The Importance of Ness 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 1994-1996 and 2008-2010 results of a Level III program for Ness 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. The 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.

Ness Lake’s monitoring program began in 1994 and since 1996, it has been coordinated by volunteers who live on the East Basin of Ness Lake in partnership with the MoE. 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.

A watershed is defined as the entire area of land that moves the water it receives to a common water body. The term watershed is misused when describing only the land immediately around a water body or the water body itself. The true definition represents a much larger area than most people normally consider. The watershed area of Ness Lake is 19.05 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 continually 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.
Ness Lake is located in the Omineca Region of B.C., approximately 35 km northwest of Prince George, via Highway 97 and Chief Lake Road. The lake lies at an elevation of 778 m, and has maximum and mean depths of 18.3 m and 6.7 m, respectively. It has a surface area of 2 km$^2$ and a shoreline perimeter of 18.8 km. Ness Lake is a popular lake for angling, and contains both sport and non-sport fish species. Sport fish include: kokanee, brook and rainbow trout. Other species include largescale and longnose suckers, red-side shiners, and prickly sculpin. Periodic stocking of sport fish in Ness Lake began in 1936, and the lake has been stocked annually with rainbow trout from 1985 to 2011, brook trout from 1982 to 2011, and with kokanee in the spring of 2010 and 2011 (FIDQ, 2012).

The lake has only one inflow, Heron Creek, and no outflows. Although unconfirmed, it has been suggested that the lake levels are maintained by a groundwater interface throughout the lake due to the lake’s position in an eskers formation, which are often made of porous sand or gravelly substrates. The flushing rate, a factor that affects water quality, is the rate of water replacement in a lake and depends on the amount of inflow and outflow. The higher the flushing rate, the faster excess nutrients can be removed from the system. The flushing rate for Ness Lake is unknown as it would be difficult, time consuming and costly to determine without an outflow, and the results would likely be inconclusive due to the complex nature of the system (Larson, 2012).

The lake has three main basins: the central and east basins, which are quite developed, and the southwest basin, which has only a few residences, is sheltered by mostly forested shoreline, and has a wetland area on the west end. The map below shows the land use within the Ness Lake watershed. There is a considerable amount of residential development surrounding the lake, as well as a 14 ha Regional Park, an Elks Camp and a large bible camp. Included in the 59% of privately owned land within the watershed is 1.39 km$^2$ of wetlands. In October of 2005, a shoreline survey was conducted along Ness Lake. Of the 265 lakeshore residences, 42.3% had complete or high riparian buffers and 57.7% had moderate, low or no riparian buffer (MoE, 2005). In 2005, a shoreline bacterial study was completed by the Ministry of Environment. The data suggested Ness Lake’s water quality is unsuitable for human consumption without prior treatment (Jacklin, 2005), which is consistent with most surface water bodies. Copies of this report are available upon request from the BCLSS office. The lake is used for general recreational purposes and provides good public access.
Point source pollution originates from municipal or industrial effluent outfalls. Other pollution sources exist over broader areas and may be harder 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 water courses 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 and phosphorus) include chemical fertilizers and improperly situated winter feeding areas.

Onsite Septic Systems and Greywater
Onsite septic systems effectively treat human waste water and wash water (greywater) 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 disposal of human waste and greywater, 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 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 water courses. 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 greywater discharges are issues. Other problems include the spread of aquatic plants and the dumping of litter. In shallow water operation, the churning up of bottom sediments and nutrients is a concern.
**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 difference 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.

Temperature was measured seasonally at three sites (Central Basin, East Basin and Southwest Basin) in 1996 and 2008—2010. Temperature patterns for the Central and East Basins are comparable. The graph above shows the 1996 temperature in the East Basin. The October 22, 1996 sample date indicates isothermy as the temperature at all depths is similar, indicating fall overturn. The graph shows stratification through out the summer with a maximum surface temperature of 21 °C and a minimum bottom temperature of 5 °C.

The 2010 temperature graph for the East Basin shows similar patterns to the 1996 graph. There is isothermy indicated on both April 26, 2010 and on October 13, 2010 indicating both the spring and fall overturn events were captured. In addition, the 2010 East Basin graph shows good stratification through out the summer as well as similar temperature ranges to the 1996 data. The 2010 graph indicates a maximum surface temperature of 22 °C and 5 °C as a minimum bottom temperature.

The Southwest Basin shows different patterns than the Central and East Basins, as seen in the graphs below. The Southwest Basin experiences near-uniform temperature profiles with only minimal stratification in both 1996 and 2010. This is likely due to the basin’s shallow depth. The 1996 temperatures ranged from a surface maximum of 22 °C to a bottom minimum of 3.5 °C. The 2010 temperature range was slightly warmer with a surface maximum of 22.5 °C and a bottom minimum of 6.5 °C, likely as a result of a warmer summer season in general. The difference between the 1996 and 2010 temperature ranges are within normal and expected margins of error.

**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) typically 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 falls below 20% saturation) where temperatures may be too warm. Fish kills can occur when decomposing or respiring algae use up all 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.

Similar to temperature, the oxygen pattern for the Central and East basins are comparable. In both 1996 and 2010, the surface and mid-depth oxygen levels remained near saturation, with maximum dissolved oxygen measured at 11 mg/L in 1996 and 12 mg/L in 2010. In addition, both basins exhibited near-anoxia in the bottom waters, which would have been unlikely to support fish during most of the sampling period as levels were below 4 mg/L which is the minimum amount of oxygen required for most fish. Vertical mixing and the aeration of bottom waters occurred with the onset of cooler fall temperatures.

Alternatively, the Southwest Basin indicates oxygen patterns that are mixed throughout the season in both 1996 and 2010. Oxygen levels ranged between 6—12 mg/L in 1996 and 6—13 mg/L in 2010. These levels indicate supersaturated oxygen levels occurring periodically.

**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 disk, a black and white disk used to indicate the depth of light penetration. Productivity is also determined by measuring nutrient levels and chlorophyll a (the green photosynthetic pigment in 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 (Nordin, 1985). 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 often have elevated algal levels and generally lack recreational appeal.

Ness Lake’s average spring TP values for the Central, East and Southwest Basins are shown on page 3. In the Central Basin (graphed below), the average TP and total dissolved phosphorus (TDP) appears to have increased from the mid-1990’s in 2008 and 2009, but has declined again in 2010, likely as a result of a longer ice-off period in 2010. All values, however, indicate oligotrophic conditions. Similarly, the spring TP values for all years in the East Basin indicate oligotrophic conditions.

The average spring TP in the Southwest Basin appear to have increased significantly from the mid-1990’s to 2008, but then decline in both 2009 and 2010. Overturn TP readings in 2008 indicate low mesotrophic conditions, however, as all data collected before and after 2008 indicate oligotrophic conditions, it is likely that 2008 may have been an anomalous year due to a late spring that year.

However, in 2010, neither the Central nor East Basin appear to have experienced internal loading. As indicated in the graph below the phosphorus levels in the Central Basin appear to have been well mixed throughout the season except for September 19th where likely a storm event caused the surface and mid-depths to mix, but did not extend to the bottom waters. The 2010 graph for the East Basin shows similar results. The Southwest Basin showed phosphorus levels to be well mixed through out the season in all three years. There was insufficient phosphorus data from the mid-1990’s to do a comparison to more recent data. All TP values observed indicate oligotrophic conditions.

The following graph displays the phosphorus cycling in the Central Basin. In 2008, it appears that internal loading is taking place in the latter half of the season when orthophosphorus (OP), the form of phosphorus released from bottom sediments, spiked. These high OP levels coincided with low oxygen levels adding weight to the indication of internal Phosphorus loading. Similar patters were observed in 2009 in the Central Basin. The East Basin also showed a small amount of internal loading in both 2008 and 2009, coinciding with low oxygen conditions.
showed a similar pattern. The Southwest Basin showed no significant difference in average secchi depth between any of the years.

The graph below shows the 2009 East Basin water clarity data. As seen in the graph, when Chlorophyll a levels drop, the secchi depth increases whereas when the Chlorophyll a increases the secchi depth becomes shallower. This is a typical pattern showing the relationship between secchi depth and Chlorophyll a. Chlorophyll a values ranged between 0.5 and 2.5 µg/L in the East Basin in 2009, which is similar to the values observed in the Central and Southwest Basins for the same year which ranged from 0.5—2.5 µg/L and 0.5—3.3 µg/L respectively.

The following two graphs show the minimum, average and maximum Chlorophyll a data from the Central and Southwest Basins. The “n” indicates the number of samples averaged together. In the Central Basin, average Chlorophyll-a levels appear to decrease from 1996 to 2008, but then increase in 2009 and 2010. The East Basin follows a similar pattern. The Southwest Basin appears to increase slightly from 1996 to 2008, and the decreases slightly in 2009 and 2010. All the increases and decreases to Chlorophyll-a data in all three basins are within normal and expected ranges, and all average values indicate oligotrophic conditions.

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.

Ness Lake has not had a plant survey done, however Isoetes l. (lake quillwort) has been identified in the lake.

Aquatic plants play an important role in the lifecycles of aquatic insects, provide food and shelter from predators for young fish, and also provide 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.

Aquatic Plants

Should Further Monitoring Be Done on Ness Lake?

In the Central Basin, TP values appear to have increased from the mid-1990’s in 2008 and 2009, but then declined again. The TP, secchi and Chlorophyll-a data all indicate that the Central Basin is oligotrophic for all years. Similarly, the TP, secchi and Chlorophyll-a data for the East Basin indicate that it is also oligotrophic for all years. The Southwest Basin has periodic spikes in TP, secchi and Chlorophyll-a data, particularly in 2008, that would indicate low mesotrophic conditions however, average values for the other years sampled are within the accepted ranges for oligotrophic conditions.

Overall, Ness Lake reflects healthy oligotrophic conditions. It is recommended to continue monitoring within the next decade to evaluate if any changes have occurred in the interim period. In addition, the Carlson Trophic State Index (USEPA, 2007) suggests a strong correlation between the TP, Chlorophyll-a and secchi data. Based on this, it would be possible for volunteers to collect regular secchi measurements as a representative parameter for determining the trophic status of Ness Lake on a year to year basis. Volunteers are also encouraged to record ice on/off dates as these are valuable for climate change studies.
Tips to Keep Ness Lake Healthy

Yard Maintenance, Landscaping & Gardening
- Minimize the disturbance of shoreline area 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 ladybugs, 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 water bodies. 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 stream banks and lakeshore
- 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 stream bank, river or lakeshore and avoid planting crops right up to the edge of a water body

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 water bodies.
- Conserve water: run the washing machine and dishwasher only when full and use only low-flow shower heads 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 water bodies 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 leak 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 labelled with the owner’s name, phone number and confirmation that barrels have been properly emptied and washed.
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References


George Floria performing Dissolved Oxygen Test.