BC Lake Stewardship and Monitoring Program

Ten Mile Lake 1984, 1999 - 2007

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

The Importance of Ten Mile 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, 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 1984 and 1999 - 2007 results of a Level II program for Ten Mile Lake.

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

The watershed area of Ten Mile Lake is approximately 49 km^2 (Cariboo Regional District, 2007). 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.

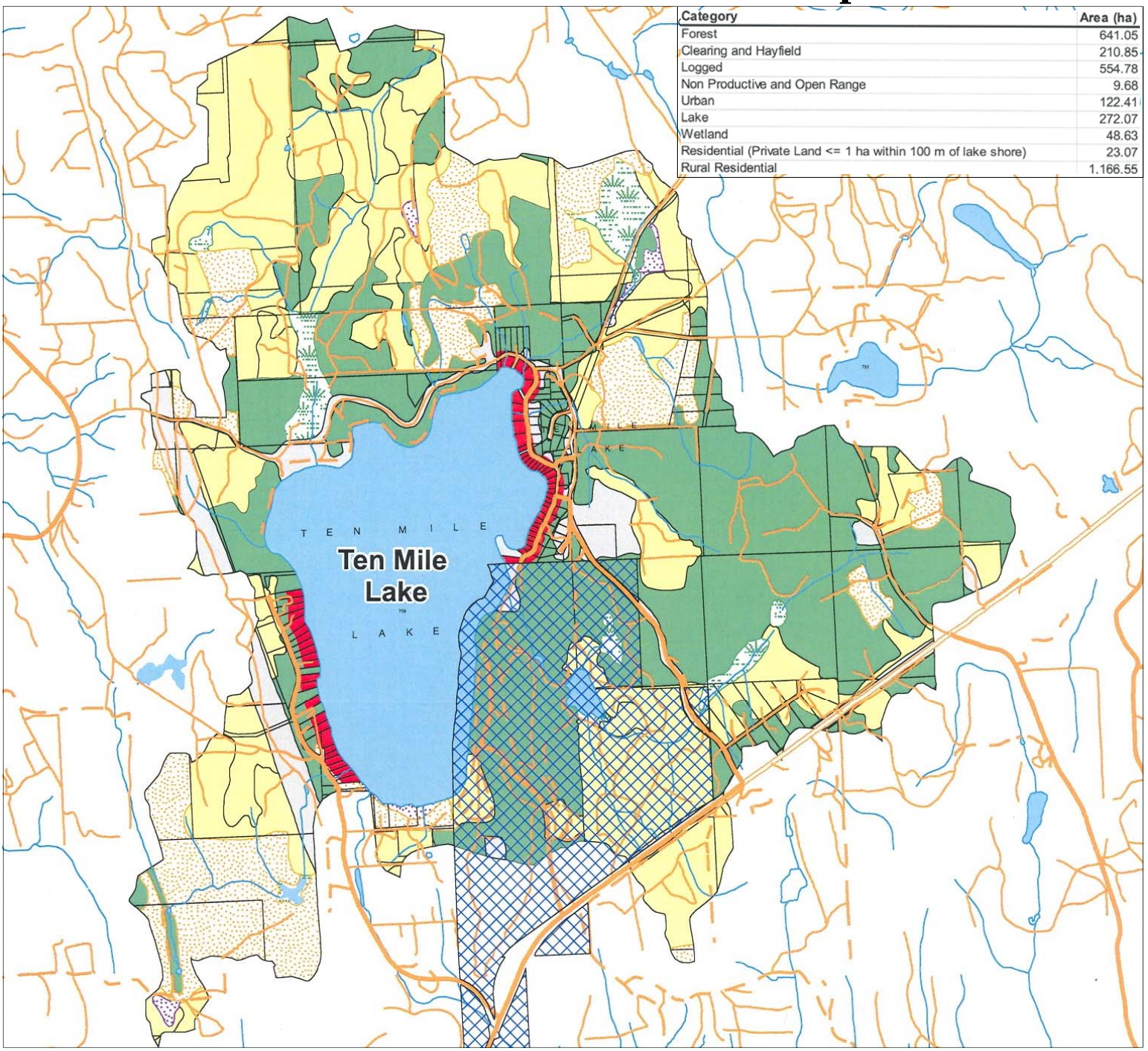
Ten Mile Lake is located approximately 12 km north of Quesnel in the Cariboo region of BC though ecologically, Ten Mile Lake can be considered to be in a transition zone between wetter ecosystems to the east and drier plateau ecosystems to the west. Ten Mile Lake is at an elevation of 707 m. The lake has a maximum depth of 21 m and a mean depth of 8 m. Its surface area is 242.9 hectares and the shoreline perimeter is 7.35 km. Ten Mile lake contains kokanee, mountain whitefish, chiselmouth, rainbow trout and redside shiner. Ten Mile Lake was named for a milepost of the Great Pacific Eastern Railway that was located there in

the early 1900's. After WW II the tracks had to be relocated due to difficulties in crossing the Cottonwood River. Evidence of the abandoned rail grade can be seen in the provincial park on Ten Mile Lake. Ten Mile Lake is a popular recreation spot for both the residents of Quesnel and visitors alike. The provincial park at Ten Mile offers a picnic area, beaches, a boat launch and a large number of trails.

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 flushing rate of Ten Mile Lake is approximately 2 years (Ministry of Environment files, 2008). This reasonably short flushing rate and moderate mean depth indicate Ten Mile Lake has some ability to assimilate additional nutrients.

The map below shows the Ten Mile Lake watershed and its associated land use practices. Land use in the watershed is approximately 34% forested, 30% logged, 63% rural residential and 7% is considered urban development. The watershed of Ten Mile Lake has undergone considerable development (Cariboo Regional District, 2007).

Ten Mile Lake Watershed Map



Non-Point Source Pollution and Ten Mile 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 is economically and culturally important. When practices are improperly managed, however, there can be significant NPS impacts, such as nutrients and pathogens from manure and damage to shorelines from livestock access.

Onsite Septic Systems and Grey Water

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

Stormwater Runoff

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

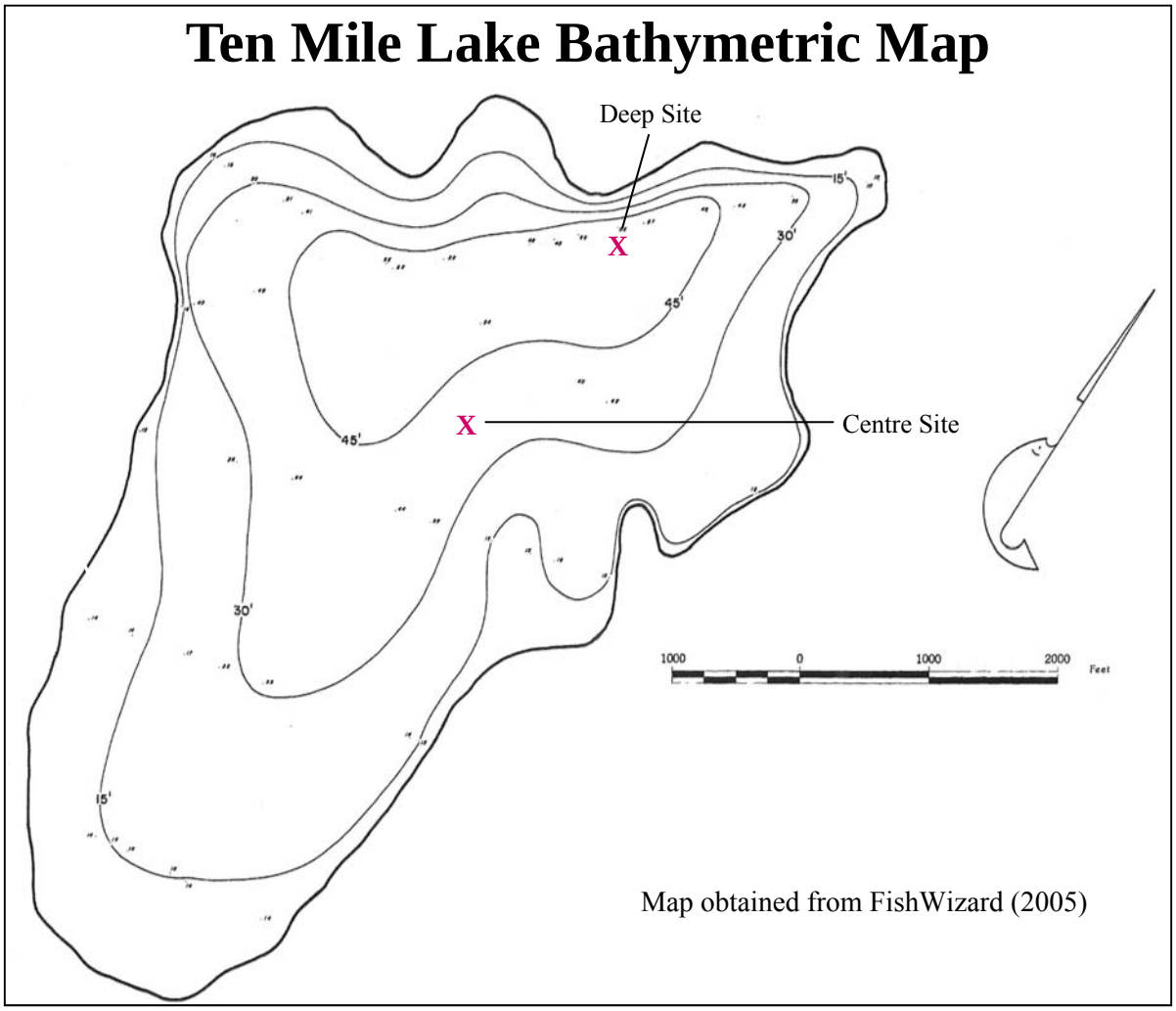
Forestry

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

Boating

Oil and fuel leaks are the main concerns of boat operation on small lakes. 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.

Ten Mile Lake Bathymetric Map



Map obtained from FishWizard (2005)

What's Going on Inside Ten Mile 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, often 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.

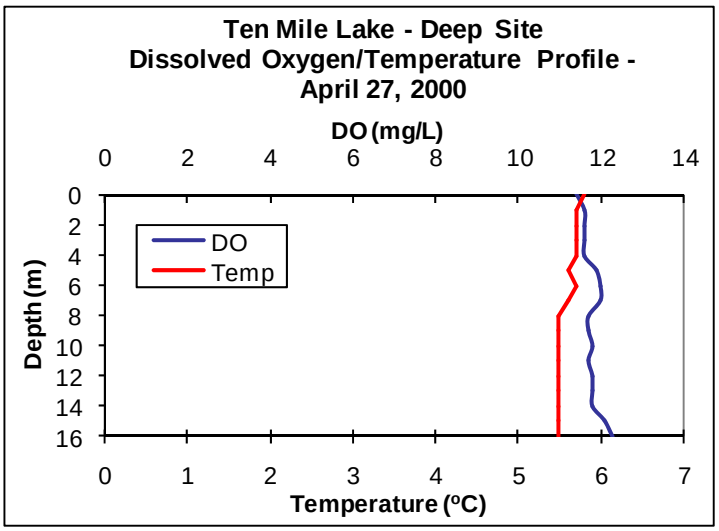
In spring and fall, these lakes usually mix from top to bottom (overturn) as wind energy overcomes the reduced temperature and density differences between surface and bottom waters. In the winter, lakes re-stratify under ice with the densest water (4°C) near the bottom. Because these types of lakes turn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

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.

Surface temperature readings serve as an important ecological indicator. By measuring surface temperature, we can record and compare readings from season to season and year to year. Temperature stratification patterns are also 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.

The timing of freeze-up and break-up of BC lakes is important information for climate change research. Volunteers are collecting ice-on and ice-off dates for Ten Mile Lake.

Dissolved oxygen (DO) and temperature data was collected at 2 sites (the deep site and the centre site) on Ten Mile Lake at or very close to spring overturn. The previous graph shows the DO and temperature data collected on April 27, 2000 at the deep site. The lake appears to be well mixed, indicating the lake was sampled during spring overturn, resulting in representative samples.



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 because oxygen has been depleted under winter ice.

As mentioned, the previous graph indicates that spring overturn was occurring, as the lake appears to be well mixed. For this reason, spring overturn is a good time to get a representative sample. Nutrient concentrations can be compared each spring to determine trends.

Trophic Status

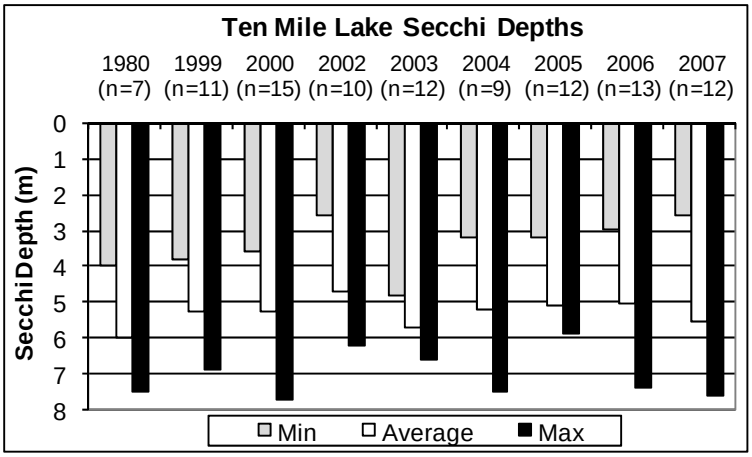
The term *trophic status* is used to describe a lake's level of productivity and depends on the amount of nutrients available for plant growth, including tiny floating algae called phytoplankton. Trophic status is often determined by measuring levels of total phosphorus (TP), algal chlorophyll *a* (chl. *a*) 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*) 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

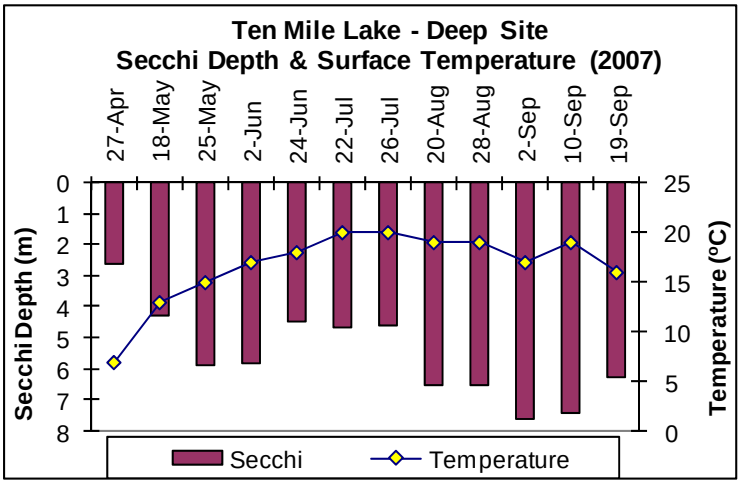
As mentioned in the previous section, one method of determining productivity is water clarity. The more productive a lake is, the higher the algal growth and, therefore, the less clear the water becomes. The clarity of the lake water can be evaluated by using a Secchi disc, a black and white disc that measures the depth of light penetration.

The Secchi depths for all years were taken at the deep site. The graph below shows the minimum, average and maximum Secchi depths recorded in Ten Mile Lake from 1980, 1999, 2000, 2002 to 2007, as well as the number of readings taken in each year (n). The 1980 Secchi data did not meet the minimum number of readings (12) and missed the spring season. However, the summer data from 1980 is consistent with the same time frame from the other sampling years.



The average summer Secchi depth measurements ranged from 4.7 m (2002) to 6.0 m (1980). From 2003 to 2007 average Secchi depths have been greater than 5 m and for all sampling years readings are within the oligotrophic range (> 5 m), with the exception of 2002 which is just below the threshold of 5 m. The Secchi data over the period 1980 to 2007 indicates relatively stable conditions.

Natural variation and trends in Secchi depth and temperature not only occur between years, but also throughout one season. For example, the following graph for 2007, shows variability in both the Secchi depth and surface temperature

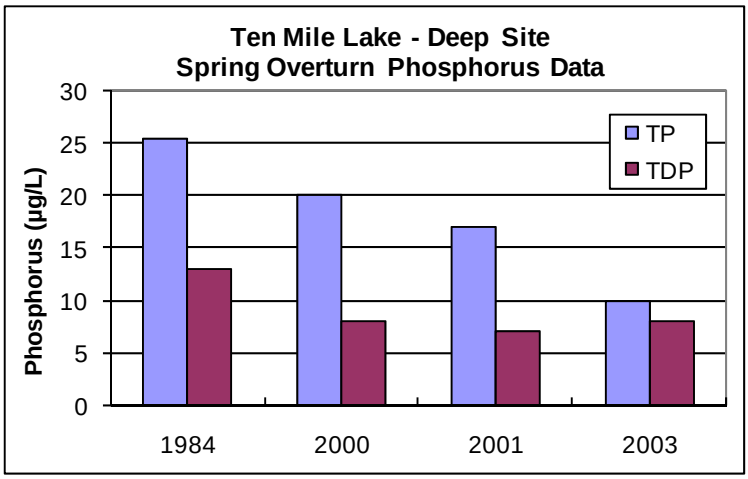


through the season. Generally, as temperature increases, so do some species of algae. Due to the increase in algae, the water clarity decreases as shown by a lower Secchi depth. While not a strong relationship, this pattern can be observed during the summer months for Ten Mile Lake.

Phosphorus

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

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



As seen in the graph above, data collected in 1984, 2000, 2001 and 2003 indicates that total phosphorus levels may have declined in Ten Mile Lake. However, total dissolved phosphorus (TDP) is less variable than TP and the 2000, 2001 and 2003 data indicates that TDP levels are stable.

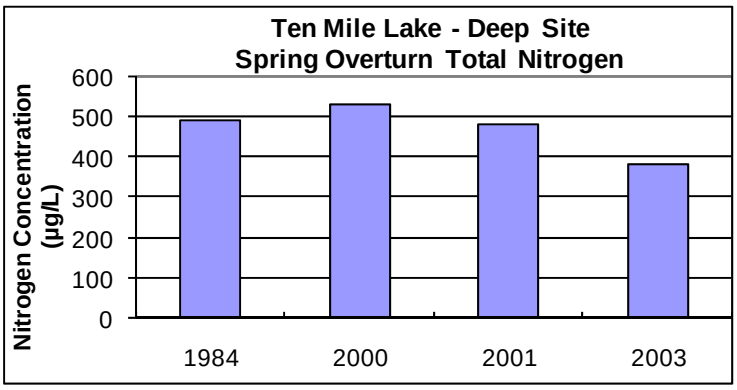
Based on the spring overturn phosphorus data for these years, the lake was exhibiting mesotrophic conditions.

Nitrogen

Nitrogen is the second most important nutrient involved in lake productivity. In BC lakes, nitrogen is rarely the

limiting nutrient for algae growth. In most lakes, the ratio of nitrogen to phosphorus is well over 15:1, meaning excess nitrogen is present. In lakes where the ratio is less than 5:1, nitrogen becomes limiting to algae growth and can have major impacts on the amount and species of algae present.

The average N:P ratio at spring overturn was approximately 28:1 which means that the lake is a phosphorus-limited system for the growth of algae. Therefore, an increase in nitrogen should not increase algal biomass, although the species composition could change, possibly to a less desirable species. With this ratio, any increase in phosphorus concentrations would result in increased algae biomass.



The previous graph shows the total nitrogen (TN) overturn data in Ten Mile Lake for 1984, 2000, 2001, and 2003. Between 2000 and 2003 there appears to be a slight decrease in the average TN overturn concentrations. The TN values from 1984, 2000, 2001 and 2003 were 490 µg/L , 530 µg/L, 480 µg/L and 380 µg/L, respectively. Based on these nitrogen values Ten Mile Lake falls in the mesotrophic state (Nordin, 1985).

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.

Historic chlorophyll *a* data from June to September 1980 averaged 2.4 and 2.8 µg/L at the centre and deep sites, respectively, indicating the lower mesotrophic range. Chlorophyll *a* data calculated from spring overturn phosphorus ranged from 4.6 µg/L in 2000 to 2.3 µg/L in 2003, again indicating lower mesotrophic conditions.

Aquatic Plants

Aquatic plants are an essential part of a healthy lake and serve many important functions including: stabilizing shorelines, providing habitat for fish, amphibians, invertebrates, birds and mammals, reducing nutrients, preventing algal blooms and producing oxygen. Factors that affect the type and amount of plants found in a lake include the level of nutrients (i.e. phosphorus), temperature, and introduction of invasive species.

Plant species found in Ten Mile Lake include *Potamogeton* (pondweed), *Rannunculus* (buttercup), *Ceratophyllum* (coon tail), *Chara* (musk grass), *Lemna* (duckweed), *Nuphar* (cow lily), *Calla Palustris L.* (water arum), *Sparganium* (bur reed), and *Scirpus* (bulrush).

Aquatic plants play an important role in the lifecycle of aquatic insects, providing food and shelter from predators for young fish, and also providing food for waterfowl, beavers and muskrats.

Aquatic plant species can spread between lakes via boaters. Be sure to check for and remove all aquatic plant fragments from boats and trailers before entering or when leaving a lake.

Should Further Monitoring Be Done on Ten Mile Lake?

The data collected on Ten Mile Lake indicates that the water quality has remained relatively stable over the period 1980 to 2003. The nitrogen, phosphorus and chlorophyll *a* data suggests a lower mesotrohpic state with good average water clarity in the slightly oligotrophic range. As Ten Mile Lake has a good baseline of spring overturn data, there are no immediate plans to continue sampling at spring overturn, however the lake should be sampled at some point in the future for comparison to baseline. Volunteers are continuing to monitor Secchi depth and surface temperature, which will provide valuable long term records and help to identify early warning signs should there be a deterioration in water quality. As well, volunteers are recording ice-on and ice-off dates which will be valuable for climate change studies.

Tips to Keep Ten Mile Lake Healthy

Yard Maintenance, Landscaping & Gardening

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

Agriculture

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

Onsite Sewage Systems

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

Auto Maintenance

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

Boating

- Do not throw trash overboard or use lakes or other waterbodies as toilets.
- Use biodegradable, phosphate-free cleaners instead of harmful chemicals.
- Conduct major maintenance chores on land.
- Use absorbent bilge pads to soak up minor leaks or spills.
- Check for and remove all aquatic plant fragments from boats and trailers before entering or leaving a lake.
- Do not use metal drums in dock construction. They rust, sink and become unwanted debris. Use blue or pink closed-cell extruded polystyrene billets or washed plastic barrel floats. All floats should be labelled 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 Environment - Cariboo Region
Suite 400 - 640 Borland Street
Williams Lake, BC V2G 4T1

Phone: 250.398.4530
Fax: 250.398.4214

The BC Lake Stewardship Society
203 - 1889 Springfield Rd.
Kelowna, BC V1Y 5V5

Phone: 250.717.1212
Toll Free: 1.877.BC LAKES
Email: info@bclss.org
Website: www.bclss.org

Acknowledgements

Volunteer Monitoring by:
Bert Sturt

Data Compiling by:
Adam Neil & Kirsten Heslop (Ministry of Environment - Williams Lake) and Carolyn Johns (BCLSS)

Lake Report Produced by:
Carolyn Johns (BCLSS)

Technical Review by:
Chris Swan (Ministry of Environment - Williams Lake)

Bathymetric Map:
FishWizard
(www.fishwizard.com)

Land Use Map:
Ministry of Sustainable Resources Management, Business Solutions Branch - Williams Lake

Photo Credit:
BC Parks (http://www.env.gov.bc.ca/bcparks/)

References

Cariboo Regional District. 2007. Shoreline Management Policy 2004. Williams Lake, BC

Nordin, R.N. 1985. Water Quality Criteria for Nutrients and Algae. Water Quality Unit, Resource Quality Section. Ministry of Environment, Lands and Parks. Victoria, B.C.

O'Keeffe, J., Zirnhelt, N., and J. Savege. 2000. Cariboo Region Lake Water Quality 1998-99. Ministry of Environment, Lands, and Parks. Williams Lake, BC.