µg/L to 2.61 µg/L when sampled in 2002 and 2003. While some of these values are slightly greater than the chlorophyll *a* parameters for oligotrophic lakes (0-2 µg/L), they do fall under the objective of ≤ 3 µg/L established as a site specific water quality objective by McKean in 1986.

Aquatic Plants

Aquatic plants are an essential part of a healthy lake. Factors that affect the type and amount of plants found in a lake include the levels of nutrients (i.e. phosphorus), temperature, and introduction of invasive species.

In recent years, residents in the Lakelse watershed have noticed growth of *Elodea canadensis* in their lake. It does appear that *Elodea canadensis* is a recent concern in Lakelse Lake as it was not mentioned in an aquatic plant survey done in 1984 and had been noticed by residents in the 3 to 4 years prior to 2003, where the growth of the plant had spread to include much of the littoral zone. Area residents are concerned about how the growth will affect lake quality and health, the recreational and fisheries value of the lake, and potentially reduce individual property values (Kokelj, 2003).

Factors affecting *Elodea* growth are not well known, and the exact link between the *Elodea* infestation and sediment and nutrient inputs to the lake is currently unclear.

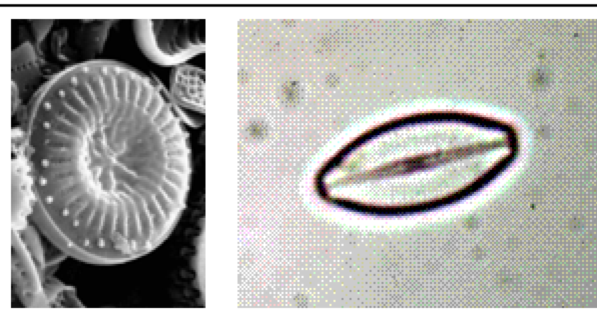
Based on patterns of infestation in other lakes in the region, it is likely that the growth of *Elodea* in Lakelse will continue, until it occupies most of the shoreline. Monitoring of *Elodea* growth in other water bodies has shown that after rapid infestation, *Elodea* has been known to subside in a similarly dramatic fashion. The Lakelse Watershed Society continues to monitor and identify trends in *Elodea* growth.

A few other aquatic plant species in Lakelse Lake consist of a variety of pondweeds (*Potamogeton sp.*), bladderwort (*Utricularia sp.*), and Buttercup (*Ranunculus sp.*).

Historical Look at Lakelse Lake

The Lakelse Lake volunteer monitoring program was initiated well after local land development and possible impacts to the lake began. 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.

Sediment core samples were obtained from the north and south basins of Lakelse Lake. The cores were separated into 1 cm slices and analyzed by Dr. Brian Cumming of Queen's University. His report, *Assessment of Changes in Total Phosphorus in Lakelse Lake, BC: A Paleolimnological Assessment*, is available upon request.



Diatoms are a type of algae commonly found in lake environments. Their glass-like shell (known as a frustule) is composed of silicon. This frustule leaves a permanent record of diatom history in lake bottoms. 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).

Historical changes in relative diatom abundance were measured directly by microscopy. By knowing the age of various core sections and the phosphorus preferences of the specific diatom in each section, historical changes in lake phosphorus concentrations, chlorophyll, and water clarity can be estimated.

Both the south and north basin cores indicate that there has been little change in the diatom species composition in Lakelse Lake. The lake appears to have been oligotrophic to slightly mesotrophic throughout the past several hundred years.

The diatom-inferred total phosphorus (TP) estimates indicate that over the past several hundred years the lake has had relatively oligotrophic conditions (TP ranging from ~4 to 8 µg/l, being slightly higher in the shallower south basin).

A comparison of pre-settlement sediment loading rates with current rates can indicate the impact of human development in an area. The sediment core analysis indicates that, in the north basin, sediment delivery rates began to increase in the 1950s and peaked in 1991. In the south basin, loading was greatest from 1967 to 1972 and 1981 to 1984. According to Kokelj (2003) significant human activities in the watershed began to occur in the 1950s and included a sawmill operation on the north end of the lake, increased logging activity, highway construction and subsequent creek diversion and landslides. These activities may be related to the increased sedimentation of Lakelse

Should Further Monitoring Be Done on Lakelse Lake?

The Lakelse Watershed Stewardship Society has completed two years of volunteer monitoring under the three year BC Lake Stewardship and Monitoring Program. There is much data for Lakelse Lake available from previous monitoring initiatives, and other agencies are involved in data collection at Lakelse Lake, including the federal Department of Fisheries and Oceans and the Regional District of Kitimat-Stikine. The Ministry of Environment feels that there is enough current data to establish baseline conditions at Lakelse Lake, and the activities of these other agencies will add to the data collected. At this point in time, the Ministry of Environment believes it would be worthwhile to repeat the summer sampling program in the future to compare against the baseline data. However, if volunteers are willing to continue monitoring with the Secchi disk, they will be providing valuable long term records and help to identify early warning signs should there be a deterioration in water quality. Given the concern about *Elodea* growth in Lakelse Lake, the limited information of the factors regarding its growth, and to monitor for changes to baseline conditions it would be worthwhile to repeat the summer chemistry sampling once every three years.

Tips to Keep Lakelse 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. Eurasian milfoil is an aggressive invasive aquatic weed. Be sure to familiarize yourself with this plant and remove and discard any fragments.
- 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

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Data Compiling by:
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Photo Credit:
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Lake Specific Document Produced by:
Dawn Roumieu & Genevieve Doyle
(BC Lake Stewardship Society)

Bathymetric Map:
Fish Wizard
www.fishwizard.com

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