BC Volunteer Lake Monitoring Program

FRASER LAKE 2000 - 2002

The Importance of Fraser Lake & its Watershed

British Columbians want lakes to provide good water quality, aesthetics and recreational opportunity. When we don't see these features in our local lakes, we want to know why. Is water quality getting worse? Has the lake been polluted by land development? What uses can be made of the lake today? And, what conditions will result from more development within the watershed?

BC Environment's Volunteer Lake Monitoring Program (VLMP), in collaboration with the non-profit BC 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 preferred uses for a given lake, and monitor water quality changes resulting from land development within the lake's watershed.

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. Fraser Lake's watershed, shown on the next page, is 6030 square kilometers.

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 cleansed and 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.

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. Finally, the VLMP allows government to use its limited resources efficiently thanks to the help of area volunteers and the BC 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.

Fraser Lake's VLMP program began in 2000 and has been coordinated by Brian Malchow through the Nad 10, 11 and 12 work experience students from FLESS. This status report summarizes information derived from the 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.

Fraser Lake is located...in the Omineca Peace region near Highway 16, adjacent to the Village of Fraser Lake, approximately 160 km west of Prince George, BC. This sizeable lake (formerly known as Nad'leh Bun) is roughly 19 km long, with maximum and mean depths of 30.5 m and 13.3 m, respectively. Its surface area is 54 km^2 and it has a shoreline perimeter of 67.1 km. The map below shows the Fraser and Burns/Decker Lake watersheds. The Francois and Tchesinkut drainages are not shown although they comprise a large portion of the Fraser watershed. We believe that land use activities in their drainages would not result in impacts downstream of either of these lakes and that improved land use practices may do little to modify the water quality of Fraser Lake. In contrast, the Endako drainage is thought to have a direct effect on Fraser Lake and has therefore been included in the watershed map.

Fraser Lake contains the following sport fish: burbot (*Lota lota*), bull trout (*Salvelinus confluentus*), lake trout (*S. namaycush*), mountain whitefish (*Prosopium williamsoni*), rainbow trout (*Oncorhynchus mykiss*), sockeye/kokanee salmon (*Oncorhynchus nerka*), Chinook salmon (*Oncorhynchus tshawytscha*), and white sturgeon (*Acipenser transmontanus*). The lake is also considered an Important Bird Area by Bird Life International. It is a globally significant wintering site for Trumpeter Swans and a continentally important site for fall migrating waterfowl, particularly the American Widgeon. Additionally, Ellis Island (Seagull Island) was designated an ecological reserve in 1991 for the protection of gull colonies, especially Ring-billed Gulls and Herring Gulls.

Land use within the watershed includes lakeshore development (~350 residences), forestry, agriculture and mining. The lake has good public access and is used for general recreational purposes by residents of Fraser Lake and surrounding communities. 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. Reports do exist in BC Environment files of algae blooms and aquatic plant infestations, with the aquatic plant *Elodea canadensis* (Canadian pondweed) being especially problematic since the early 1980s.

Fraser Lake Sub-Watershed and Land Use Map

THEORETICAL PHOSPHORUS SUPPLY

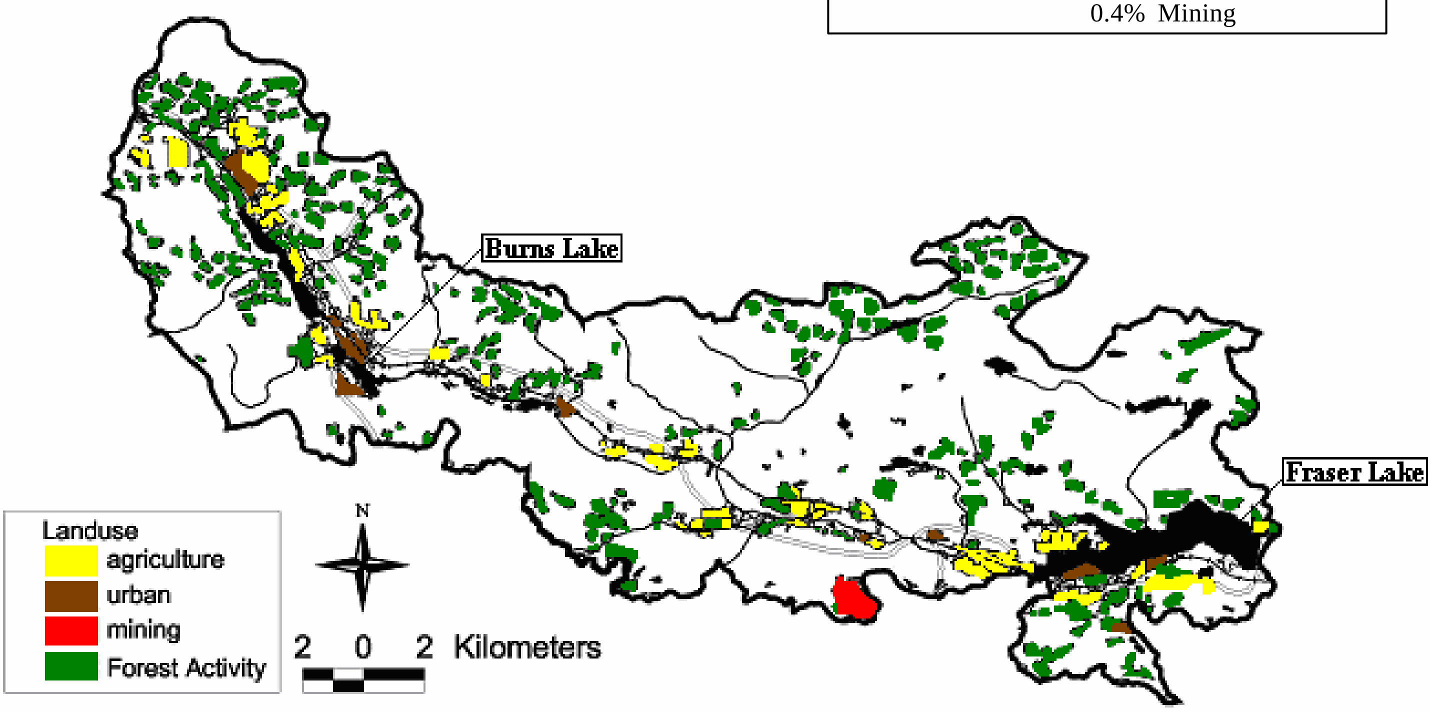
Avg. Spring Overturn P (ug/L):	22.2
Sedimentation Rate Coefficient:	(0.4)
Flushing Rate (#/yr):	1.6
Yearly P Loading ($gm/m^2/yr$):	0.69

SUB-WATERSHED CHARACTERISTICS

Area: 2261 km^2

Percent Land Usage:

1.3%	Residential (Urban)
4.0%	Agricultural/Range
9.3%	Forestry
0.4%	Mining



Non-Point Source Pollution and Fraser 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.

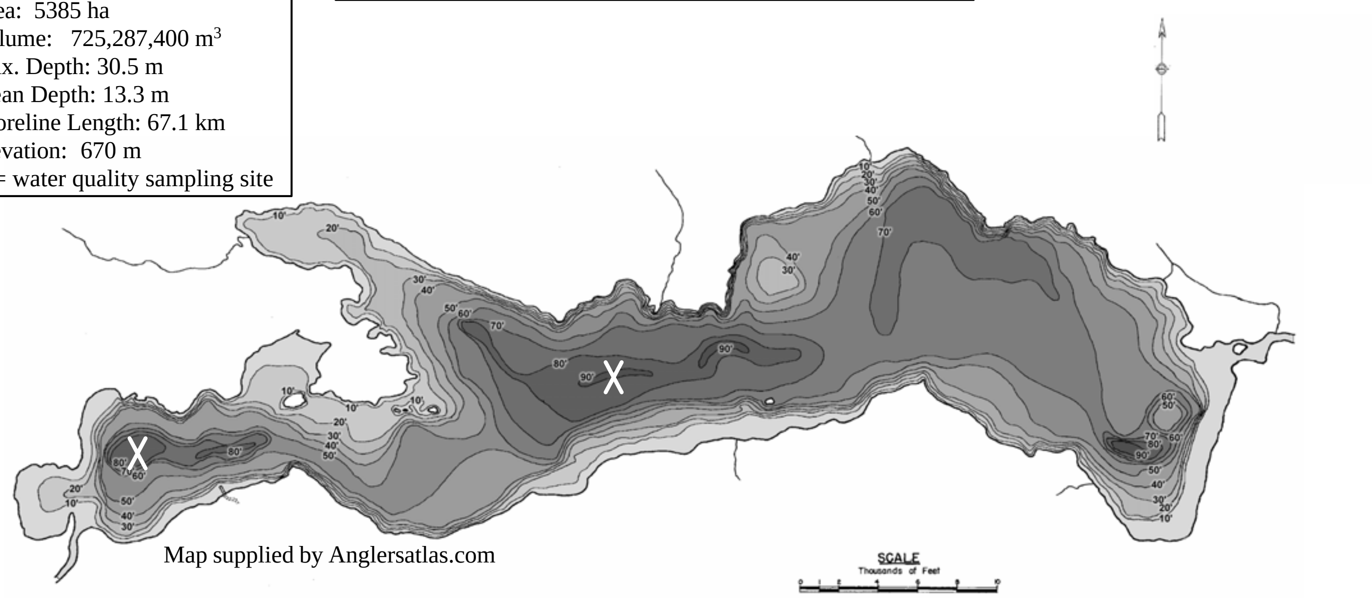
Boating

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.

LAKE CHARACTERISTICS

Area: 5385 ha
Volume: 725,287,400 m^3
Max. Depth: 30.5 m
Mean Depth: 13.3 m
Shoreline Length: 67.1 km
Elevation: 670 m
X = water quality sampling site

Fraser Lake Contour Map



Map supplied by Anglersatlas.com

FRASER LAKE TROPHIC CHARACTERISTICS

	1982	1984	1985	1987	1993	2000	2001	2002
Max. Surface Temp (°C):	-	-	-	-	-	17.5	17.0	16.5
Min. Near-bottom Oxygen (mg/L):	-	-	-	-	-	0.6	0.8	3.0
***Spring Overturn TP (ug/L):**	**25**	**24**	**21**	**21**	**24**	**26**	**21**	**16**
*Avg. Chlorophyll a (ug/L):	-	-	-	-	-	3.1	3.5	3.6
*Avg. Secchi Depth (m):	-	-	-	-	-	4.5	4.3	3.3

*These parameters have been averaged between the two sampling locations.

What's Going on Inside Fraser Lake?

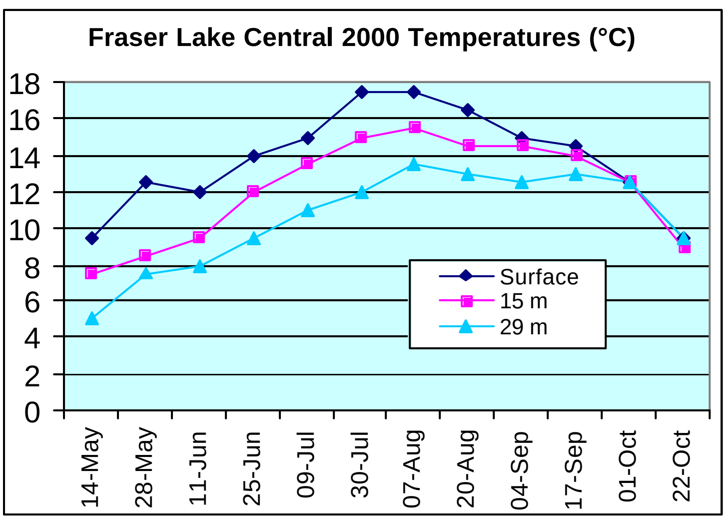
Temperature

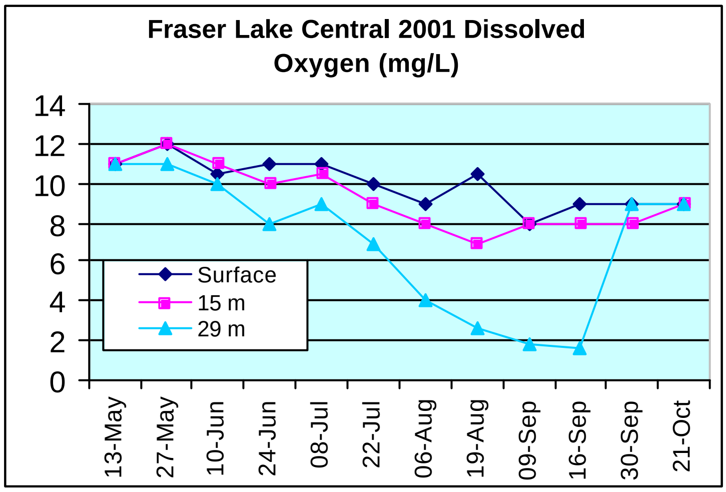
Lakes show a variety of annual temperature patterns based on each lake's location and depth. Most interior lakes form layers (stratify), with the coldest summer water near the bottom. Because colder water is denser, it resists mixing into the warmer, upper layer for much of the summer. In spring and 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 both the west and central basins of Fraser Lake during 2000-02. The figure below illustrates Fraser Lake water temperatures in the central basin for 2000. The central basin temperature patterns were comparable to those in the west basin. These temperature patterns were similar for all three study years. Given their moderate depths, both basins stratified in early May. The maximum surface temperature, reached by late July (2000), was 17.5 °C in the central basin and 1 °C cooler in the west. Mid-depth and bottom temperatures were also 1-2 °C cooler in the west basin over much of the summer. This difference in temperature between the two basins may be attributable to cold water inflows from Francois Lake in the west basin. Shorter days and cooling air temperatures through September caused a loss of lake stratification, leaving the water temperature nearly uniform with depth at 9.5 °C by early to mid-October.





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 of the central basin for 2001. They are comparable to the oxygen patterns in the west basin, as well as the other two study years. Surface water oxygen remained near saturation, not dropping below 8 mg/L. Both basins displayed gradual declines in mid-depth and bottom oxygen to 7.0 and 1.6 mg/L, respectively. This bottom anoxia existed for only a short time (two weeks in the central and three weeks in west basin), but bottom waters, with less than 4 mg/L oxygen, would not have supported fish for a period of roughly one month. The short duration of bottom anoxia suggests that the amount of internal phosphorus loading would have been minimal (refer to page 5 for a more in-depth look at internal phosphorus loading). Vertical mixing and the aeration of bottom waters occurred with the onset of cooler fall temperatures. This happened two weeks earlier in the central basin, and again was likely the result of that basin's relative turbulence.

What's Going on Inside Fraser 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 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.

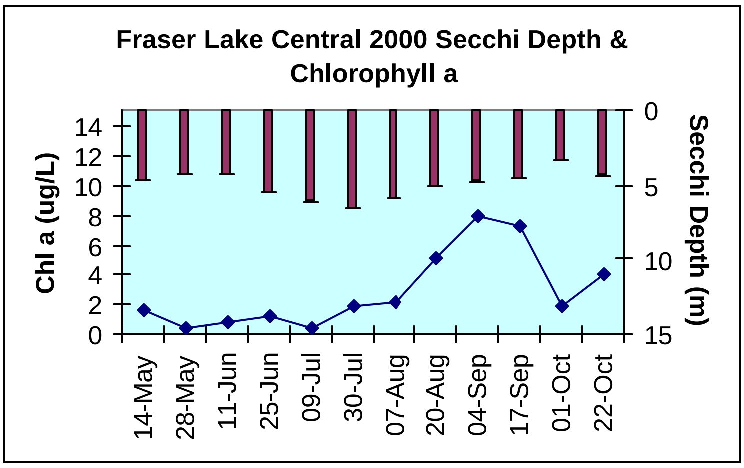
The trophic status of a lake can be determined by measuring productivity. The more productive a lake is the higher the algal growth and therefore the less clear the water becomes. Water clarity is measured using a ***Secchi disc***. Productivity is also determined by measuring nutrient levels and ***chlorophyll***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

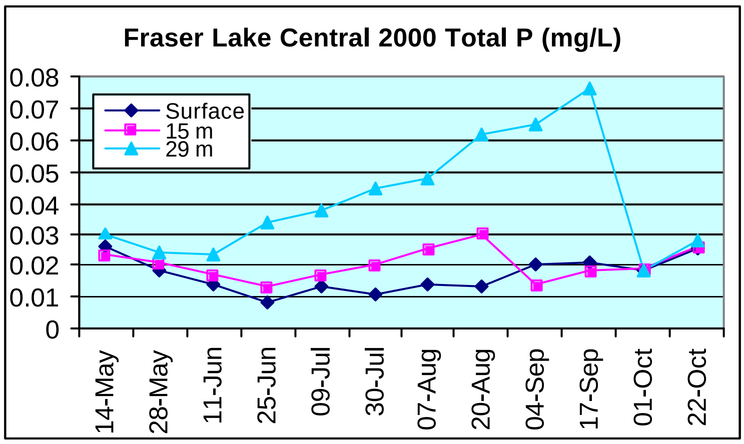
Lakes of low productivity are referred to as ***oligotrophic***, meaning they are typically clear water lakes with low nutrient levels (1-10 ug/L TP), sparse plant life (0-2 ug/L Chl. a), and low fish production. Lakes of high productivity are ***eutrophic***. They have abundant plant life (>7 ug/L Chl.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

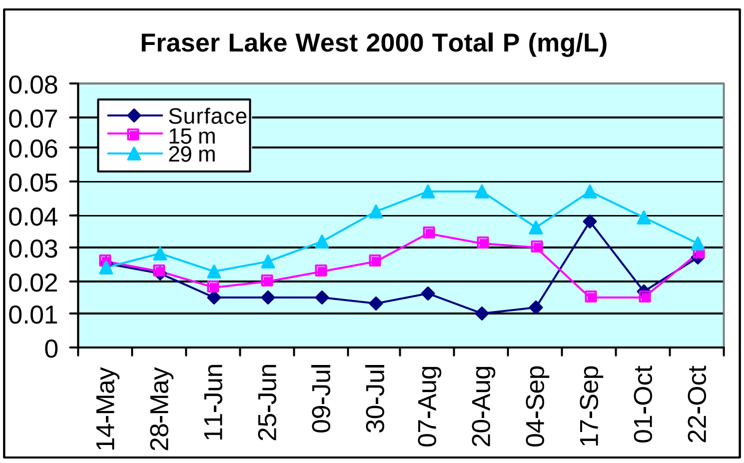
Lake sediments can themselves be a major source of phosphorus. If deep-water oxygen becomes depleted, a chemical shift occurs in bottom sediments. This shift causes sediment to release phosphorus to overlying waters. This "internal loading" of phosphorus can be natural but is often the result of phosphorus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

Fraser Lake spring TP levels (page 3) have averaged 22.2 ug/L since 1982, implying mesotrophic conditions. There has been no large variation in TP levels between basins, however there has been some variation annually. The 2002 spring TP has a value of 16 ug/L, significantly lower than the mean. The data also suggest that summer algal densities and water quality have been stable. However, older algal chlorophyll and secchi data are generally lacking and limit comparison with present conditions. The figure to the upper right displays Fraser Lake algal chlorophyll concentrations and visibility, as measured by Secchi disc. Secchi was a reasonable indicator of chlorophyll in 2000. Chlorophyll averaged 2.9 ug/L in the central basin, again suggesting mesotrophy.

The latter diagrams below display 2000 phosphorus cycling in Fraser Lake (these graphs are representative of the three years studied). Average summer total phosphorus (TP) in the central basin was 21 ug/L at the surface. An unexplained September peak (38 ug/L) did occur in west basin surface waters. Both basins displayed gradual increases in near bottom total phosphorus, peaking at 76 ug/L in the central and 47 ug/L in the west basin. Given the presence of oxygen and the lack of hydrogen sulphide during these buildups, they are more likely the result of organic settling than internal phosphorus loading. Roughly 50 % of peak TP in the west basin was ortho-P, versus 70 % in the central. This suggests that more of the west basin phosphorus had recently been contributed by external sources (Stellako-Endako River system and the Village sewage treatment system).







Historical Look at Fraser Lake

Lake Coring; What does it Mean?

The Fraser 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.

Fraser Lake's central and west basins were cored and sectioned by BC Environment in 1999. The 40 cm cores, which represent sedimentation over the last 200 years, were analysed by Dr. Brian Cummings of Queen's University. His report is available on 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 preference of the specific diatom in each section, historical changes in lake phosphorus concentrations, chlorophyll, and water clarity can be estimated.

Dating processes indicated that the Fraser Lake cores were of good quality and would provide reliable records of environmental history over the past 200 years. However, interpreting the west basin core was difficult due to higher sedimentation rates associated with the major inflows.

Both central and west basin cores indicate that Fraser Lake has undergone only minor changes in diatom assemblage. It has maintained a moderate inferred phosphorus concentration between 20 and 30 ug/L, indicating mesotrophic conditions over the past 200 years. This compares well with the recent spring phosphorus measurements that have shown little change since 1982 and average 22.2 ug/L (see page 3).

Research currently underway by Dr. Jules Blais of the University of Ottawa suggests that phosphorus variations calculated through the Fraser Lake core history may be related to shifts in salmon population densities over time, and that nutrient levels in Fraser Lake may be at least partly determined by salmon carcasses.

Both cores also suggest that sedimentation rates have increased since circa 1900 and particularly since 1950 in the west basin. Watershed activities are thought to have caused unusual rates of sedimentation. These do not appear to have caused changes in diatom assembledge, and indirectly water quality, that are unusual for this lake.

SUMMARY

Recent VLMP and sediment coring results suggest that Fraser Lake has fair to good recreational water quality that has remained stable over the past 200 years. The cores do suggest that unusual rates of sedimentation from watershed activities have occurred since 1950. Additional years of VLMP data during spring overturn are recommended to confirm the lake's current nutrient status, and evaluate annual fluctuations in spring TP levels. Regardless, all residents and land developers within the watershed are advised to practice good land management such that nutrient or sediment addition to the lake and its tributaries are minimized.

Household Tips to Keep Fraser 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 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.
- 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

Ministry of Water, Land and Air Protection
Contact: Bruce Carmichael
Public Feedback Welcomed
3rd Floor, 1011-4th Ave
Prince George, BC, V2L 3H9
Ph: (250)-565-6455
Email: Bruce.Carmichael@gems9.gov.bc.ca

Fraser Lake Volunteer Water Quality Testing Group:
Contact: Brian Malchow, President
Nad
Box 274
Fraser Lake, BC
V0J 1S0
Ph: (250)-699-7739
Fax: (250)-699-7789
Email: bmalchow@bcgroup.net

Regional District of Bulkley-Nechako
Contact: Pam Hext, Director of Planning
Regional District of Bulkley-Nechako
P.O. Box 820
Burns Lake, BC, V0J 1E0
Ph: (250)-692-3195
Toll-Free: 1-800-320-3339
Fax: (250)-692-3305

The BC Lake Stewardship Society
Contact: Heidi Bennett
Science Building, 3333 College Way
Kelowna, BC, V1V 1V7 **or**
#4 552 West Ave,
Kelowna, BC, V1Y 4Z4
Ph: 1-877-BC-LAKES (or 250-717-1212)
Fax: (250)-717-1226
Email: heidib-bclss@shaw.ca **or** angiec-bclss@shaw.ca

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