BC Lake Stewardship and Monitoring Program

Eaglet Lake 2005 - 2007

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

BRITISH COLUMBIA
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Ministry of Environment

The Importance of Eaglet 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 (BCLSS), in partnership with the Ministry of Environment (MoE), has designed a program, entitled *The BC Lake Stewardship and Monitoring Program* (BCLSMP), 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. The level for a particular lake depends on study objectives as well as funding and human resources available. This report provides the three year results of a Level III program for Eaglet Lake.

Through regular status reports, the BCLSMP 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.

Eaglet Lake's monitoring program began in 2005 and has been coordinated by the Eaglet Lake Farmer's Institute in partnership with the MoE. This status report summarizes information derived from the program. Quality of the data has been found to be acceptable however MoE audit records indicate that field data quality was at times suspect with regard to oxygen measurement. Data quality information is available on request.

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. The watershed area of Eaglet Lake is 265 km^2.

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.

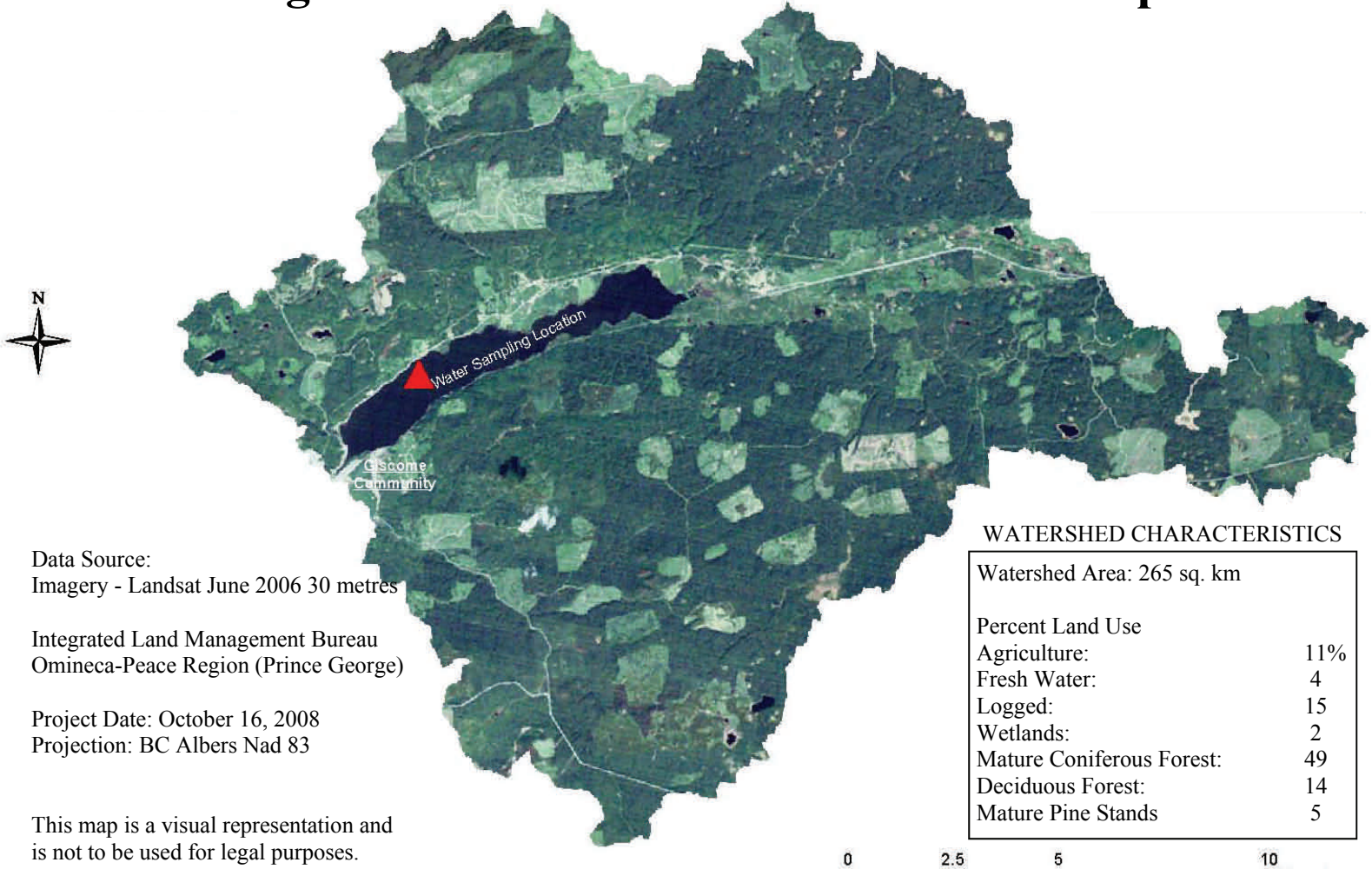
Human activities that impact water bodies range from small but widespread and numerous *non-point* sources throughout the watershed to large *point* sources of concentrated pollution (e.g. waste discharge outfalls, spills, etc). Undisturbed watersheds have the ability to purify water and repair small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

Eaglet Lake is located approximately 40 km northeast of Prince George B.C., in the Omineca region and along the Upper Fraser Road. The lake lies at an elevation of 592 m. The single lake basin is 9.5 km long and has maximum and mean depths of 9.5 m and 5 m, respectively. It has a surface area of 8.5 km^2 and a shoreline perimeter of 23 km. Eaglet Lake contains both sport and non-sport fish species. Sport fish include: burbot, bull trout, mountain whitefish, and rainbow trout. Other species include: northern pikeminnow, redside shiner, peamouth chub, largescale and longnose suckers. Chinook salmon have been observed in the Hay Creek outlet stream. While there are fishing opportunities at Eaglet Lake, it is not a highly popular fishing lake.

The map below shows the land use within the Eaglet Lake watershed. Around 1912 the railroad was built along the south shore, and two saw mills opened on the lake, one on the west end, the Giscome mill, and the other on the east end (Carlson, 2008, pers. comm.). The Giscome mill supported a sizeable community, also called Giscome (see map below). Originally, horse logging was done in the area and logs were transported to the mills for processing via floating on the lake. The Giscome mill dammed the outlet stream (Hay Creek) in order to keep the lake level high enough for floating logs. It is uncertain what effluent treatment occurred, but the mill and/or community may have impacted water quality on the lake and/or Hay Creek. While there are still logging activities taking place in the watershed, the east mill closed in the 1940's and the Giscome saw mill closed in the mid 1970's (Carlson, 2008). There are currently about 10 lakeshore residences on the west and north shore, two of which are seasonal. In the 1950's approximately 180 head of cattle were contained in 6 farms around the lake (Carlson, 2008). Currently, cattle pasture borders most of the northeast shore, supporting approximately 300 head. Winter feeding areas are close to the lake and runoff from these and other pastures in the spring and summer does occur (MoE, Prince George office). Some pastures provide livestock with direct access to the lake shore in winter. A rail ballast quarry exists to the west of the lake, but is believed to sit mainly outside the Eaglet Lake drainage. A lime quarry had been proposed for the upper Bateman Creek watershed, but the project is currently on indefinite hold. The lake is used for general recreational purposes and provides good public access, including from one regional park.

The greatest challenge to Eaglet Lake is likely the control of phosphorus (nutrient) loading from various land uses within the watershed. This loading may promote summer algal blooms and the spread of aquatic plants. Ministry of Environment files have records of algal blooms on the lake, and residents report ongoing problems with algal blooms each summer. Aquatic plants, particularly *Elodea canadensis* (Canadian pondweed), have not been identified on the lake, but may be present.

Eaglet Lake Watershed and Land Use Map



Data Source:
Imagery - Landsat June 2006 30 metres

Integrated Land Management Bureau
Omineca-Peace Region (Prince George)

Project Date: October 16, 2008
Projection: BC Albers Nad 83

This map is a visual representation and is not to be used for legal purposes.

WATERSHED CHARACTERISTICS

Watershed Area: 265 sq. km	
Percent Land Use	
Agriculture:	11%
Fresh Water:	4
Logged:	15
Wetlands:	2
Mature Coniferous Forest:	49
Deciduous Forest:	14
Mature Pine Stands	5

0 2.5 5 10 Kilometers

Non-Point Source Pollution and Eaglet 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.

Agriculture

Agriculture including grains, livestock, and mixed farming, can alter water flow and increase sediment and chemical/bacterial/parasitic input into water bodies. Potential sources of nutrients (nitrogen & phosphorus) include chemical fertilizers and improperly situated winter feeding areas.

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 nutrient loading to 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.

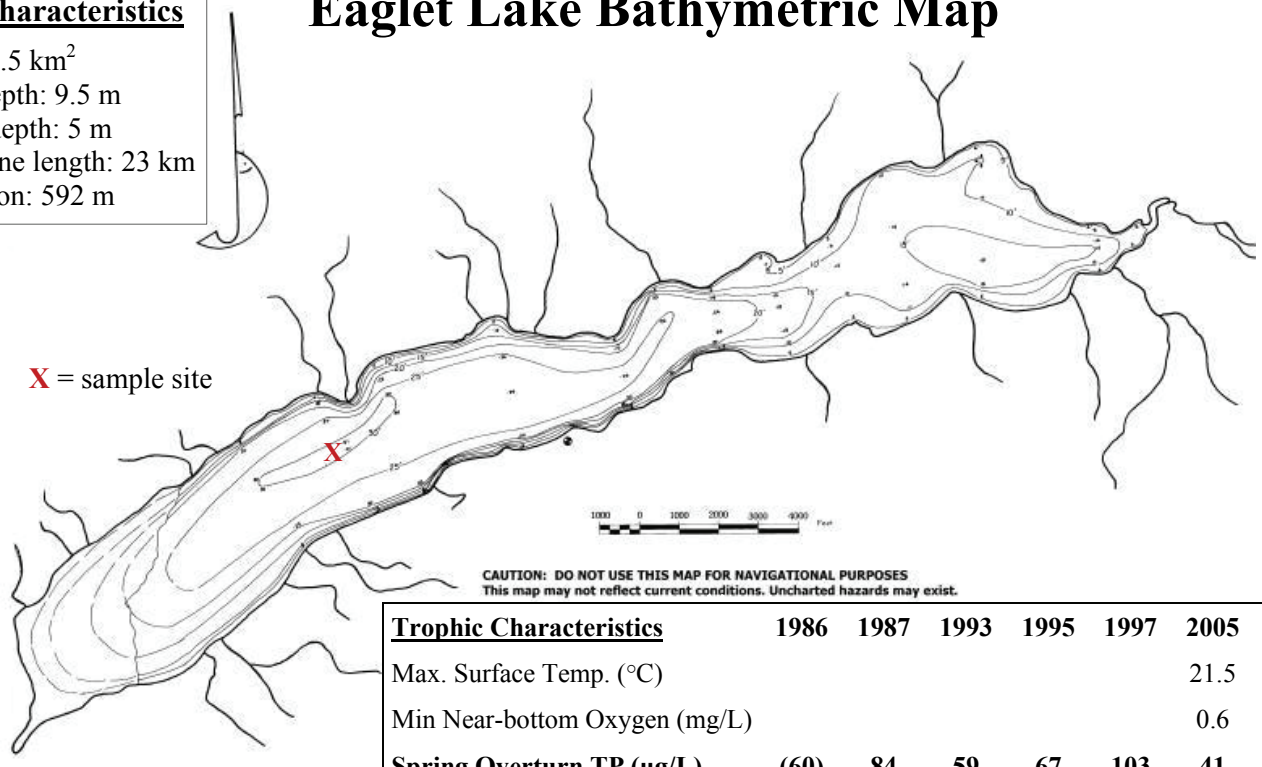
Boating

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 concern.

Eaglet Lake Bathymetric Map

Lake characteristics

Area: 8.5 km^2
Max depth: 9.5 m
Mean depth: 5 m
Shoreline length: 23 km
Elevation: 592 m



Map obtained from www.fishwizard.com (2005)

Trophic Characteristics	1986	1987	1993	1995	1997	2005	2006	2007
Max. Surface Temp. (°C)						21.5	22	23
Min Near-bottom Oxygen (mg/L)						0.6	0.8	0.2
Spring Overturn TP (µg/L)	**(60)**	**84**	**59**	**67**	**103**	**41**	**42**	**(55)**
Avg. Chlorophyll *a* (µg/L)						17.9	22.3	13.5
Avg. Secchi Depth (m)						1.1	1.1	1.1

Note: Bracketed values indicate averages are suspect

What's Going on Inside Eaglet Lake?

Temperature

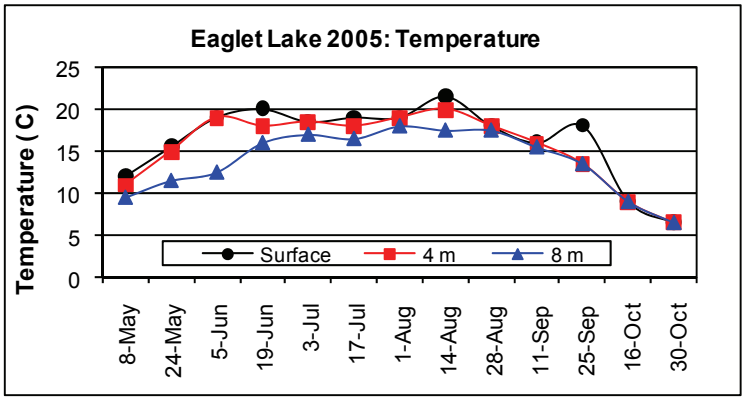
Lakes show a variety of annual temperature patterns based on their location and depth. Most interior lakes form layers (stratify), with the coldest summer water near the bottom. Because colder water is more dense, it resists mixing into the warmer, upper layer for much of the summer. In spring and fall,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

The review of ice-on and ice-off dates is important to the growing issue of climate change, particularly with how it is affecting B.C. lakes. Eaglet Lake volunteers have been collecting these data since 2005.

Temperature was measured on Eaglet Lake from 2005 to 2007. The graph below shows the 2005 temperature data (comparable to 2006 and 2007) for Eaglet Lake. The May 8th sample date shows a similar temperature at all depths, indicating recent spring overturn. Stratification in Eaglet Lake is relatively weak. In 2005 the lake experienced uniform temperature profiles more than once in the sampling period. This is likely due to the lake's shallow depth and long distance over which the wind can blow uninterrupted, which can cause mixing of the stratified layers. The August 1st profile is uniform, followed by weak stratification on August 14th. The lake becomes uniform again on August 28th which holds until ice cover (sometime after October 30th) with the exception of the September 25th profile where there is an increase in surface temperature. Data from 2006 and 2007 show Eaglet Lake becoming uniform for an extended period starting in late summer through the sampling season (mid to late fall). The maximum surface temperature in 2005 was 21.5°C (August 14th).

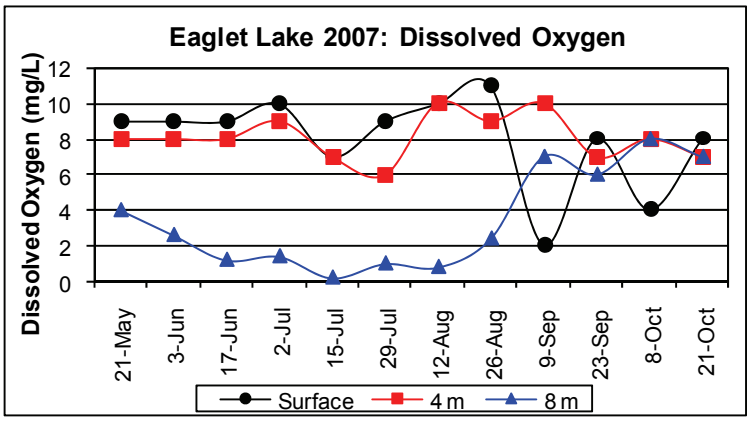


Dissolved Oxygen

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 in summer, 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 (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 because oxygen has been depleted under winter ice.



The figure above shows the 2007 oxygen pattern for Eaglet Lake, which was generally representative of the other two years measured. These oxygen patterns are dynamic and complicated. Bottom oxygen typically declined soon after the onset of summer stratification to levels that would not support fish and could promote internal phosphorus loading from lake sediments (to be discussed later). Stratification was often interrupted by short mixing periods, caused either by wind or by extended fall overturn. These periods were often concurrent to substantial oxygen sags in surface waters, suggesting that the mixing rate was faster than the time required to aerate water at the surface. Surface oxygen was at times insufficient to support fish. Periods of surface algal blooms were usually associated with high oxygen concentrations in surface and mid-depth waters. However, it is expected that these same blooms could be responsible for short term oxygen depletion and perhaps fish kills in surface waters during calm summer nights. As previously stated, MoE audit records suggest the quality of some field oxygen data is suspect. This would need to be factored into data interpretation.

Trophic Status and Phosphorus

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. Algae are important to the overall ecology of the lake 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*** (the green photosynthetic pigment of algae). The concentration of chlorophyll *a* in lake water is an indicator of the density of algae present in that same water and is directly related to the Secchi depth. Phosphorus concentrations measured during spring overturn can be used to predict summer algal productivity.

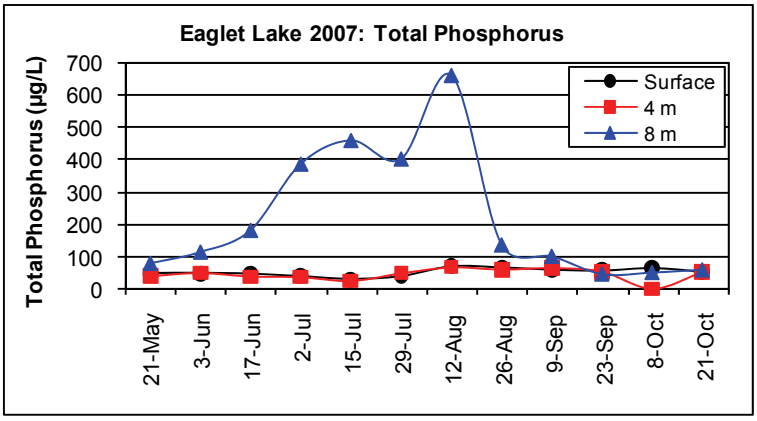
Lakes of low productivity are referred to as ***oligotrophic***, meaning they are typically clear water lakes with low nutrient levels (1-10 µg/L TP), sparse plant life (0-2 µg/L chl. *a*) and low fish production. Lakes of high productivity are ***eutrophic***. They have abundant plant life (>7 µg/L 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 the result of external phosphorus addition. Lakes displaying internal loading have elevated algal levels and generally lack recreational appeal.

Eaglet Lake's historical spring TP values are shown in the Trophic Characteristics table on page 3. The 1997 value appears to be an anomaly and may have been influenced by the late sample date. Using all values except 1997 gives an average of 58 µg/L implying eutrophic conditions. As the table shows, spring TP values in Eaglet Lake have declined since 1986. While this would normally imply improving water quality, summer internal phosphorus loading events and related algal blooms also need to be considered.

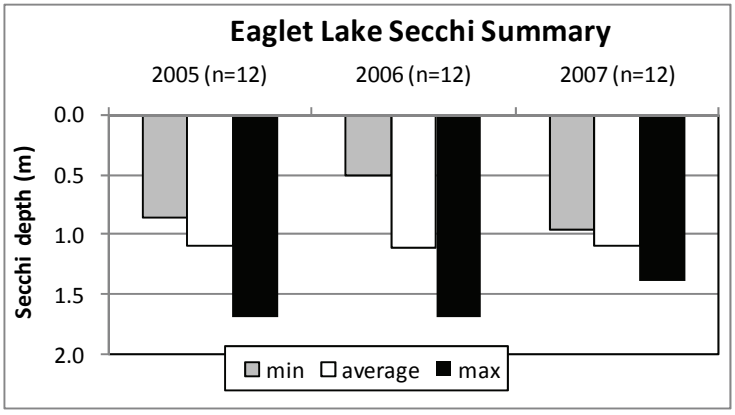
The 2005 to 2007 data show similar phosphorus cycling patterns in all years and forms sampled. In 2006 and 2007 the pattern shows two peaks in bottom TP, whereas in 2005 only one peak is evident. The major peaks in TP occurred on August 14th, July 9th and August 12th of 2005, 2006 and 2007, respectively. This suggests some loss of stratification and the mixing of deep water phosphorus into the algal-growing zone at the surface.

The following graph displays the 2007 phosphorus cycling in Eaglet Lake. On August 12th Eaglet Lake experienced an internal loading event. TP near the bottom (8 m) reached 660 µg/L and ortho-phosphorus (OP), the form released from bottom sediments, spiked to 450 µg/L (68% of the TP). High OP levels at bottom coincide with low DO levels, further supporting the claim of internal phosphorus loading from sediments, which later mixed into surface waters..

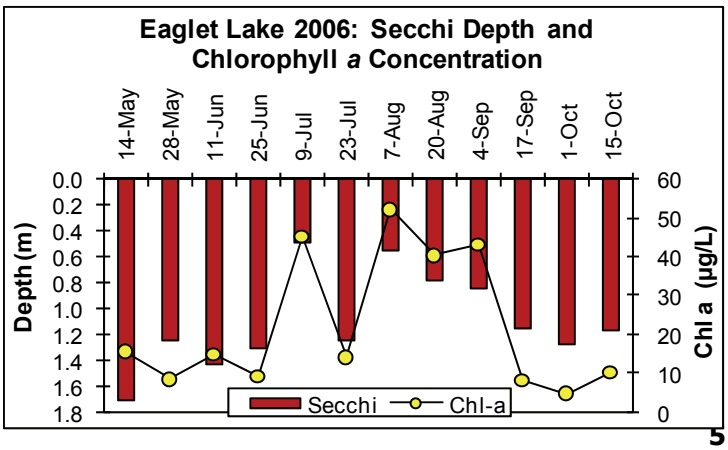


The phosphorus levels in Eaglet Lake reinforce the eutrophic classification as all surface phosphorus samples in 2007 are above 30 µg/L with the exception of July 15th (28 µg/L).

The graph below shows the minimum, average and maximum Secchi readings on Eaglet Lake from 2005 to 2007, as well as the number of readings in each year (n). The average Secchi depth measurement was 1.1 m in all sampling years. Based on these values Eaglet Lake was exhibiting eutrophic conditions (0 - 2 m Secchi depth) for all years measured.



The graph below shows the correlation between Secchi and chlorophyll *a* in Eaglet Lake. The 2006 Secchi depths for Eaglet Lake ranged from 1.7 m (May 14th) to 0.5 m (July 9th).



As algal concentrations increase, Secchi readings decrease, suggesting Secchi values in Eaglet Lake are a reasonable indicator of chlorophyll *a*. Chlorophyll *a* averaged 17.9 µg/L in 2005, 22.3 µg/L in 2006 and 13.5 µg/L in 2007, confirming the eutrophic condition of the lake.

In general, the highest chlorophyll *a* values are in July and August, indicating the greatest growth during these months. Early in the sampling season (May and June) greater Secchi depths correspond to lower chlorophyll *a* levels.

A Historical Look at Eaglet Lake

The Eaglet Lake monitoring program was initiated well after local land development and possible impacts to the lake began. While this program can accurately document current lake water 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.

The deepest point in Eaglet Lake was cored on September 14, 2005 by Ministry of Environment staff. The 35 cm core, which represents the past 350 to 400 years in the lake's history, was analyzed by Dr. Brian Cumming of Queen's University. His report is available upon request.

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. The microscopy work on Eaglet Lake appears to provide the best analytical results.

The Eaglet Lake core appears to have good stratigraphy as evidenced by the cyclical diatom abundances in the core. However the lead 210 activity of the Eaglet Lake core was low and hence confidence in the actual dates of the diatom cycling is not great (Cumming, 2008, pers. comm.).

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).

The Eaglet Lake core contained approximately 100 diatom taxa. Cumming (2006) found that the recent history of the lake was dominated by mesotrophic to eutrophic planktonic species. There has been no appreciable change in the absolute concentration, relative abundance and productivity of diatoms in Eaglet Lake over the last 400 years (Cumming, 2006). However, cyclical changes in dominant diatom taxa may be related to changes in climate over this time frame. There is evidence of a substantial change in percent organic matter between circa 1900 and 1960 that is possibly due to major watershed disturbance(s). This timing coincides with the operation and closure of the two mills on the lake. Given the relative stability of livestock numbers over recent time, impact to the lake may have been greater in past decades due to the mills as implied by declining spring TP values (discussed earlier). It is important to note that the impacts of the disturbance(s) around Eaglet Lake have been within the variance in natural variation in trophic conditions, at least as indicated by diatoms. An assessment of the Eaglet core for changes in pigments related to summer algal blooms should be considered.

In conclusion, Cumming (2006) found that the core results indicate a relatively productive but stable lake over the last 400 years. The MoE and BCLSS believe that Eaglet Lake was (and still is) at the eutrophic level.

Should Further Monitoring Be Done on Eaglet Lake?

Eaglet Lake is eutrophic as indicated by high phosphorus and chlorophyll *a* values, as well as by low Secchi disc (clarity) readings. The lake does not stratify strongly during summer and evidence exists of significant internal phosphorus loading during the same period. Interpretation of the sediment core indicates the lake has maintained a relatively stable, eutrophic nature for the past 400 years, at least in terms of diatoms which may or may not be related to problematic mid-summer algal blooms. It may be useful to analyze the core (or a new core) for long term cyanopigment and/or chironomid patterns in an attempt to better understand past trends in summer algal densities.

Because land uses in the watershed may have affected water quality, a watershed assessment may be warranted. Monitoring of inlet streams may be valuable in order to understand phosphorus mass loading to the lake. If volunteers are willing, continued collection of Secchi disc and surface temperature readings would be valuable for comparison to the data presented here. The regular collection of spring phosphorus data is considered a cost effective priority. Finally, repeated comprehensive (BCLSMP) sampling of the lake in five to ten years is recommended. Volunteers are also encouraged to continue recording ice on/off dates as these are valuable for climate change studies.

Tips to Keep Eaglet 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 polystyrene (completely contained and sealed in UV treated material) 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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Photo Credits:
Gabriele Matscha

Land Use Map:
Sean Barry - Integrated Land Management Bureau (ILMB)

Bathymetric Map:
Fish Wizard

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Eaglet Lake volunteers

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