BC Lake Stewardship and Monitoring Program

Mahood Lake 1975 - 2005

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

The Importance of Mahood 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 1975 and 2003 - 2005 results of a Level II program for Mahood 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 Mahood Lake is approximately 904 km^2. 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.

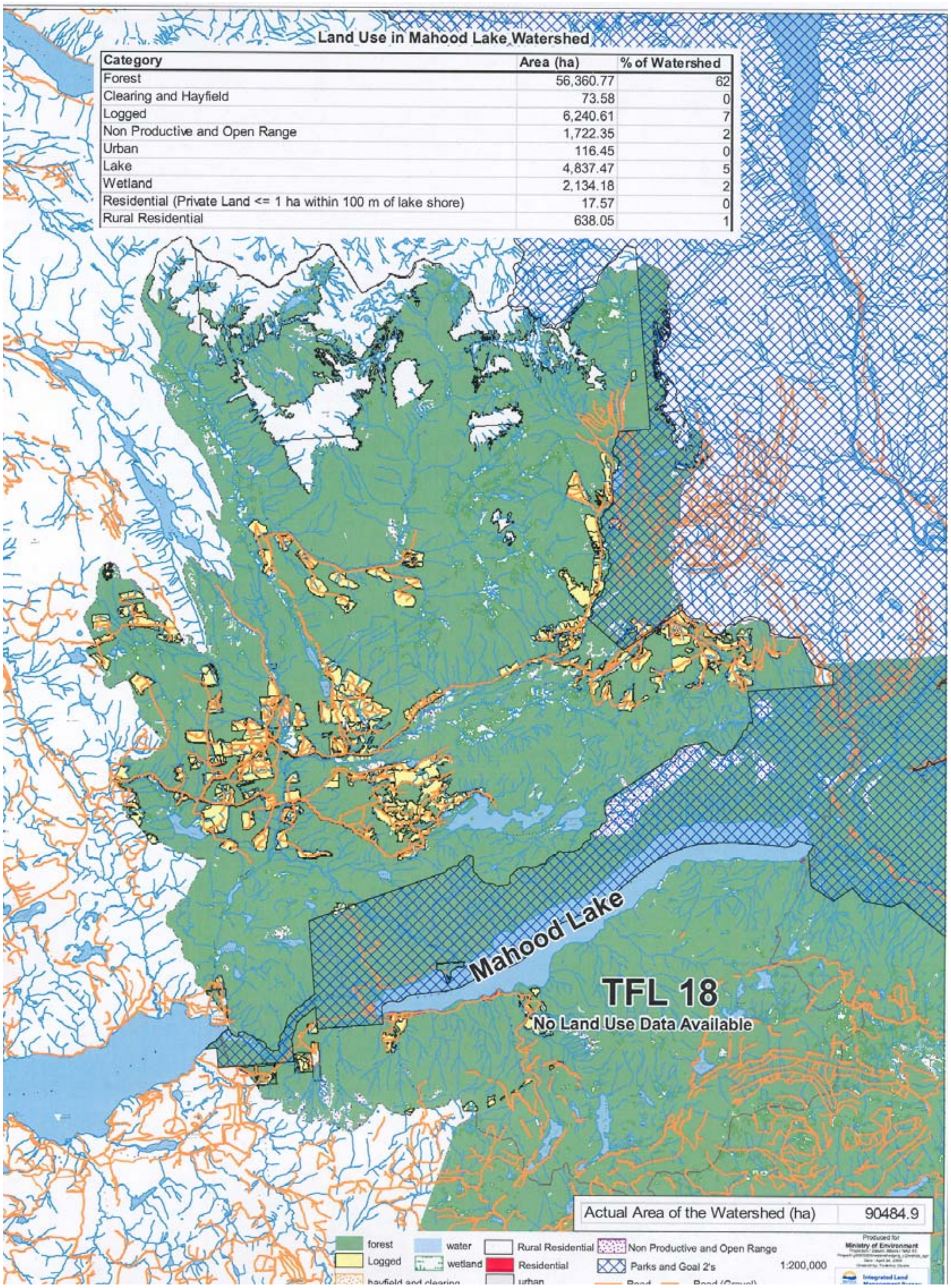
Mahood Lake is located in a U-shaped valley between the northern Quesnel Highlands and the southern Shuswap Highlands in the Cariboo Mountains. The nearest communities to Mahood Lake include 100 Mile House, Lone Butte and

Bridge Lake. Mahood Lake is at the southwestern tip of Wells Gray Provincial Park and is a popular destination for camping, fishing and hiking. The lake has a maximum depth of 208 m and a mean depth of 94.2 m. Its surface area is 3310 hectares and the shoreline perimeter is 47.9 km. Mahood Lake's elevation is 629 m and it is the only lake located within Wells Gray Park that is not glacier fed, making the summer temperature ideal for swimming. Mahood Lake contains kokanee, lake trout, longnose sucker, mountain whitefish, northern dace and rainbow trout.

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. There is no information for the flushing rate of Mahood Lake at this point in time.

The map below shows the Mahood Lake watershed and its associated land use practices. It should be noted that the Tree Farm License (TFL) is not included in the watershed and land use area calculations. Land use around the lake is approximately 62% forested, 7% logged, 2% non-productive, 1% rural residential and the lake is approximately 5% of the watershed size.

Mahood Lake Watershed Map


Land Use in Mahood Lake Watershed

Category	Area (ha)	% of Watershed
Forest	56,360.77	62
Clearing and Hayfield	73.58	0
Logged	6,240.61	7
Non Productive and Open Range	1,722.35	2
Urban	116.45	0
Lake	4,837.47	5
Wetland	2,134.18	2
Residential (Private Land <= 1 ha within 100 m of lake shore)	17.57	0
Rural Residential	638.05	1

Non-Point Source Pollution and Mahood 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 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.

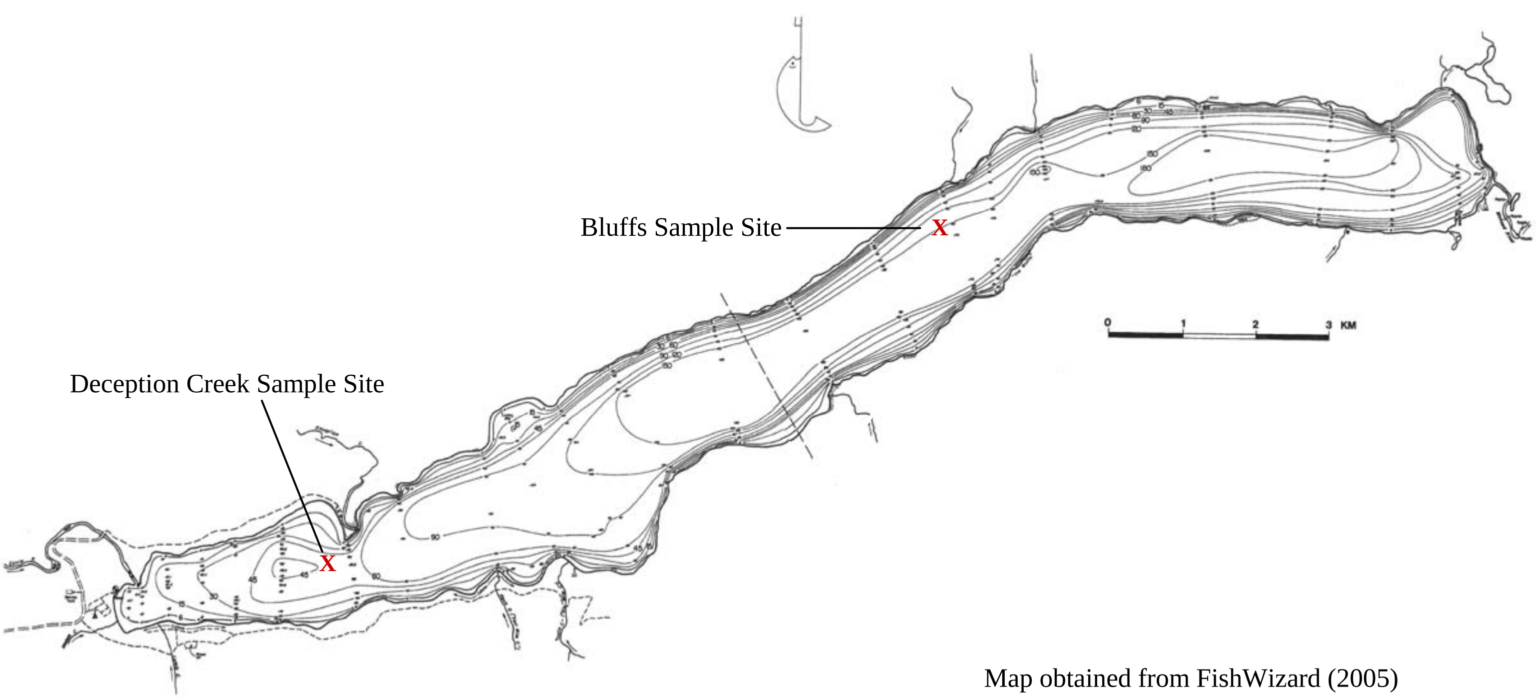
Forestry

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. 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.

Mahood Lake Bathymetric Map



Map obtained from FishWizard (2005)

What's Going on Inside Mahood Lake?

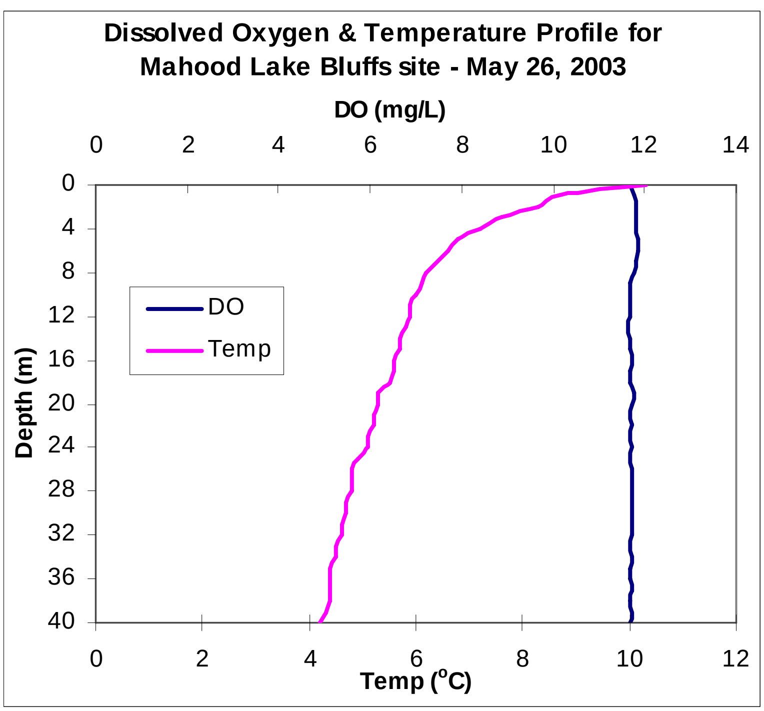
Temperature

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 BC.

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 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 (DO) and temperature data was collected during spring overturn at 2 sites on Mahood Lake between 2003 and 2005. The two sites sampled are the Bluffs site and Deception Creek site, shown on the bathymetric map on page 3. The previous graph shows the dissolved oxygen and temperature data collected on May 26, 2003 at the Bluffs site. The lake was completely mixed at spring overturn. Surface warming indicates the onset of thermal stratification, indicating the lake was sampled after the lake underwent spring overturn.

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 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 (fish 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.

As mentioned, the previous graph indicates that spring overturn had recently occurred, as the lake appears to have been thoroughly mixed. For this reason, spring overturn is a good time to get a representative sample as chemicals in the water column are uniform. Nutrient concentrations can be compared each spring to determine trends.

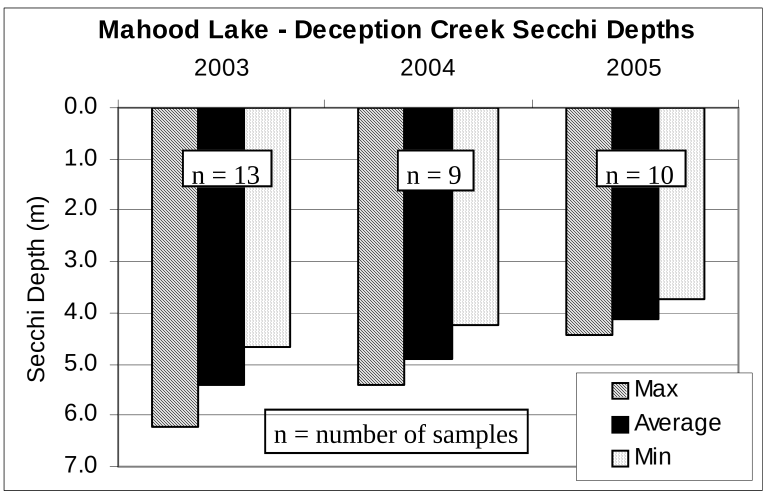
Trophic Status

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 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.

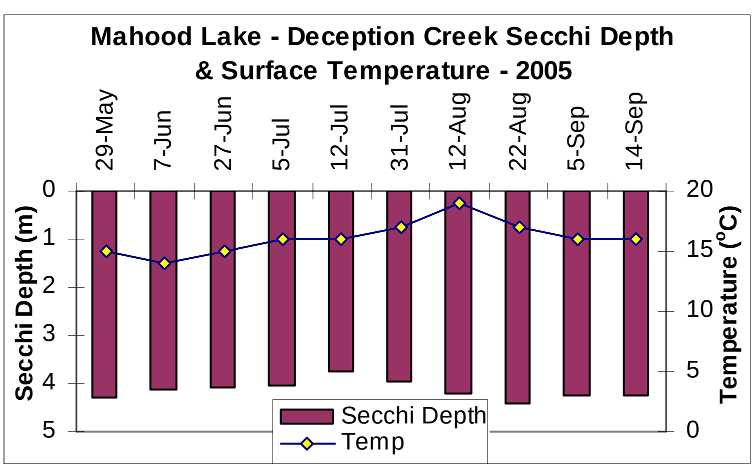
Lakes of low productivity are referred to as ***oligotrophic***, meaning they are typically clear water lakes with low nutrient levels (1-10 *ug*/L TP), sparse plant life (0-2 *ug*/L chl. *a*) and low fish production. Lakes of high productivity are ***eutrophic***. They have abundant plant life (>7*ug*/L 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.

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 Secchi depths for all three years were taken at the Deception Creek sample site. Summer Secchi depth measurements ranged from 5.4 m (2003) to 4.1 m (2005). The lowest average reading falls in the mesotrophic (2 - 5 m) classification while the maximum average reading places the lake in the oligotrophic (>5 m) range.



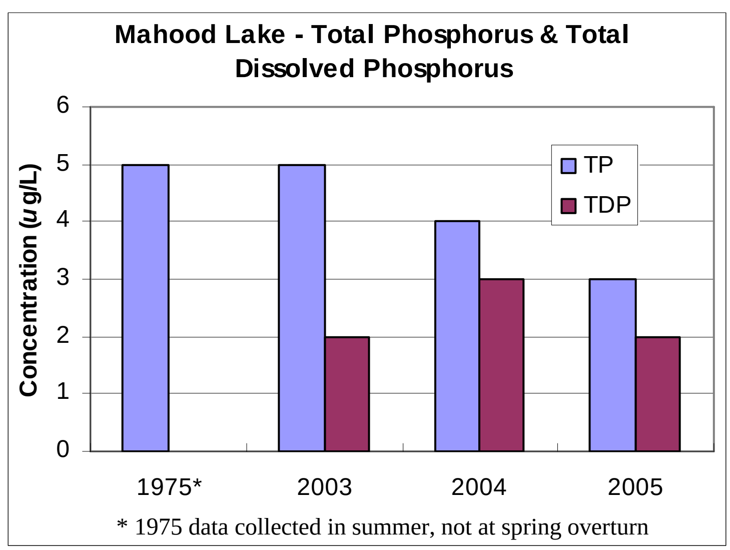
The small range in average Secchi depths show there has been little change in water clarity over the sample years at the Deception Creek sample site.

Natural variation and trends in Secchi depth and temperature not only occur between years, but also throughout one season. For example, the previous graph, for 2005, indicates that the temperature increases to a maximum on August 12th and then declines, while the Secchi depth varies slightly throughout the sampling season. Generally, as temperature increases, so do some species of algae. Due to the increase in algae, the water clarity can decrease and the Secchi depth decreases as well. This particular trend is not seen in the Mahood Lake data.

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. Mahood Lake does not experience internal loading events.



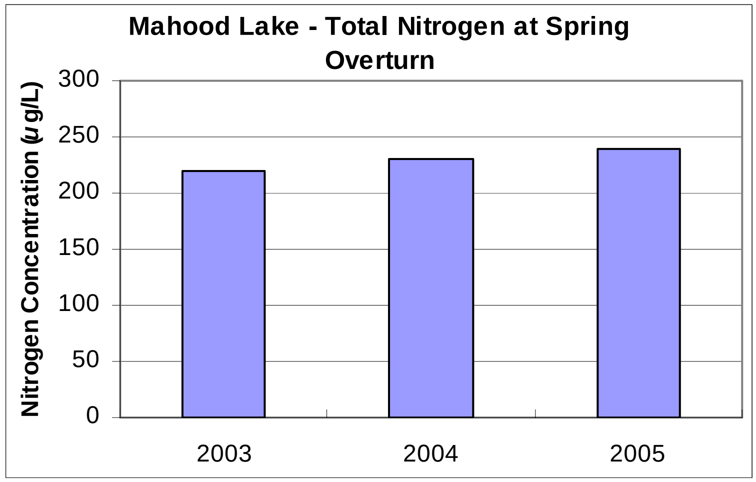
The historical data from 1975 was collected in mid summer during lake stratification, therefore the values do not reflect spring overturn conditions. For this reason a comparison is not made between these values and those calculated for 2003 through 2005 during spring overturn. However, the 1975 values are an indication that Mahood Lake water quality has not declined over the past 30 years.

As seen in the previous graph, data collected from 2003 to 2005 indicates that the total phosphorus levels declined slightly in Mahood Lake, but this likely reflects natural variability. Total dissolved phosphorus levels appear to be quite stable. Based on the spring overturn phosphorus data for these three years, the lake was exhibiting oligotrophic conditions which generally agrees with the average Secchi depth classification.

Nitrogen

Nitrogen is the second most important nutrient involved in lake productivity. In BC lakes, nitrogen is rarely the limiting nutrient for algae growth (see phosphorus). In most lakes, the ratio of nitrogen to phosphorus is well over 15:1, meaning excess nitrogen is present. In lakes where the N:P 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 N:P ratio is approximately 53:1, which means the lake is a phosphorus limited system. Although an increase in nitrogen should not increase algae biomass, it could result in a change to the species of algae present, possibly to a less desirable species.



The total nitrogen (TN) collected on August 12, 1975 was 160 *u*g/L. Since the 1975 data was collected in the summer it is not included in the above graph for comparison to the spring overturn samples collected in 2003, 2004 and 2005. The average spring overturn TN concentrations were 220 *u*g/L, 230 *u*g/L and 240 *u*g/L, in 2003, 2004 and 2005, respectively, likely reflecting natural variability. As the above graph shows, the total nitrogen concentrations have remained relatively stable since 2003.

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 level of nutrients (i.e. phosphorus), temperature, and introduction of invasive species.

Plant species surveyed in Mahood Lake include: *Chara* (musk grasses), *Carex* (sedges), *Equisetum* (horsetails), and *Myriophyllum* (water milfoil family) species, *Ranunculus sceleratus* (celery-leaf buttercup), *Hippuris vulgaris* (mare's tail), and 2 species of *Potamogeton* (pondweeds).

Elodea Canadensis (Canadian waterweed), a common native aquatic plant, was identified in Mahood Lake in 1999. This aquatic plant has a history of population explosions and sudden declines.

Elodea and other aquatic plants play an important role in the lifecycles of aquatic insects, providing food and shelter from predators for young fish, in addition to providing food for waterfowl, beavers and muskrats.

Many aquatic plant species can spread between lakes via boaters potentially resulting in species introduction. 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 Mahood Lake?

The data collected on Mahood Lake indicates that the water quality has remained virtually unchanged for the last 30 years when analyzing phosphorus levels. The data collected does not indicate further monitoring is necessary at this time. The Ministry of Environment believes it would be worthwhile to repeat the summer Secchi disk program in the future to compare against the baseline data presented here. However, if volunteers are willing, freeze-up and break-up of ice should be recorded for climate change studies.

Tips to Keep Mahood 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 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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Chris Swan (Ministry of Environment - Williams Lake)

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FishWizard
(www.fishwizard.com)

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

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

References

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.