# District of Lake Country Source to Tap Assessment of the South Kalamalka Lake Intake – July 2010.

## Executive Summary


The objectives of this assessment of the South Kalamalka Lake Intake were to characterize the lake and its immediate watershed, identify current and forecast future drinking water hazards and vulnerabilities, characterize the risk posed by each hazard and provide recommendations to reduce the impacts on District of Lake Country South Kalamalka intake.

This assessment characterized natural and man-induced hazards to drinking water quality as physical, chemical or biological. Existing research was augmented by field studies of water currents near the intake and lab studies on the fall rates of particulate contaminants. This research was used to define a proposed Intake Protection Zone (IPZ), based on a two hour travel time of water currents to the intake. The hazard assessments were then divided into those occurring inside the IPZ and those occurring outside the IPZ. The same hazard occurring outside the IPZ was given a lower risk rating than that hazard presented within the IPZ where there is less dilution and less time to react to a contaminant.

Specific recommendations and action plans were developed: (1) source protection for South Kalamalka Lake (2) water treatment and system protection plan and (3) future large expenditure improvements to the DLC Kalamalka Lake water system. Key recommendations include: applying for a License of Occupation over the Intake Protection Zone; considering bylaws to protect the foreshore; modifying the water quality monitoring to comply with IHA filtration deferral; replacing the raw water sample line on the intake to comply with IHA requirements; continue to collect data on extending the intake; have a Comprehensive Emergency Plan prepared, and work with the railway and Hwy 97 on materials hauled and appropriate spill containment.

This assessment confirms what we all know; source protection is important to preserving low-cost safe drinking water and it requires the co-operation of every Okanagan resident.


## Acknowledgements:


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**EXECUTIVE SUMMARY**

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# 1.0 Introduction

## 1.1 Study Background

On-going monitoring and research can be used to meet most of the criteria for the IHA requested Modules 1, 2, 7 and 8 of the Drinking Water Source to Tap Assessment for District of Lake Country's 22 m Kalamalka Lake Intake. Because Lake Country is proactive, monitoring and research on their intakes has been in place for years. For example, research into alternate intake depths is into its $5^{th}$ year in Kalamalka Lake. Information from their intake studies and the extensive data base collected by the Ministry of Environment was brought to bear on this project. Additional innovative research was undertaken to round out the data base for this Source to Tap Assessment. This report is intended for both water research and regional planning audiences.

## 1.2 Study Purpose

This report compiles new research and known data into the Source to Tap Assessment format for use identifying District of Lake Country Kalamalka Lake Intake's strengths, its liabilities and to allow for water quality protection and improvement planning. The goal is to achieve the best possible water quality through watershed protection and to minimize the water treatment and expense required to maintain excellent water quality to GVWs system.

## 1.3 Study Plan

This report was written using the Kalamalka Lake studies (2000 – 2009) commissioned by DLC and GVW. Reports created by Provincial agencies including Ministry of Environment were reviewed. Several reports prepared for the City of Kelowna by Hay and Company were also utilized.

The research/sampling component of this source to tap report was completed in 2009 and it involved:

- Collecting sediment samples from beneath the intake for total coliforms and *E. coli*
- Sediment traps were deployed near the intake for 7 months (October 2009 – May 2010)
- A caffeine analysis from the raw water to identify the presence/absence of dilute human outfall/septic wastes
- A drogue study of long-shore currents near the Kalamalka Intake was conducted because no water current modeling is available for this lake as it is for Okanagan Lake
- A combination of organic and inorganic material washed off a filter from the Kalamalka Lake system was allowed to settle to determine fall velocities for its constituent particulates

## 1.4 Definitions

The following terms are defined as they are used in this report.

**ALGAE BLOOM: A superabundant growth of algae. Many species are capable of coloring the water or covering the surface of a lake.**

**ANAEROBIC or ANOXIC ZONE: A zone that develops along the sediments where decomposition of algae etc consumes oxygen faster than it is supplied by the surrounding water. Anaerobic zones accumulate color, nutrients, THM precursors and taste & odor compounds.**

**BENTHIC: Organisms that dwell on or are associated with the sediments.**

**BIOFILM: A thin usually resistant layer of microorganisms, such as bacteria, that form on and coat surfaces such as water pipes.**

**BLUE-GREEN ALGAE (CYANOBACTERIA): The family of bacteria-like algae having cyanochrome as the main photosynthetic pigment and chlorophyll as a secondary pigment. Many members of this family reproduce rapidly and some cause algae blooms. They are notorious for taste and odor problems.**

**CONDUCTIVITYY: Electrical conductivity of water samples is used as an indicator of how salt-free, ion-free, or impurity-free the sample is; the purer the water, the lower its conductivity.**

**DIATOMS: The family of algae containing chlorophyll as the primary photosynthetic pigment and having hard, silica-based "shells" (frustules). Diatoms affect filtration and produce a range of taste and odors.**

**DROGUE: Float used to track current paths at a depth below the water surface determined by the position of vanes (or other surface to intercept currents) suspended beneath the float.**

**EUTROPHIC: Refers to a nutrient-rich, biologically productive water body where concentrations of mineral and organic nutrients have reduced dissolved oxygen, producing environments that frequently favor plant over animal life.**

**Lake Classification by Trophic Status Indicators**

| **Trophic Status** | Chlorophyll-a ug/L | Total P ug/L | Total N ug/L | Secchi disc m | Primary Production mg $C/m^2$/day |
|---|---|---|---|---|---|
| Oligotrophic | 0 – 2 | 1 – 10 | <100 | > 6 | 50- 300 |
| Mesotrophic | 2 – 5 | 10 – 20 | 100 – 500 | 3 – 6 | 250 – 1000 |
| Eutrophic | >5 | > 20 | 500 - 1000 | < 3 | >1000 |

After Nordin 1985

**FALL OVERTURN: In fall, surface waters cool and sink, eroding the thermocline until a wind storm mixes the entire water column.**

**FRESHET: Freshet is commonly referred to as "spring runoff" and is the period when accumulated winter snow melts, causing substantially increased stream flow.**

**GENERA:** The usual major subdivision of a family or subfamily in the classification of organisms, usually consisting of more than one species.

**GREEN ALGAE:** The large family of algae containing chlorophyll as the primary photosynthetic pigment.

**IRON RELATED BACTERIA:** Non-disease-producing bacteria that grow in water and use dissolved iron as part of their metabolism.

**LIMITED, NUTRIENT LIMITATION:** In any environment, a nutrient or other growth requirement will limit or restrict the potential growth of organisms. For example, phosphorus usually limits algae production in lakes; if there is an increase in all of the other nutrients, no increase in algae growth will result because phosphorus is the "bottleneck". Conversely, even a small increase in the phosphorus supply will result in increased algae growth.

**LIMNOLOGY:** The study of freshwater; physical and chemical considerations such as lake thermal behavior, nutrient cycling, basin morphology, sediment structure, etc.

**MACRONUTRIENT:** Macronutrients are the major constituents of cellular protoplasm and usually limit biological production. They include nitrogen, phosphorus, carbon, hydrogen and sulphur.

**MARL:** A marl event involves the precipitation of calcium carbonate, magnesium carbonate and calcium sulphate (gypsum) when the water warms or pH increases.

**METALIMNION:** The water layer containing the thermocline that is between the surface epilimnion and the bottom hypolimnion.

**MICRONUTRIENT:** Relatively minute amounts of a micronutrient are required to maintain plant growth within its environmental constraints. These include; Mn, Fe, Co, Zn, Cu, Mo etc.

**MONOMICTIC:** Refers to a lake that experiences only one period of mixing that extends from fall, through the winter to early spring.

**NANNOPLANKTON:** Minute algae that pass through the mesh of fine (No. 20) bolting cloth. Most are less than 5 microns in their largest dimension.

**PAHs** Polynuclear (or polyclyclic) aromatic hydrocarbons (PAHs) are hydrocarbon compounds with multiple benzene rings. PAHs are typical components of asphalts, fuels, oils, and greases.

**PHYTOPLANKTON:** Algae that float, drift or swim in standing water.

**PHOTIC ZONE:** The zone in a water body that receives sufficient sunlight for photosynthesis.

**PLANKTON:** Organisms that float or swim in water. Phytoplankton refers to plants; zooplankton to animals.

**RIPARIAN:** A riparian zone or riparian area is the interface between land and a stream or lake. Plant communities along the river margins are called riparian.

**SECCHI DEPTH:** **The depth to which a 20 cm disk with alternate black and white quadrants can be seen through the water column.**

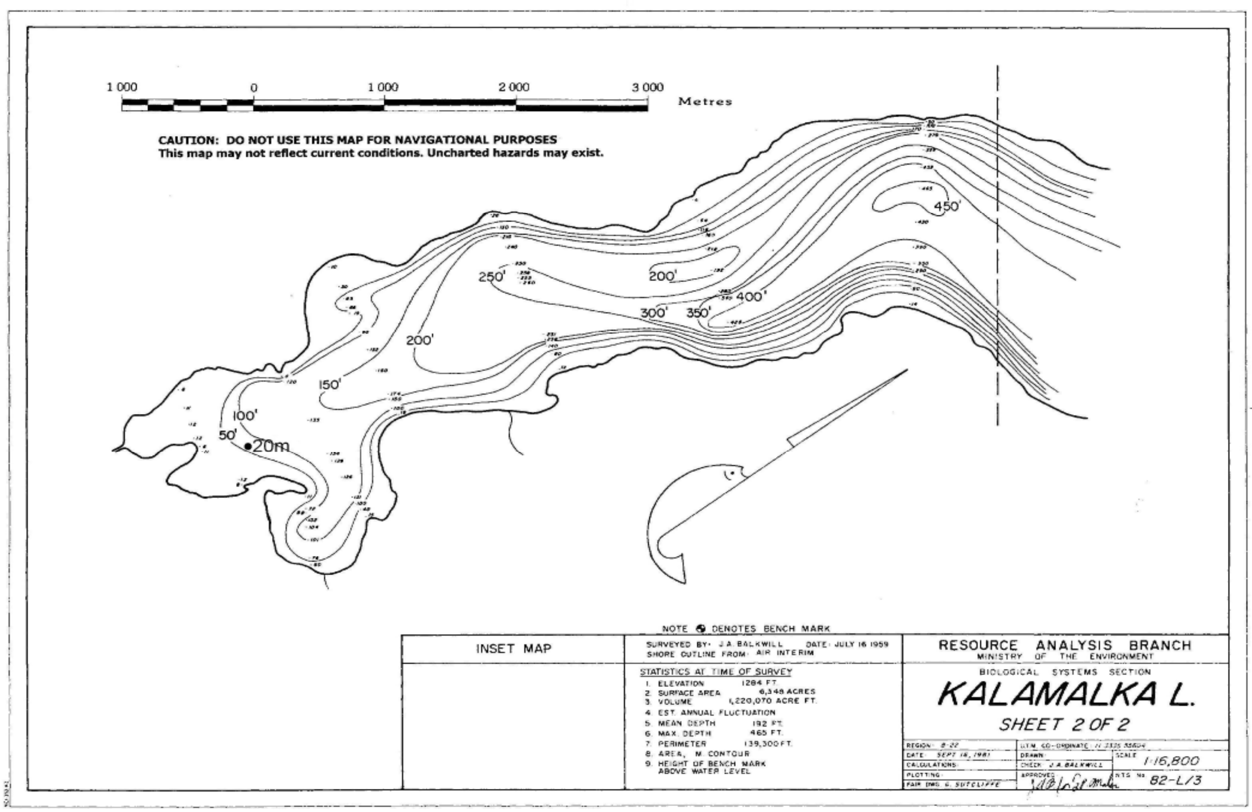
**SEICHE:** **Wind-driven tipping of the water layers during the summer. Seiches cause the water layers to oscillate for days after a wind storm.**

**THERMOCLINE:** **The zone of greatest change in water temperature with depth (> 1$^{o}$C/m) that separates the surface water (epilimnion) from the underlying cold hypolimnion.**

**ZOOPLANKTON:** **Minute animals that graze algae, bacteria and detritus.**

***Report abbreviations****:* *DLC = District of Lake Country; MoE = Ministry of Environment:*
*LAC = Larratt Aquatic Consulting; GEID = Glenmore-Ellison Irrigation District;*
*C of K= City of Kelowna; GVW = Greater Vernon Water OBWB= Okanagan Basin Water Board*
*UBC-O= UBC Okanagan campus IHA=Interior Health Authority*

**FIGURE 1.1: Aerial Image and Bathymetric Map of South Kalamalka Lake**

# 2.0 Kalamalka Lake Intake Module 1: Characterization of Source

## 2.1 Kalamalka Lake Physical Features and Watershed

Kalamalka Lake contains 1520 x $10^6$ $m^3$ and drains a small watershed, resulting in a comparatively long residence time of 55 - 65 years.

Kalamalka Lake receives significant groundwater inflows and submerged springs have been noted by residents along the eastern shore. This groundwater probably contributes to the marl precipitation in the lake. Kalamalka Lake's immediate watershed includes grassland / forest park; shoreline residential with modified shorelines and docks; day-use beaches; and moderate density subdivisions with roads and storm water outfalls. Over 80% of the inflow to Kalamalka Lake is derived from Coldstream Creek. Intense, long-term agricultural use including cattle has damaged Coldstream Creek's riparian areas and rendered this watershed vulnerable to erosion. For example, a serious failure occurred in January 2010 during a rain-on-snow event and the resultant organic loading created over a meter of foam on the creek and adversely impacted the entire North Arm of Kalamalka Lake for weeks. The balance of the annual inflow comes from Wood Lake (Figure 1.1).

Assessments of human impact utilize conservative ions (Ca Na Mg K) of which Na is the best and anions (Cl $SO_4$ $CO_3$ and $HCO_3$) of which Cl is the best – i.e. it participates in the fewest reactions. Both sodium and chloride have shown a slow, steady increase since 1976, indicating increased watershed disturbance, particularly municipal wastewater and storm water run-off (Bryan, 1996).

The sediments under a lake also bear witness to adjacent land use. Sediments deposited after European settlement show increased Mg Al Fe and P. A lens of arsenic and lead correspond to the use of lead arsenate as a pesticide. Recent sediments show increased lead and zinc – the later from galvanized metals such as culverts (Walker et al., 2003).

**Shoreline Impacts** Ecoscape Environmental Consultants estimated that 53.7% or 25 kilometers of shoreline has a high level of impact. Areas of moderate and low impact account for 10.7% or 5.0 km and 33.3% or 15.5 km of the shoreline respectively (Schleppe, 2010). Impacts along the shoreline include lakebed substrate modification, riparian vegetation removal, construction of retaining walls, docks and other man-made features.

Specifically, impacts included:

- 360 docks
- 213 retaining walls totaling 7 km (15%) of the shoreline
- 26 breakwater groynes
- 11 boat launches and 9 marinas with over 6 slips, 1 with on-water refueling
- 40% of shore length has received substrate modification

The predominant land use around the lake was natural area parks (28%), followed by transportation (23.3 %). Single family areas were the third most commonly observed land use type, accounting for 22.3% of the shoreline; Stream confluences were the most rare shore type around the Kalamalka Lake, accounting for only 2.3 % of the shoreline length. This rare shore type was 66% disturbed. Wetland habitats accounted for 4.5% of the shoreline and in these areas the disturbance was much less, with only 23% of the shore length impacted (Schleppe, 2010).

The predominant shore types around the lake were gravel beaches (45%) and rocky shores (27%), followed by cliff / bluff (17%) and sand beaches (3.7%) of the shoreline. Aquatic vegetation occurs along 6.8% of the shoreline length. Of this, emergent vegetation was the most commonly observed (e.g., emergent grasses, willows, or other areas with vegetation inundated during high water). The large littoral areas prohibited mapping of the native beds of submergent vegetation. There were some small patches of floating vegetation that were observed (Schleppe, 2010).

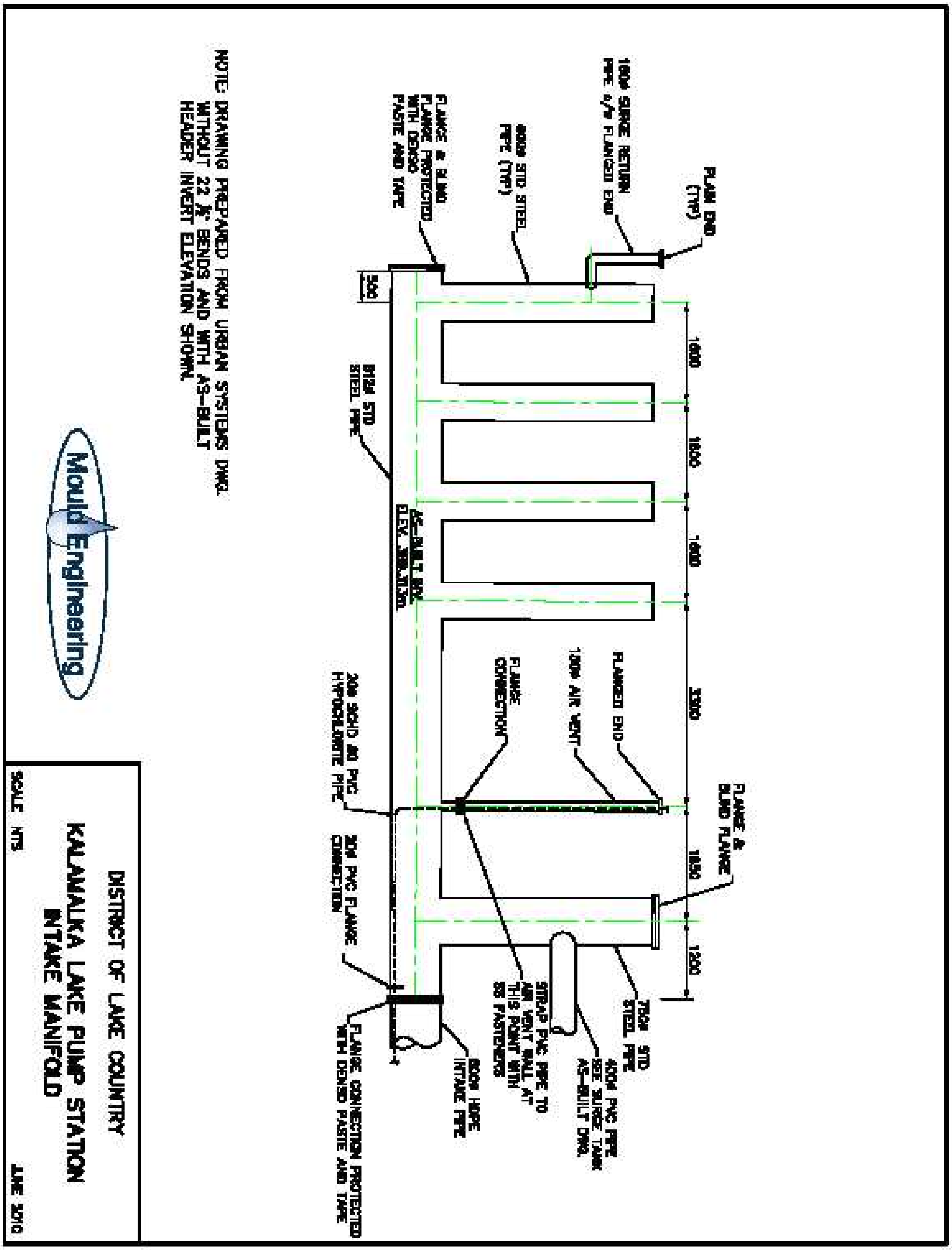
It is beyond the scope of this report to address efforts needed to prevent lake-wide chemical and nutrient impacts on Kalamalka Lake as a whole. DLC does not control their source water and relies on the co-operation of all agencies, residents and users.

## 2.2 Description of Intake: Intake Location, Design, Construction and Maintenance

### Location and depth

The DLC Kalamalka intake is located in 22 m of water and has 2 m of clearance from the substrate. The 800 mm diameter HDPE intake pipe is 440 m long measured from the lake shore. The intake manifold is detailed in the diagram below:

### Physical Features and Design



**Maintenance and Inspection/cleaning**
The intake screen is diver-inspected and cleaned as needed, usually every 5 years or as required.

The pump house is enclosed in a tamper-resistant building that does not attract vandalism.

**Water Treatment Overview:** Water treatment on the Kalamalka Lake intake involves coarse screening, pre-chlorination at the inlet and hypochlorite chlorination at the pump station. No additional injections of chlorine are required in the distribution system.

**Water Monitoring Overview:**
Water quality samples are collected on a routine outlined below:

**Kalamalka Lake – Raw Water**

**1** sample per week: (4 samples per month)
Currently there is no dedicated raw water test line: It must be installed to allow DLC to apply for filtration deferral. Sample pump must be allowed to run for 15 minutes. Chlorine is tested and if there is none detected, then the following samples are collected:

- **Bacterial** Total Coliform/E.coli, True color and UV Transmissivity (125mL bottle or 2 - 50 mL)
- **Water chemistry:** NTU, temp, pH conductivity , apparent color, water hardness
- On-line WQ equipment verification check

**Distribution System**

**1** sample per week:
- **Bacterial** Total Coliform/E.coli

1 – 2 other locations per week testing water chemistry only
- **Water chemistry:** Free & Total Chlorine, NTU, temp, pH, conductivity, apparent color
- 1 P/A sample per month

## **2.3 Kalamalka Lake:** Limnology, Thermal Data, Seiches, Light Penetration

**Hydrology** Kalamalka Lake is the largest source of potable water in the North Okanagan (A. Cotsworth, pers. comm.) Kalamalka Lake is deep for its size. It has a maximum depth of 142 m, contains 1520 million $m^3$ and has a residence time of 55 – 65 years. About 20% of its annual inflow comes from Wood Lake and 80% from Coldstream Creek and groundwater. Kalamalka Lake is a marl lake and has elevated concentrations of calcium and sulphate. Most of Kalamalka Lake is oligotrophic with phosphorus and occasionally nitrogen controlling algae growth (Nordin et al, 1988). In general, nutrient concentrations at the north and south end of Kalamalka Lake move in concert, indicating whole-lake influences are more important than localized inputs.

**Coldstream Creek** Coldstream Creek imports nutrients and *E. coli* bacteria to Kalamalka Lake. From Noble Canyon downstream, 45% of its riparian area needs restoration (Ecoscape, 2010). Agricultural impacts on Coldstream Creek include stream bank erosion, surface discharge of nutrients and horse/cattle/avian fecal material as well as nitrate-enriched groundwater discharge. In the downstream urban areas, the most obvious impacts stem from direct discharge of storm water. In MoE research, Coldstream Creek is far more impacted than Mission Creek or Shingle Creek in terms of nitrates and bacterial counts (Sokal, 2010).

**Wood Lake Inflows** Water generally moves northward from Wood to Kalamalka Lake through the Oyama Canal. Wind action and lake seiching frequently cause oscillations in the flow through the canal. In late summer and particularly in dry years, a net overall southerly flow occurs (MoE, 1975). In 2000, wastewater treatment replaced septic systems on Wood Lake and progressively lowered nutrient loading from Wood to Kalamalka Lake. The flushing time for Wood Lake is about 20 years (Nordin et al., 1988).

The Hiram Walker plant pumped 22,730 $m^3$/day of cooling water from Okanagan Lake into Upper Vernon Creek (Nordin et al., 1988). Its drainage included Duck Lake to Middle Vernon Creek to Wood Lake and ultimately to Kalamalka Lake. This influx temporarily increased Kalamalka Lake's flushing rate to 37 - 45 years. The plant closed in 1992, and the flushing stopped. Kalamalka Lake reverted to its original 55 – 65 year flushing time (MoE 1985). Normally, increasing a lake's flushing rate lowers nutrient concentrations but in this case, nutrient-rich Duck Lake water accelerated algae production in Wood Lake with a ripple effect to Kalamalka Lake.

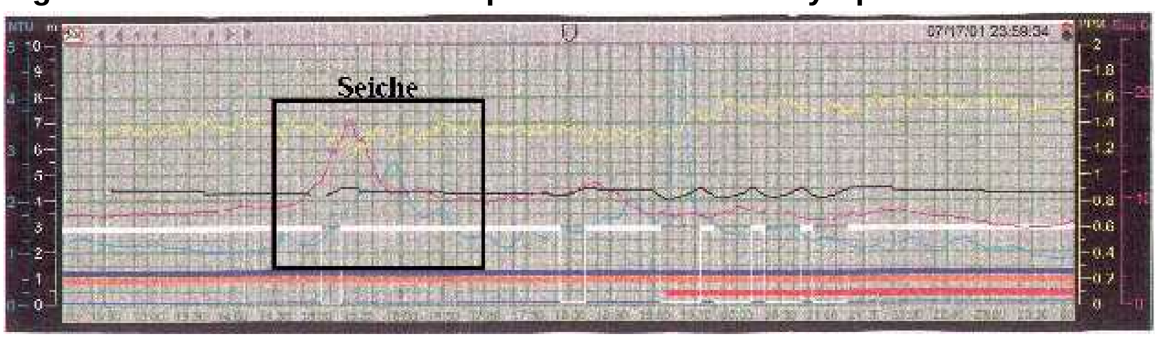
Removal of the distillery cooling water was estimated to cause a reduction in nutrient transfer of 15%N 23% P from Duck Lake to Wood Lake and 31% N 32% P from Wood Lk to Kalamalka Lake (BC Research, 1974). Although the flushing water itself is of good quality, the consequent increase in Vernon Creek flows result in a significant increase in nutrient transfer from Duck to Wood and ultimately to Kalamalka Lake (BC R, 1974) Normally, increasing a lake's flushing rate lowers nutrient concentrations but in this case, nutrient-rich Duck Lake water accelerated algae production in Wood Lake with a ripple effect to Kalamalka Lake. BC Research found that Kalamalka Lake algae production increases in response to Wood Lake inflows. Further, they found that an algae bloom in Wood Lake surface water can be transported into the surface water at the South end of Kalamalka Lake where it mixes slowly within the epilimnion. Dispersion of the nutrient-rich Wood Lake water is largely dependent on the wind (BC Research, 1974). Although there is some disagreement today about the effects of the water transfer (Walker et al., 1994), Kalamalka Lake may well be better off without the increased flushing from Hiram Walker in its drainage system (J. Allingham, pers comm. 2008).

To manage the fishery, the Oceola Fish and Game Club manage the releases from eutrophic Duck (Ellison) Lake to Wood Lake. Releases begin in September and run all winter to early summer.

**Limnology** Every year, Kalamalka Lake begins to stratify during late March. Stratification is firmly re-established by mid-May. Thermal/turbidity disturbances at the intakes caused by seiches (internal waves) tend to cluster in early June. The thermocline gradually drops as Kalamalka Lake heats up over the summer. During the fall, the thermocline oscillates deeper into the lake. These oscillating periods (Aug/Sept/Oct) are marked by mild taste/odor and turbidity events. Nutrients released from the sediments may stimulate algae growth by mixing into the water column during seiches. After October, the Lake Country intake withdraws water from the cooling surface layer. Mixing continues as the thermal stratification became increasingly fragile until storms break down the water layers during November. Thermal mixing is complete by early December (Bryan, 1990). After December, the entire lake cools as a unit until very subtle inverse stratification sets up in January.

**Seiches**
Seiches are wind-driven tipping of a lake's water layers during the summer. Seiches cause the water layers to oscillate for days after a wind storm. For a fixed intake, seiches mean a rapid fluctuation in water temperature and turbidity as the intake alternately draws water from the surface layer and the deep hypolimnion (Figure 2.1).

### Figure 2.1: Seiche-Induced Temperature and Turbidity Spike at Intake




Temperature and turbidity spike measured at GVW N-Kal Intake ___Temperature ___Turbidity

In the summer, the DLC Kalamalka intake draws from the bottom water layer except during seiches. The vertical movement of a seiche is coupled to large internal waves. These waves break at the sides of the basin like surface waves do and they are significant sources of turbulence (Wetzel, 2001). For the water purveyors, seiches cause increased water temperature and a turbidity spike as surface water is transported down to intakes for a period of 2-10 hours before the oscillating thermocline rises again, returning the bottom water layer to the intake. The main transport mechanism of surface contaminants to the Kalamalka Lake intake is seiches in the stratified (May – October) period.

Characteristics of seiches within Kalamalka Lake include:

- North or south-west winds with gusts exceeding 30 km/hr could generate a seiche depending on the duration of the wind event. A typical period for the seiche to travel from the N to the S chain (15.4 km) would be approximately 11.7 x 2 = 23.5 hours.

- Seiches produce noticeable spikes in water temperature, conductivity, turbidity, color and algae densities at the Lake Country 22 m intake. Seiches have the biggest impact on abstracted water quality during the spring and fall.
- Turbulence and seiches are more intense at the South end of Kalamalka Lake than they are at the North due to the shape of the lake basin.
- Lake Country's S thermistor chain recorded a 6 °C excursion at 30 m during 2005 but a 2-3 °C fluctuation is more common. As intake depth increases, the intensity of seiches diminishes. An intake would need to be positioned deeper than 40 m in order to evade all seiches.
- Seiches and water currents direct the movement of "water parcels"- discrete inflows that gather in localized areas and travel as a mass while gradually mixing with an increasing volume within the lake. For example, Coldstream Creek plumes often travel a "river of water" within Kalamalka Lake

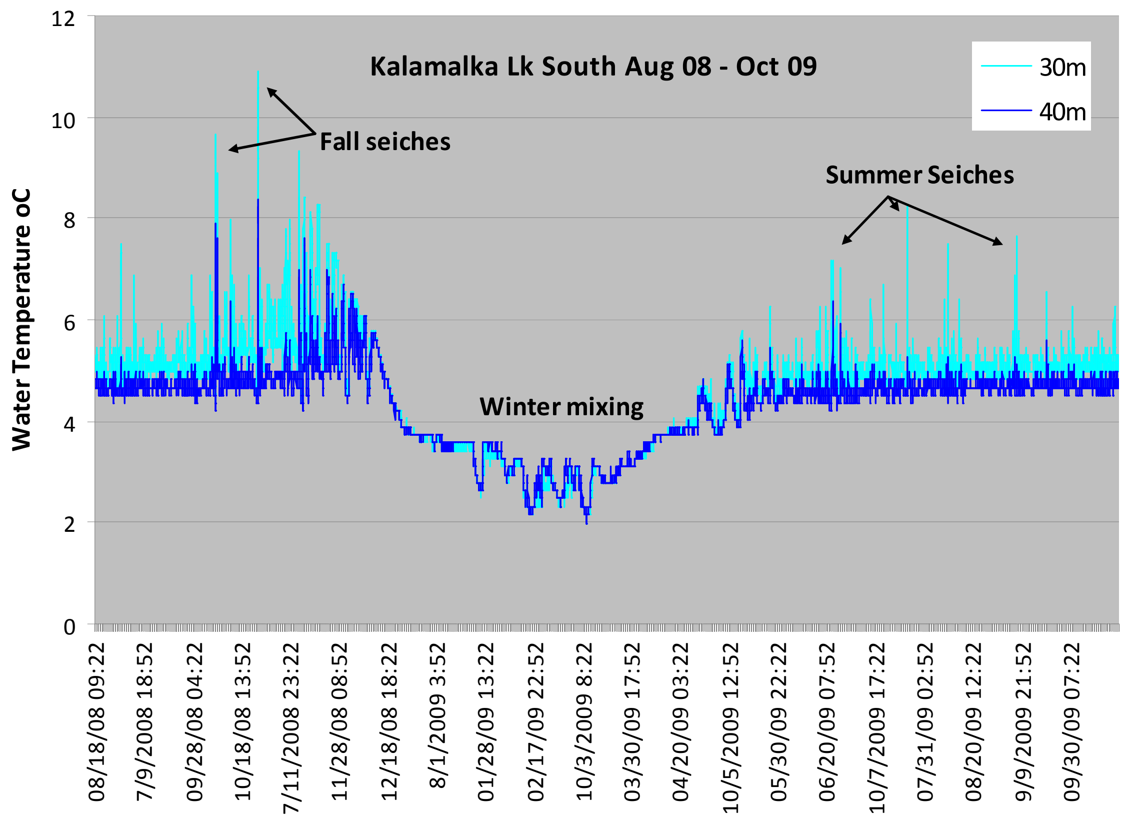
Large summer seiches are common in Kalamalka Lake (Figure 2.2). Each year, 7 - 12 major seiches were detected by the N and S thermistor chains. Seiche activity was always greatest in the early summer as the water layers set up and again in the early fall as the surface layer cools and loses buoyancy (Figure 2.2).

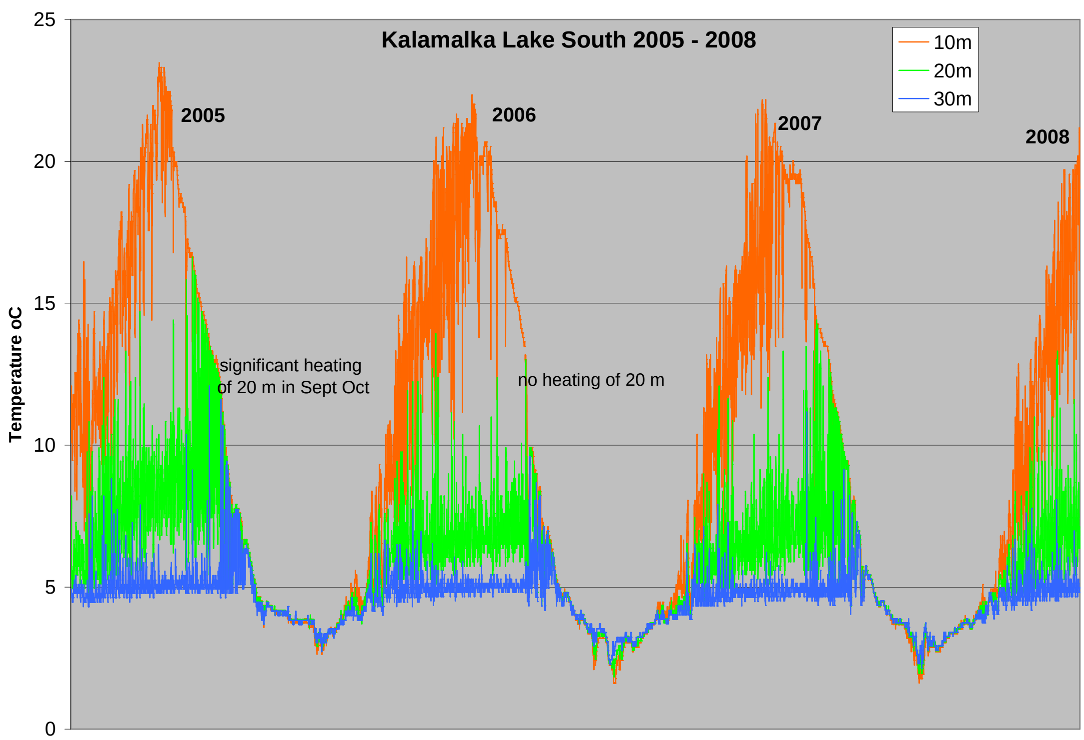
Seiches increase the vulnerability of an intake to contaminants introduced to the surface water layer by a storm water outfall or a spill for example. Further water quality sampling of chemical and biological parameters at 30 and 40 meters is planned for 2010.

At the South end of Kalamalka Lake, seiches penetrate deep into the water column because of the shape of the lake basin. The largest seiches occur in mid-June every year. During 2008, the maximum seiche temperature change at 20 m was 10°C but was only 4°C at 30 m (Figure 2). Water temperature changes of 5-8 °C within 48 hours are routine at the current Lake Country 22 m intake (Larratt, 2008). In a warm summer, average intake temperatures reached 10.8 °C as opposed to the normal 7.5 – 8.5 °C range. With seiches, peak temperatures can reach 13.6 °C at the LC intake.

As the cooling lake approached fall overturn, increased mixing thickened the surface water layer, pushing the thermocline down to the 20 m intake depth by September 22 2007 and October 8 2008 (Figure 2). A turbidity / taste and odor event can accompany the transition from bottom to surface water. After the thermocline mixed below 20 m, the Lake Country intake draws water from the cooling surface layer. Mixing continued and is usually complete by early December (Bryan, 1990) and in every year of this study, mixing beyond the 40 m depth was complete by November 28.

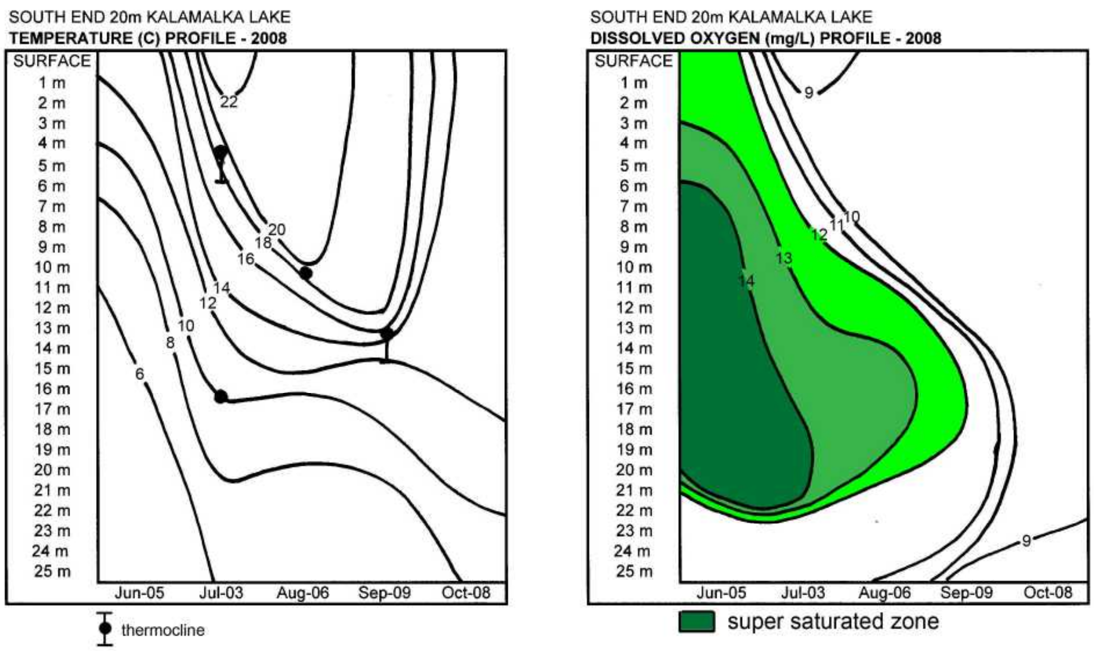
**FIGURE 2.2 Thermistor Water Layer Temperatures for 1 year and multi-year**



**Dissolved Oxygen/Thermal Profiles** A large microfloral crop generates a large super-saturated zone in early summer as shown in Figure 2.3, below. The supersaturated zone is frequently smaller at the 30 m site than at the 20 m site, indicating lower algae and bacteria production at 30 m than at 20 m. The super-saturated profiles correlate to increased turbidity at the respective intakes and to elevated algal and bacterial counts.

**FIGURE 2.3: Kalamalka Lake South Intake Site Temperature and Dissolved Oxygen Profiles, 2008**

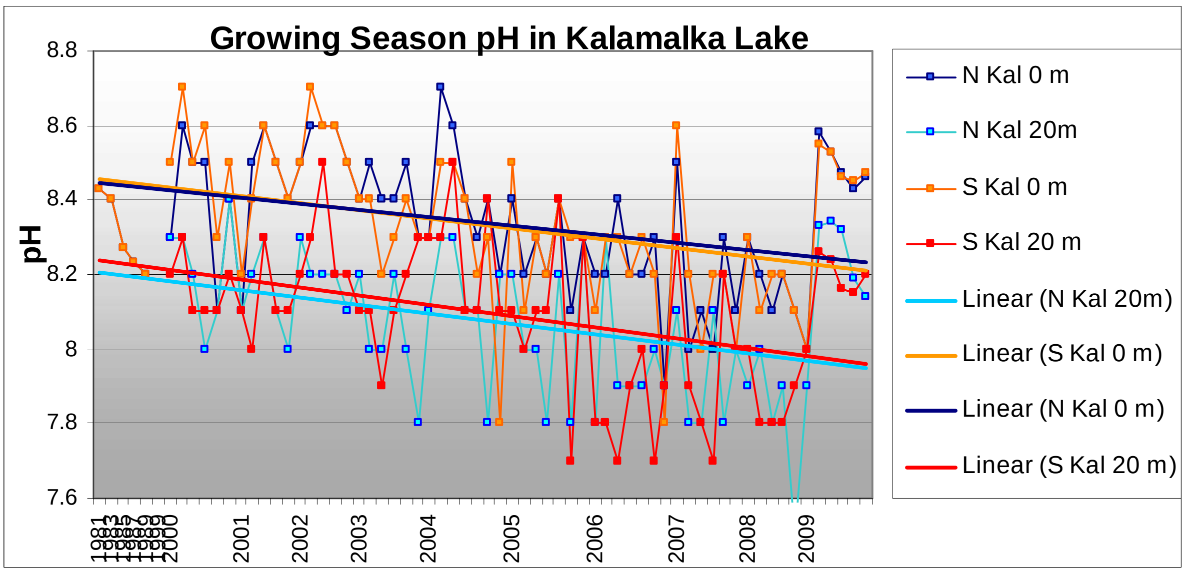


## 2.4 General Kalamalka Lake Water Chemistry

Every year, the single greatest impact on water quality in Kalamalka Lake is the size of the freshet, affecting nitrogen-N, phosphorus-P, pH, calcium, sulphate and organic/inorganic particulate inputs. Low inflow years import far less phosphorus to Kalamalka Lake since P adheres to soil particles. Modest freshet flows result in small microfloral densities. In general**,** nutrient concentrations at the North and South sites on Kalamalka Lake move in concert, indicating whole-lake influences such as freshet (P) or groundwater (N) nutrient inflow.

**pH** During the course of this study, pH appears be in slow decline. The trend toward lower pH may signal a reduction in the intensity of the marl precipitation events. Overall, the linear regression lines still show decreasing pH but there is considerable pH oscillation shown in the lines with markers in Figure 2.4.

**FIGURE 2.4: Growing Season pH in Kalamalka Lake 1981- 2009**




NOTE: This graph emphasizes data from 2000 to present

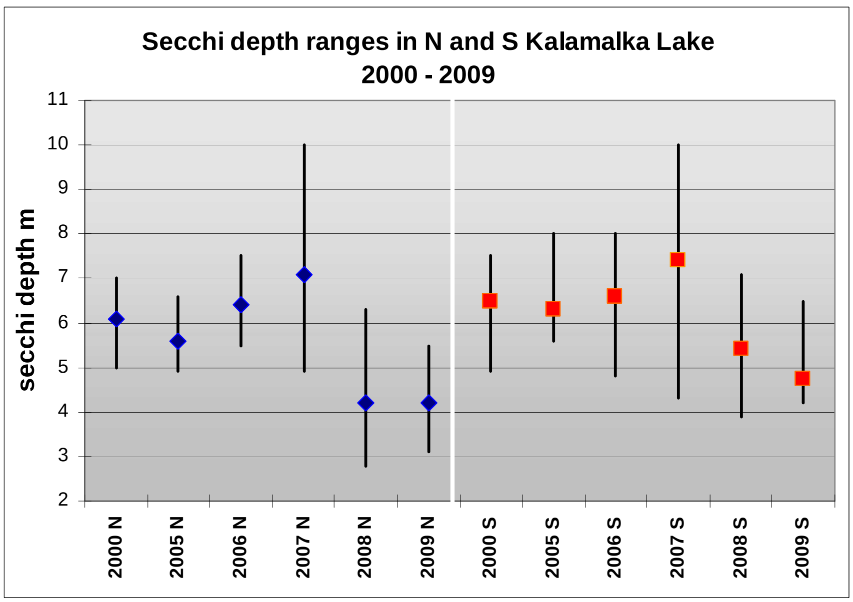
If the lower pH trend detected in this data is genuine, it could have repercussions on the summer marl precipitation events and ultimately increase the nutrient balance of Kalamalka Lake. pH is usually higher during a wet, high productivity year.

**Sodium and Chloride** Sodium and chloride give an indication of animal, human, and storm water impact on a lake system, although in Kalamalka's case, donation of these metals from marine shales in the Noble Canyon section of the Coldstream Valley is an additional natural source. Sodium averaged 16.1 mg/L in the MoE 1970-1988 data set and is still near that concentration today. Unlike sodium, chloride concentrations increased three-fold since 1970 – 1988 when it averaged 1.88 – 2.01 mg/L (Larratt, 2008). Dissolved sodium and chloride ion concentrations are increasing in Kalamalka Lake, pointing to human impact on water quality as opposed to climatic factors (Ashley et al., 1998).

**Marl Precipitation** Every summer, a spike in bottom water turbidity, alkalinity, conductivity and calcium concentrations and increased surface water clarity herald the marl (calcium carbonate + gypsum) precipitation. The timing of the marl precipitation depends on water temperature, calcium concentrations and pH. The dates ranged from July 20 1998 to August 6 2008. A gradual reduction in marl precipitation may be indicated over the past 20 years, but the data from this study are inconclusive and are complicated by freshet impacts. The carbonate/marl cycle in Kalamalka Lake protects this lake from nutrient enrichment and raises its sedimentation rate to 2.9 mm/yr (Dill, 1972). It also probably explains why Kalamalka has lower algal production than Okanagan Lake despite their similar nutrient concentrations

**Water Transparency** Historic secchi depths measured 6 – 7 m in 1935 and 3.8 – 10.7 m (avg 6.5 m) from 1975 – 1988 (Bryan, 1990). Within this study, growing season secchi depths ranged from 2.8 m during spring freshet algae production to 10.1 m post-marl precipitation – a similar range to Bryan's work. The average growing season secchi depth reacts to the size of the freshet. Large freshet years such as 2008 had lower overall secchi depths, particularly at the North end (Figure 2.5).

**Figure 2.5: Secchi Depth Range and Average in North and South Kalamalka Lake 2000 - 2009**



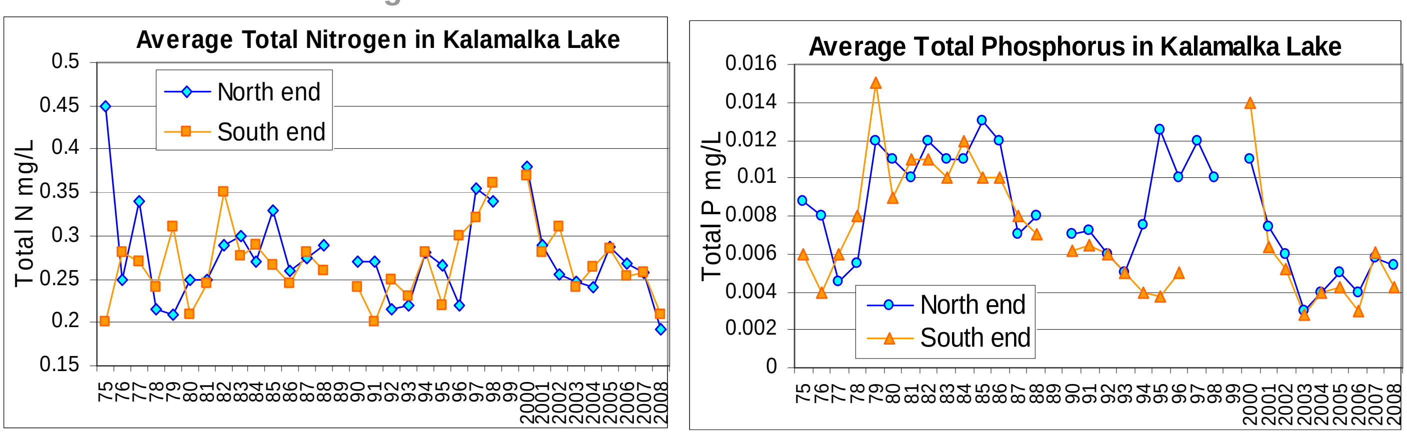

**Total Organic Carbon (TOC)** Total organic carbon measures microflora and dissolved organic molecules and for that reason, TOC concentrations move in concert with algae growth. TOC will react with chlorine, absorbing it and increasing the production of trihalomethanes. Historic TOC's are comparable to recent TOC measurements. In the 1980's, TOC averaged 6.2 mg/L in the South end of Kalamalka Lake, and 2.6 mg/L in the main section of the lake (Bryan, 1990). Organic carbon concentrations exceeded the B.C.WQ criteria of 4.0 mg/L through most of the growing season, particularly in surface samples because algae concentrate where light intensity is high and because pollen, leaf debris etc., accumulate on the surface. In all cases, TOC decreased with depth, however, the water quality advantage of a 30 m intake over the existing 22 m intake would be minor i.e. a 0.1 – 0.2 mg/L TOC difference.

**Nutrients** The main body of Kalamalka Lake is currently oligotrophic. Available phosphorus concentrations control the growth of algae in the lake, according to the formula that P is limiting when the nitrogen to phosphorus ratio falls below 15:1 (Nordin, 1985). Although Kalamalka Lake is phosphorus-limited, co-limitation with nitrogen was also possible as the greatest algae growth was obtained in test cultures by adding both nitrogen and phosphorus (OBA,1973).

Nutrients are important to water quality because they direct microfloral production. Their concentrations at the North and South ends of Kalamalka Lake move in concert, indicating whole-lake influences such as freshet nutrient inflow via Coldstream Creek (80%) and inflows from Wood Lake (20%). The direction of flow in the Wood-Kal channel is dependent on Wood Lake and Kalamalka Lake levels. Wood Lake is a periodic source of organic nitrogen and phosphorus to Kalamalka Lake. Small peaks in S Kalamalka nutrients over N Kalamalka nutrients in Figure 2.6 may relate to greater inflow from Wood Lake during those years (Appendix 1). Within Kalamalka Lake, the arms are more productive than the main body of the lake.

Spring nutrient concentrations in Kalamalka Lake provide a good forecast of the nutrients available to support plant growth during the growing season. High run-off years import more total phosphorus to Kalamalka Lake, often as a result of particulate phosphorus inputs. Damaged riparian areas in the Coldstream watershed accelerate the nutrient loading in wet years. For example, the early 1980's were wet years and phosphorus concentrations were higher (Ashley et al., 1999). High freshet years also act to increase N concentrations because N is poorly retained by Okanagan soils and nitrate migrates with groundwater (Dill, 1972). High runoff years with more groundwater input are more likely boost Kalamalka Lake's nitrogen content than low runoff years. The large freshets of 1999 and 2000 resulted in nutrient peaks that were not repeated in the following years (Figure 2.6). The current decline in nutrient concentrations is highly desirable.

**FIGURE 2.6: Average Total N and P In Kalamalka Lake 1975 - 2008**




MoE objective = 0.008 mg/L TP for Kalamalka Lake;
0.015 mg/L TP for Wood Lake (Nordin et al, 1988)

The goal for Kalamalka Lake is to restrict nutrient loading, even in wet years. This will require riparian restoration along Coldstream Creek and proper manure handling/storage, particularly by Panoramic Farms and Coldstream Ranch.

Since marl co-precipitates phosphorous, the timing of the marl precipitation in Kalamalka Lake affects algae growth. Ironically, algae growth also influences the marl precipitation by raising pH. The other trigger for marl precipitation is water temperature. Warm, dry years such as 2002-2004 favour earlier and larger marl precipitation (Walker et al., 1993). Marl precipitation not only limits phosphorus availability, it also shades the water column and removes B12 vitamins. These all act to limit algae production in Kalamalka Lake relative to Okanagan Lake, despite their similar summer nutrient concentrations.

With full lake mixing, nitrate concentrations are restored in December to the winter maxima and trigger increased blue-green algae growth each year. Over the past century, water quality was relatively stable in Kalamalka Lake (Bryan, 1980). Its unique marl precipitation protects Kalamalka Lake from phosphorus loading arising from human activities.

**Chlorophyll-a Analysis** Chlorophyll-a concentrations increased over 1971–1998 (MoE database), paralleling an increase in phosphorus concentrations. Figure 2.7 shows annual spring peaks in microfloral production as measured by chlorophyll-a. Algae production stalls after the annual marl precipitation removes phosphorus from solution.

**FIGURE 2.7: Chlorophyll-a in Kalamalka Lake 1999 - 2009**

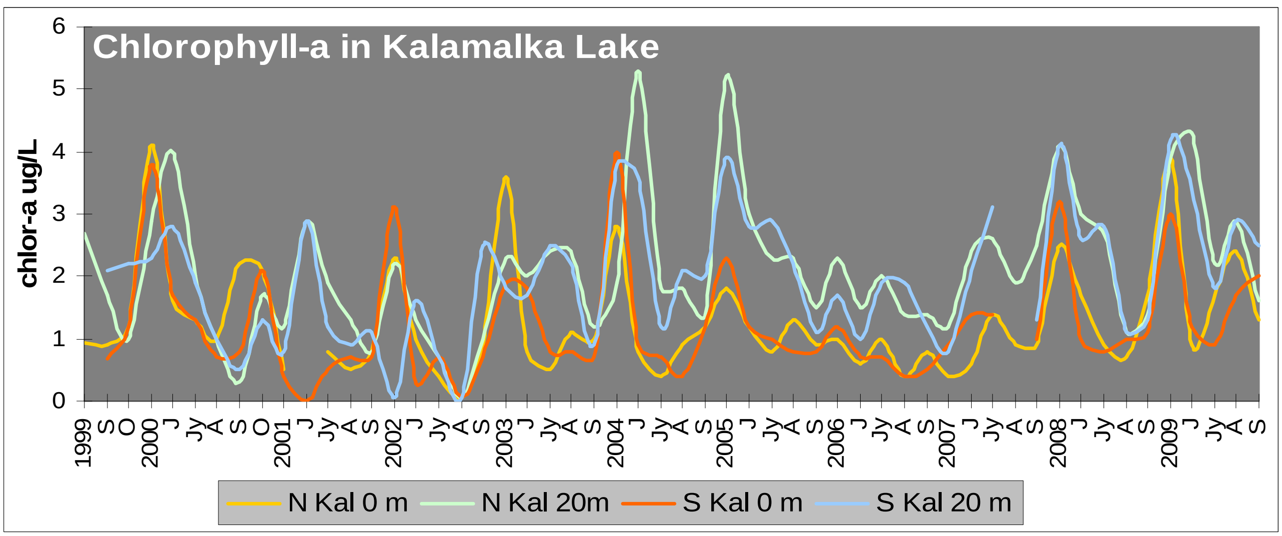
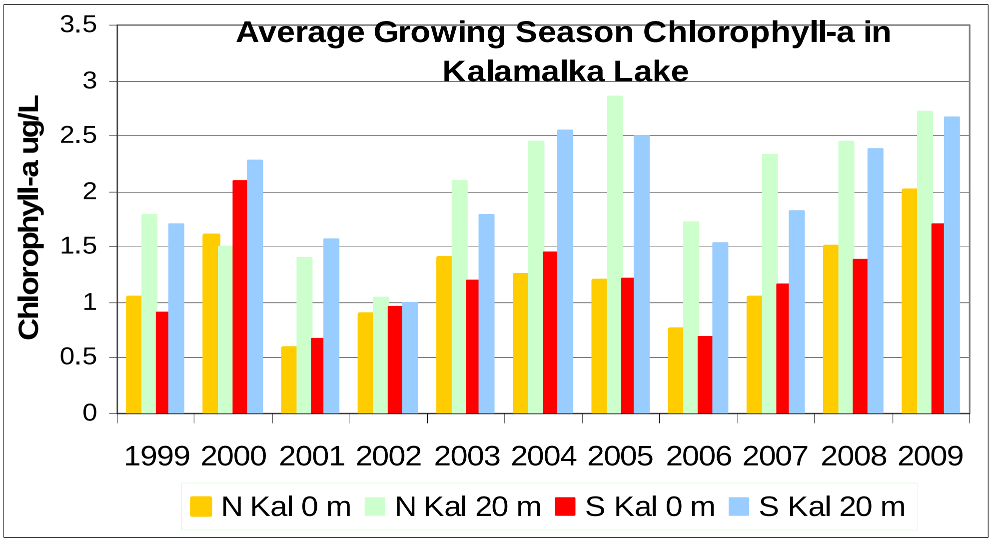



Figure 2.7 was highlighted to show the similarities between the N and S ends of Kalamalka Lake. There is far more correlation by depth than by location. On most dates, the productivity of the 20 m bottom water was far higher than the surface water near both intakes. Samples collected from 30 and 40 m contained less chlorophyll-a than samples from 20 m (Larratt, 2008). To realize the benefit of lower algae production at the 30 or 40 m sites, a new intake should be positioned at least 3 m above the substrate. Historically, chlorophyll-a measured 1.80 ug/L at S Kalamalka, 1.26 ug/L in Kalamalka main basin and 4.42 ug/L in Wood Lake (Bryan, 1990). Kalamalka Lake samples are slightly elevated today above the historic norm.

**Figure 2.8 Average Growing Season Chlorophyll-a 1999-2009**




## 2.5 Water Chemistry Relevant to Drinking Water Safety

**Algae Analyses** Kalamalka Lake experiences a spring diatom/blue green bloom, a summer lull and a smaller fall bloom led by blue-green algae (cyanobacteria). Within this general pattern, there is considerable year-to-year variation.

Study since 2000 to present shows that the prevalence of blue-green algae appears to be increasing. MoE data also shows a gradual increase in the blue-green component since the 1970's. A total of 15 blue-green genera including *Lyngbya* were observed in Kalamalka Lake. In order of prevalence during 2008 they were: (*Lyngbya limnetica* >> *Anacystis cyanea* > *Gomphosphaeria lacustris* > *Synechocystis* > *Chroococcus dispersus* >> *Dactylococcopsis sp* > *Aphanocapsa elachista* > *Chroococcus Prescotti* > *Planktothrix anghardii* > *Anabaena circinalis* > *Anabaena planktonica* > *Aphanizomenon sp (solitary)* > *Microcystis aeruginosa* > *Oscillatoria spp* > *Lyngbya Birgea).*

Several of these genera are known to produce toxins but were not present in amounts sufficient to impair water quality. Algae density near the Lake Country intake tends to be larger when Kalamalka Lake receives Wood Lake water. The Lake Country intake has smaller algae counts and is spaced 2 m from the bottom versus GVW's intake that is only 0.6 – 0.7 m from the substrate and has large algae counts.

In the South Kalamalka algae samples, the 30 m samples showed a distinct advantage over the surface and 20 m samples. On average, the 20 m samples contained more chlorophyll-a than the surface samples because dying algae settle to the bottom and because storms and seiches create turbulence that suspend microflora from the sediments. For example, the 2008 average chlorophyll-a at the surface was 1.4 ug/L but increased to 2.4 ug/L at S-20 m and was only 1.8 ug/L at S-30 m. It is important to note that summer samples from 30 and 40 m in Kalamalka Lake still contained 200 – 800 cells/mL of cyanobacteria (Larratt, 2008). Samples for chlorophyll-a will be collected from S-40 m in 2010.

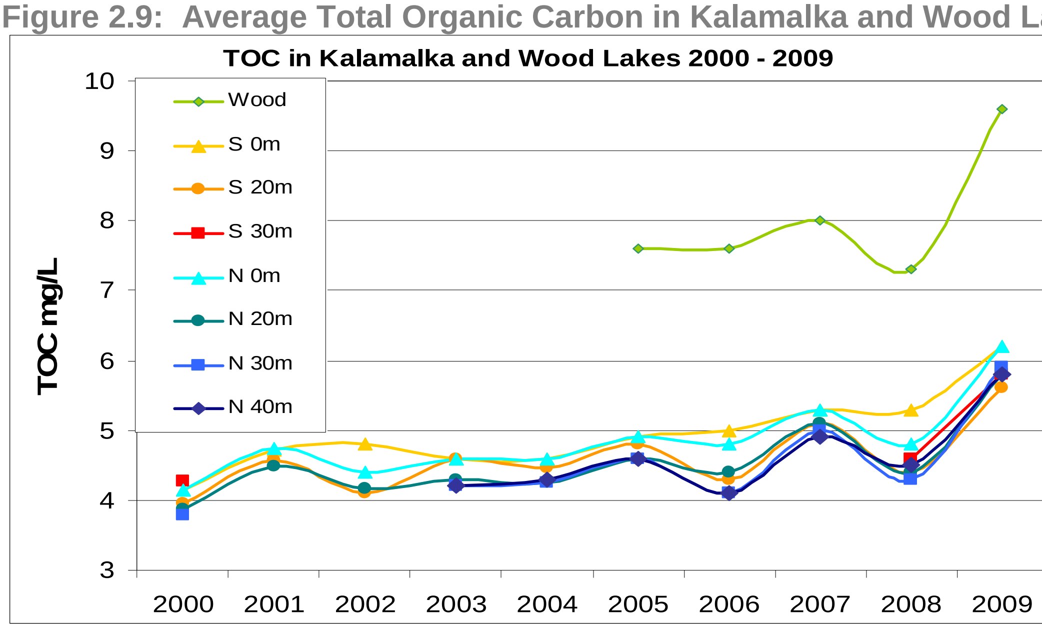
Overall, samples collected from 30 and 40 m contained less chlorophyll-a than samples from 20 m (Larratt, 2009). To realize the benefit of lower algae production at the deeper proposed intake sites, a new intake should be positioned at least 3 m above the substrate.

**Taste and Odor** High algae counts and complaints of fishy or musty taste and odor in Kalamalka Lake water are correlated. Blue-green cyanobacteria and other algae produce a musty, decaying taste and odour when they are decomposed by *Actinomycetes*. During the lake-wide 1999 taste and odor event, cyanobacteria counts exceeded 1700 cells/mL at the intakes. The periodic taste and odour problem occurring in Kalamalka Lake are usually caused by unusually high cyanobacteria concentrations, possibly made worse by A*ctinomycetes* decomposers and re-suspended detritus.

Less frequently, a seiche-induced turbidity/odor event can occur as on the week of September 22 2007. In this case, the turbidity particles were primarily detritus and bacteria, rather than algae. An intake right on the bottom of Kalamalka Lake would be much more vulnerable to taste and odor events. The minimum intake clearance should be 3 meters. Rate payers appear to be reluctant to call about mild taste and odor events and they may be under-reported. Most complaint calls are from end-of-line areas and they trigger a line flushing (Hansen, pers comm.).

**Total Organic Carbon (TOC)** Total organic carbon measures microflora and dissolved organic molecules and for that reason, TOC concentrations move in concert with algae growth. Historic TOC's are comparable to recent TOC measurements. In the 1980's, TOC averaged 6.2 mg/L in the South end of Kalamalka Lake, and 2.6 mg/L in the main section of the lake (Bryan, 1990). Organic carbon concentrations exceeded the B.C.WQ criteria of 4.0 mg/L through most of the growing season, particularly in surface samples because algae concentrate where light intensity is high and because pollen, leaf debris etc., accumulate on the surface (Figure 2.9). In all cases, TOC decreased with depth, however, the water quality advantage of a 30 m intake over the existing 22 m intake would be minor i.e. a 0.1 – 0.2 mg/L TOC difference.

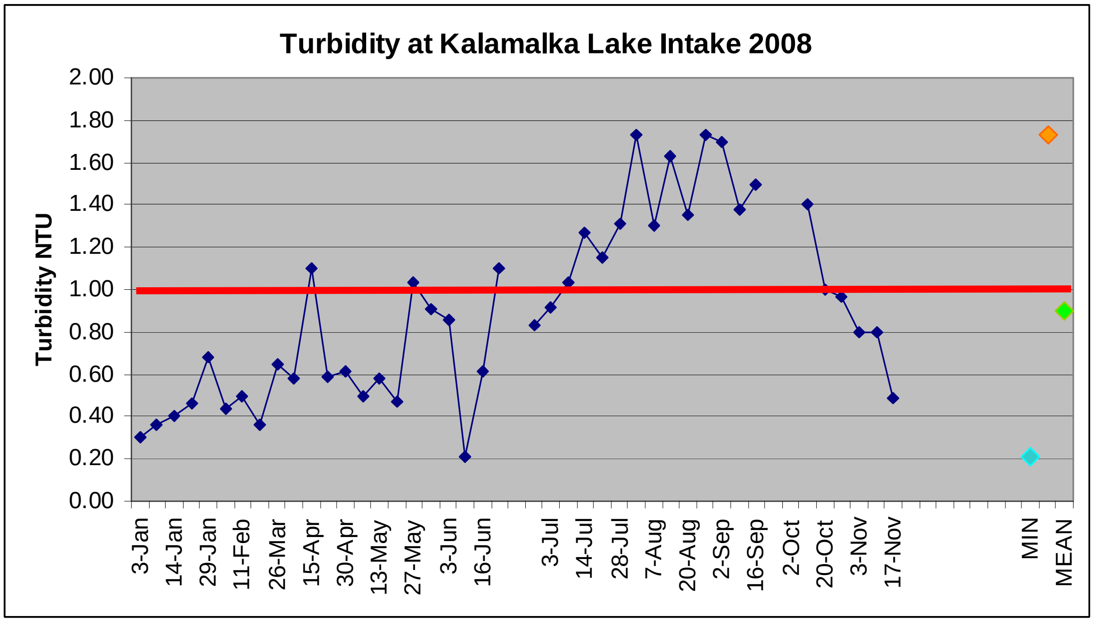
**Figure 2.9: Average Total Organic Carbon in Kalamalka and Wood Lakes**



**Turbidity** Turbidity is naturally high in Kalamalka Lake, near 0.4 – 1.2 NTU from July to October due in part to the marl precipitation (Figure 2.10). Other natural sources of turbidity include freshet plumes, seiches, lake overturn and algae pulses. Annual turbidity averaged 0.73 NTU in Kalamalka from 1973 – 1989. Average Kalamalka Lake turbidity appears to be relatively steady since 1990 but has decreased slightly since 2004 (Figure 2.12).

While freshet caused brief turbidity spikes, summer turbidity exceeding 1.0 NTU was measured at all Kalamalka Lake intakes in the July to September period during most summers (Figure 2.10). The 20 m summer samples with turbidity exceeding 1 NTU contained precipitated marl and also contained higher concentrations of blue-green alga *Lyngbya limnetica* and detritus. Turbidity generally decreased with depth i.e. a 30 or 40 m intake would have lower turbidity than the existing intake.

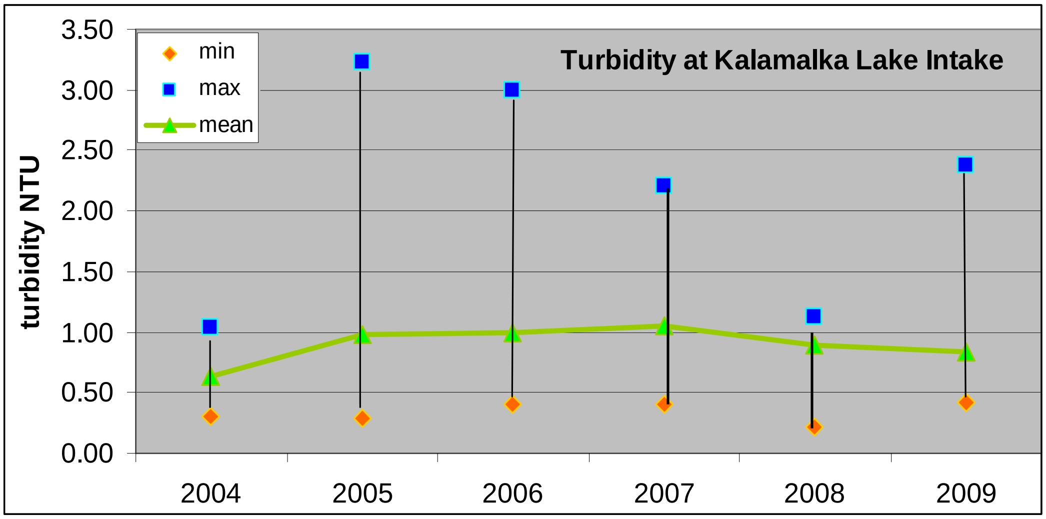
**Figure 2.10: Turbidity at South Kalamalka Lake Country Intake 2008**




IHA requires a Water Quality Advisory when turbidity exceeds 1 NTU, but posting the Advisory can be avoided based on IHA's decision tree.

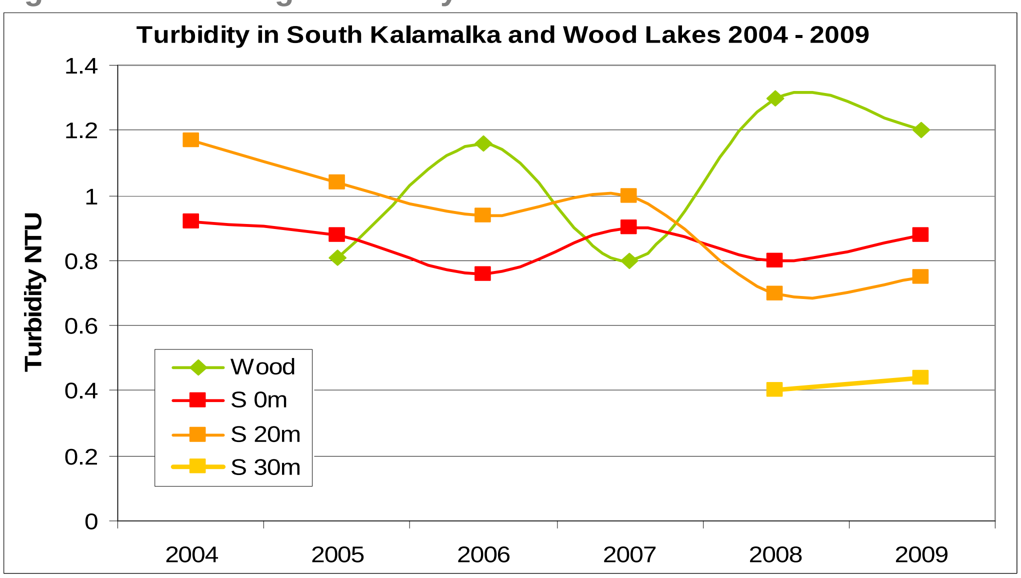
Some summers are worse for turbidity than others (Figure 2.10). 2005 and 2006 were particularly high due to seiches, extensive marling and algae production. Generally, years with large freshets have higher turbidity throughout the summer because of the "ripple effect" of the larger nutrient donation.

Figure 2.11: Annual Average Turbidity at DLC Kalamalka Lake Intake




Measurements of turbidity collected from several points in the Oyama water system ranged from 0.24 to 2.36 with an average of 0.72 NTU. These elevated turbidities generally occurred at the end- of- line sites, but in 2007 and 2008, elevated turbidity occurred throughout the system especially after the marl precipitation developed in Kalamalka Lake. Flushing and/or additional chlorine is required to maintain residuals when marl or aquatic organic matter (algae; detritus) becomes a problem (Hansen, 2008). Turbidity was slightly higher in Wood Lake over South Kalamalka, with a turbidity pattern opposite to that of Kalamalka Lake (Figure 2.12). The reason for the opposing turbidity trends in Kalamalka and Wood Lakes is not known.

Figure 2:12: Average Turbidity at South Kalamalka and Wood Lakes




IHA has a Turbidity Decision Tree (Apr 27/09) that suggests a water quality advisory when turbidity exceeds 1.0 NTU unless DLC can provide scientific evidence as to the safety of the water. Without a raw water line, the scientific evidence cannot be provided, hence turbidity exceeding 1 NTU currently triggers a Water Quality Advisory.

**UV Transmissivity** Measurements of turbidity and transmissivity are not a match because dissolved organic molecules lower transmissivity but do not affect turbidity. Most sample sites on Kalamalka Lake had their lowest transmissivity in June and October. Spring transmissivity is lowered by the freshet to as little as 66% in the surface water. UV transmissivity ranged from 86 – 94 % in Kalamalka Lake with an average at the intakes of 90-91%. For example, in 2009 intake UV transmissivity ranged from 88 – 95% with an average of 91% at LC Kalamalka Intake (LC reports).

In the turbidity range of 0.35 to 0.80 NTU, Kalamalka Lake UV transmissivity was stable at 88% - 94%. Unlike turbidity, there was no significant difference between transmissivity at the 20 m, 30 m and 40 m depths during 2006 through 2008. Kalamalka Lake UV transmissivity was not adversely affected by the marl precipitation because algae counts decline as marl particles increase.

## 2.6 Calculation of Intake Protection Zone for DLC Kalamalka Lk Intake

*An intake protection zone defines the area where the intake should take precedence over every other use or consideration and defines the areas of land and water where special care must be taken in the use and handling of potential contaminants to prevent them from accidentally entering the lake and affecting the intake.*

The decision on the size of an intake protection zone should be based on the existing and potential hazards, and on the speed with which they can be transported to the intake, both horizontally and vertically. Vertical transport is dominated by fall rates and seiches while horizontal movement in lakes is dominated by wind-driven currents and inflow plumes. The default intake protection zone defined by IHA is a 100 m radius around the end of the intake. The protection zone should be modified from a circle to reflect consistent influences on water travel near the intake such as stream inflows, water currents and seiche patterns. A second layer of protection zone could be imposed on adjacent land development where subsurface (waste water; irrigation water management) and surface (storm water) flows delivered to the intake protection zone would be significantly impacted by the land development.

The minimum intake protection zone safety factor recorded in the Lake Ontario Source to Tap Study is 2 hours and 1 km radius (Stantec, ,2007). Lake Ontario is a large lake with heavy industrial use; and not analogous to Kalamalka Lake. None the less, a decision must be made on the acceptable time-safety factor that would give DLC a reasonable timeframe to react to an emergency such as a spill. The maximum speed of water transport at the surface and at the intake depth both vertically and horizontally were then used to estimate the intake protection zone.

**Vertical Transport – Fall Velocity** When solutions are introduced to a lake, the dissolved material remains suspended indefinitely and diffuses, while the particulate material settles out according to its fall velocity. April/May 2005/6 samples from Kalamalka Lake's North end were sent to UBC Mining Lab for particle size analysis on an Elzone 280 PC. Particle sizes were generally small with all particles from Kalamalka Lake reported as less than 75 microns in diameter. All samples exhibited a bimodal size distribution where the smallest particles of marl peaked below the detection limit of 1.1 micron diameter (Larratt, 2005). The second peak recorded larger particles carried by freshet flows and large algae from the lake. Very fine (<1.5 microns) particles of marl are abundant and increase the turbidity and sedimentation rate of Kalamalka Lake.

Large particles of sand introduced from creek or storm water outfall plumes settle out almost immediately while finer sand/silt is transported further into Kalamalka Lake. Very small particles remain suspended, including algae and microbes such as *Cryptosporidium* and *Giardia* cysts. Both cyst types and *E. coli* have been detected in the North Arm of Kalamalka Lake and the probable source is Coldstream Creek inflows (Clarke & Brett, 2005). The potential for plume-introduced contaminants to remain suspended in the South end of Kalamalka Lake is the same as it is in the North end.

The fall velocity of fine clay is small 0.0011cm/s (0.04 m/hr or about 1 m/day); for marl it is about 0.6 m/day and for *E. coli* bacteria it is far smaller at 0.00000410 cm/s (0.00354 m/day) (Hayco, 2009; USGS 2007). It will take several weeks for clay to settle through the water column; less as it clumps with other materials (larger sediment particles, organics). Marl particulates are in the same size-range as bacteria but they readily clump with bacteria and other organics, and settle out of the water column gradually over a period of months. It could take years for bacteria to settle out based strictly on fall velocity. Their fall velocity will be accelerated by clumping with other suspended materials. Bacteria can also be consumed by zooplankton and deactivated by sunlight or aging (Wetzel, 2007).

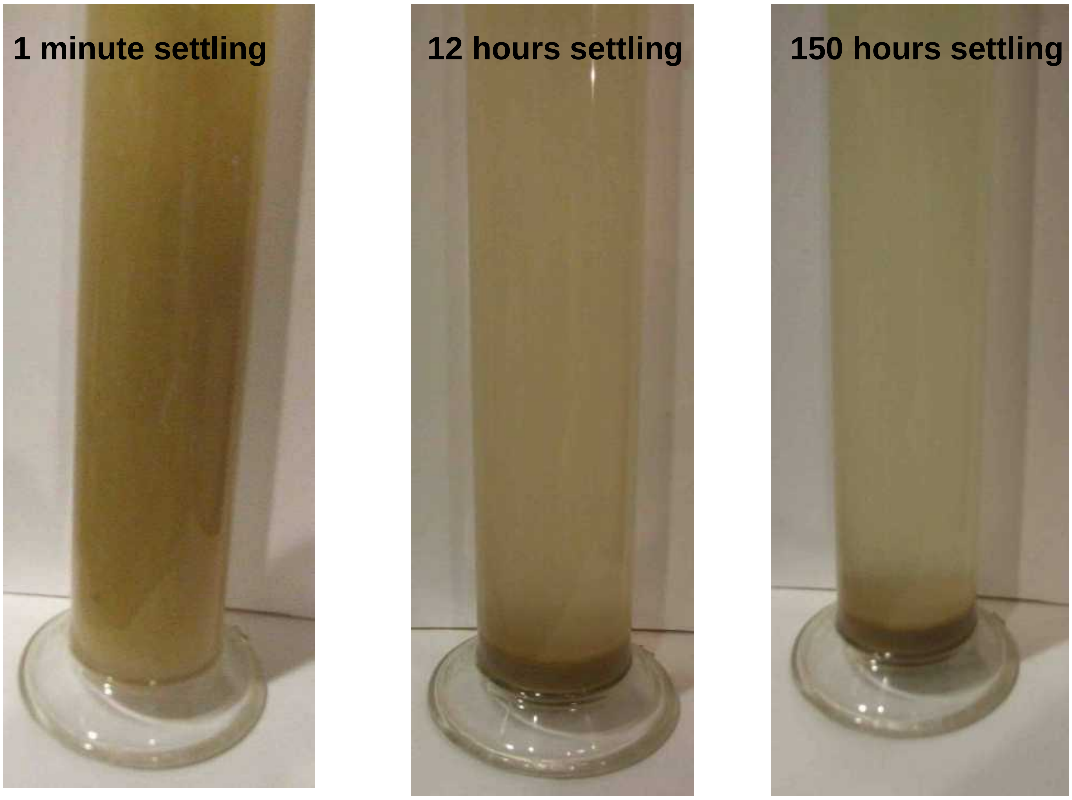
A fall-rate experiment was conducted on material rinsed from filters collecting material from the GVWU Kal-North intake (Table 2.1). Particulates were suspended in a 1 L 75 cm tall graduated cylinder. The solution was allowed to settle and microscope samples were drawn off at 1 minute, 1 hour, 12 hours, 70 hours and 150 hours (Figure 2.13). The large clumps of organic material settled within an hour, leaving marl, bacteria, filamentous cyanobacteria flagellates and small diatoms. After 70 hours of settling, bacteria and fine filamentous cyanobacteria (*Lyngbya sp.*) were still suspended. Finally, after 150 hours of settling, marl filamentous were still suspended and bacteria were growing. Table 2.1 summarizes fall velocities from this experiment with established fall rates in 10-20 $^{o}$C water.

**Table 2.1: Size and Fall Velocity Estimates for Kalamalka Lake Particulates**

| Material | Size | Fall velocity estimate |
|---|---|---|
| Inorganic | | |
| Sand | >63 – 100 microns | > 100 m/day |
| Silt | 4 – 63 microns | 21 m/day |
| Clay | 0.1 – 4 microns | 1 m/day |
| Marl | <1.5 microns | 0.6 m/day |
| Biological | | |
| Organic clumps | > 100 microns | >100 m/day |
| Large algae and diatoms | 22 – 70 microns | < 50 m/day |
| Small algae | 6 – 14 microns | <1 m/day |
| Lg filament cyanobacteria | 5 x 200 microns | 0.1 m/day |
| Sm filament cyanobacteria | 1 x 100 microns | >0.007 m/day |
| Giardia / crypto cyst | 4 – 8 microns | 0.02 – 0.1 m/day |
| Bacteria – *E. coli* | 0.7 – 10 microns | 0.0035 m/day or more |

(Dia and Boll, 2006; Hayco, 2009; USGS 2007; Larratt 2010)

**Figure 2.13: Photos of Settling Velocity Experiment; Kalamalka Lake, 2009**




**Vertical Transport - Vertical Currents** Vertical currents generated by a strong wind event can theoretically reach 5 m/sec with a seiche, however, with a typical maximal vertical velocity of 0.08 cm/sec (3 m/hr) for a water current after a strong wind, fine material suspended in the water or disturbed from the sediments could potentially be transported to the surface in 8 hours from a depth of 25 m (the depth near the LC intake). There are no persistent vertical currents in a lake; the direction of vertical currents oscillates following the upward and downward water motions in the lake (Hayco, 2009). Vertical currents are capable of transporting materials from the bottom up 2 m to the intake for brief periods.

**Vertical Transport - Seiche Transport and Autumn Overturn Turbulence**
During the summer stratified period with no seiche activity, sediment fall in the epilimnion would be in proportion to depth. In practice, waves erode the shallows and mixing transfers sediment to deeper water. A storm therefore can increase sediment concentrations at an intake by seiche disturbance and by wave turbulence-mixing transfer. Rapid current reversals and increased velocity at the thermocline occurs during a seiche and can suspend sediments. Seiche-driven sediment re-suspension decreases linearly with depth (Hilton et al., 1986). Normal wind-driven currents in deep areas of a lake are unlikely to create sufficient turbulence to destroy the boundary layer near the sediment surface and bring the sediment into suspension.

During the autumn overturn, near-bottom sediments traps catch 2-4 times more material than shallow traps due to re-suspension from all over the lake bed. During spring and fall high seiche periods, over half of the material in traps was re-suspended material. The greatest turbulence is associated with the fall overturn (destratification).

The height to which the settled materials can be re-suspended depends on their particle size. Because substrate materials tend to clump, the height of re-suspension is usually only a few meters and the rate of return to the substrate is rapid – a matter of hours (Table 2.1). Finer material such as marl and bacteria that become re-suspended from the sediments will travel further and remain suspended longer.

**Water Currents (Horizontal Transport)** Like most lakes, currents in Kalamalka Lake show a seasonal variability that is strongly related to wind speed. Horizontal water currents are strongest in the top 5 meters of most lakes. There was no existing water current information for the south end of Kalamalka Lake and a drogue study was undertaken.

The drogue studies conducted as part of this report measured water currents in the immediate vicinity of the intake. Drogues were deployed at the South end of Kalamalka Lake on July 16, Sept 17 and Sept 29, 2009 (Table 2.2). The thermocline over these dates ranged from 11-14 m. Wind speeds were average, ranging from 0 – 10 km/hr. The relationship between wind speed and water current speed as measured by the drogues and was similar to the energy transfer estimate of 2-3% used in Hayco's modeling.

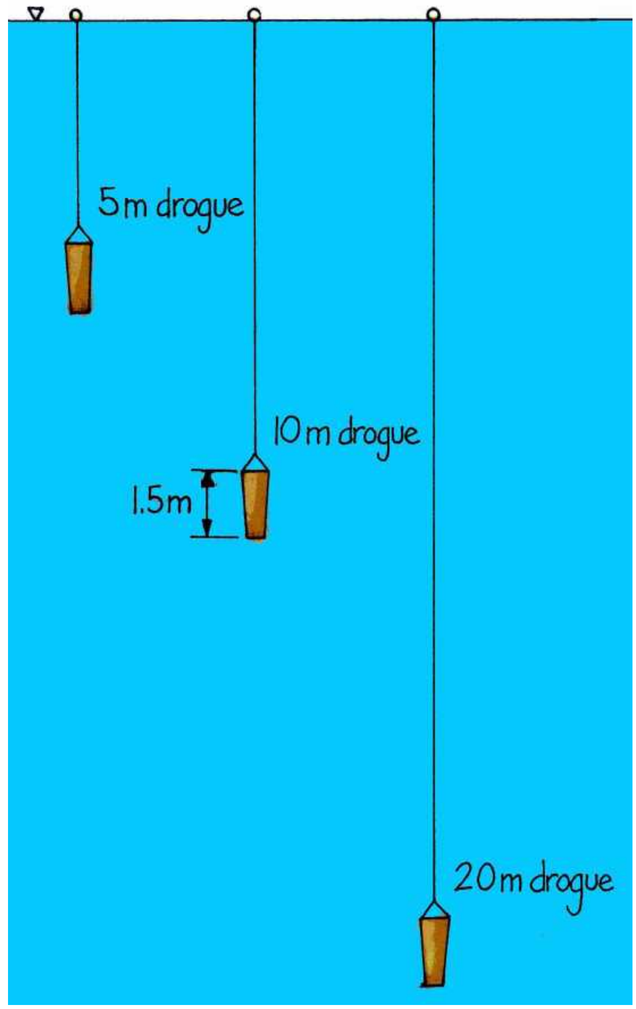
Water movement followed the general direction of the wind and more specifically traveled parallel to the shoreline of Kaloya Park – an example of long-shore currents. Often there was no significant difference in speeds at various depths. However on Sept 29, 2009, water speed at 10 m was more than twice the speed of the water at 5 m and at 20 m. On this date one 5 m drogue traveled ENE while the other traveled NNE. Speeds on this date at 5 m were 27-54 m/hr, at 10 m were 98-128 m/hr and at 20 m were 44-60 m/hr. The slowest speeds were on the surface, where the direction was less consistent. On the other two drogue sampling dates, water current speeds were more typical and ranged from 35-80 m/hr with the fastest currents measured in the surface water (Figure 2.14; Table 2.2).

**Figure 2.14 South Kalamalka Lake Drogue Trials, 2009**


White Line = 5 m drogue
Blue line = 10 m drogue
Yellow Line = 20 m drogue
Circle = start point



**Drogue Diagram**



The direction of travel of the drogues was scattered, reflecting the effect of the bays, points and shallows deflecting the wind-driven currents (Figure 2.14). Contradictory travel in different water layers was often observed and was the result of seiches, deflected currents or a change in wind direction. The surface 5 m of the lake can change directions and velocity faster than deeper water can.

**Table 2.2: Drogue Results for Lake Country Kalamalka Lake Intake 2009**

| | July 16 | | Sept 17 | | Sept 29 | |
|---|---|---|---|---|---|---|
| Depth m | m/hr | direction | m/hr | direction | m/hr | direction |
| 5 | 80 | SSW | 49 | N | 40 | ENE |
| 5 | 57 | SSW | 53 | NNE | 42 | NNE |
| 10 | 45 | SSW | 59 | N | 111 | NE |
| 10 | 50 | SSW | 47 | NNE | 116 | NE |
| 20 | 44 | SSW | 36 | N | 49 | NE |

The drogues were not used during an intense storm, but currents are estimated to reach surface speeds of up to 9.5 cm/s (342 m/hr) in the open reaches of Kalamalka Lake. The currents would slow and deflect as they reached the south end shallows. Both the drogue and thermistor studies confirm that extensive mixing and turbulence occurs as currents traveling south slam into the end of the lake.

**Calculation of the Intake Protection Zone** The minimum intake safety factor recorded in the Lake Ontario Source to Tap Study is two hours (Stantec, 2007). The speed of travel for surface contaminants is important because materials can fall vertically or be transported downward by the South end's powerful seiches. Doubling the wind speeds that were measured by the drogues covers 80% of the wind events expected in a year. Doubling the fastest drogue indicates that a surface contaminant could traverse a 100 m intake protection zone in 20 minutes. Conversely, to achieve the two hour guideline, the intake protection zone radius would have to be 464 m (Figure 2.15). The shape of the intake protection zone should be modified from a circle by prevailing directions of water travel and the locations of potential contaminant introduction. In the case of the South end of Kalamalka Lake, the turbulence was very random, suggesting that the IPZ should be roughly circular. The IPZ would diminish in size if the intake was deeper.

Long-shore water currents driven by wave action are temporary and frequently reverse the angle that they are striking the shore, making them a weak transporter of potential contaminants over long distances of shoreline (Hayco, 1999). The DLC intake is 440 m off-shore because of the wide littoral shelf and this long intake is protected from wave-generated long shore currents.

Figure 2.15 Proposed DLC Kalamalka Lake Intake Protection Zone


The white circle encompasses the area that the fastest drogues traveled in two hours with light winds.

The black modified circle encompasses the area water currents can travel in two hours with 80 % of the wind events that occur on Kalamalka Lake and is the recommended Intake Protection Zone (IPZ) (464 m radius).

An Intake Protection Zone that included the area water currents can travel in wind storm events within two hours would include the entire southern end of Kalamalka Lake.

The intake protection zone does not encompass the entire area capable of impacting the intake, rather it delineates the “highest risk” area. In a severe storm, a spill anywhere on Kalamalka Lake could theoretically impact DLC’s intake. An intake protection zone based on two hours of water travel under normal wind conditions represents the minimum safety factor recommended in this study. An IPZ should be understood as a critical protection area nested into a larger area of concern (South end) and finally into the entire area of concern – Kalamalka Lake and Wood Lake and their watersheds.

## 2.7 Hazards Impacting the Intake Protection Zone

Contaminants that can affect the intake that are injected within the intake protection zone have the greatest potential to impact the intake water quality and the least available dilution.

### 2.7.1 Fecal Bacteria and *E. coli*

Total coliforms are a broad category of bacteria that include soil bacteria and along with background colonies, they indicate the amount of bacterial loading in the water. Fecal coliforms are found in warm-blooded animal wastes and they serve as an indicator of recent fecal contamination (WSDH, N.D.). Unfortunately, there are non-fecal bacteria that can give false positive fecal readings such as *Klebsiella*, *Enterobacter* and *Citrobacter,* leading to declining reliance on the fecal coliform assay in the water industry (Doyle et al., 2006). *E. coli* (*Escherichia coli*) are the most common type of true fecal coliforms. Only a few of the thousands of *E. coli* strains are disease-causing, however, if *E. coli* are present, recent fecal contamination is probable. The presence of other pathogenic bacteria such as *Campylobacter* may be correlated, while *E. coli* counts do not correlate well with viruses or other pathogens (Carter et al. 1986; Keith et a, 1999).

The criteria set by IHA for source/raw water is (1) No more than 10% of source/raw water *E. coli* samples exceed 20 cfu/100 mL *E. coli* within any 6 month period. (2) No more than 10% of source/raw water total coliform samples exceed 100 cfu/100 mL total coliform within any 6 month period (Filtration Deferral Document, IHA).

Lake Country collects bimonthly bacterial samples from the intake (*Samples from years where there was no unchlorinated raw water sampling line were not considered in this summary).* The highest peaks in fecal bacteria and *E. coli* counts in the South DLC Kalamalka Intake occurred in January and February each year when the lake was not stratified. Peaks also occurred with severe storms. For example, a storm with a seiche on August 22, 2006 had 300 fecal mpn/100 mL and 25 *E. coli* mpn/100 mL. A severe storm on October 19, 2009 caused a fecal count of “overgrown without fecal bacteria” and 1 mpn/100 mL *E. coli.* Both storms must have introduced storm water to the intake area and kicked up bottom sediments. All of these peaks occurred when surface water can access the intake; in winter when the entire water column is circulating and in summer when seiches transport surface water to the intake depth.

Bacterial samples are also collected weekly from the DLC Kal Lk intake. In 2006, out of 17 intake samples, two had detectable *E. coli*; one sample with 25 *E. coli* per 100 mL and one sample with 1 *E. coli* per 100 mL (Meger et al., 2006). In 2007, all 47 water samples had 0 detectable total coliforms and 0 *E. coli* (Meger et.al., 2007). These are typical results for DLC’s Kalamalka Intake and indicate low bacterial loading rates except during storms. May to October in-lake samples from the South end of Kalamalka Lake were all <1 cfu/mL during 2008 and 2009 (Table 2.3). Further sampling will occur at 0, 20, 30, and 40 m in 2010.

**Table 2.3: Kalamalka Lake South Bacterial Water Quality 2009**

**Kalamalka Lake South Bacterial Water Quality 2009**

| Parameter | 19-May-09 | | | 16-Jun-09 | | | 16-Jul-09 | | |
|---|---|---|---|---|---|---|---|---|---|
| mg/L | 1m | 20m | 30m | 1m | 20m | 30m | 1m | 20m | 30m |
| Total Coliforms CFU/100 | 2 | 400 | 43 | 1 | 55 | 20 | | NTCWitho | <1 |
| Background Colonies | | DGT200 | DGT200 | | DGT200 | DGT200 | | <200 | DGT200 |
| E.coli CFU/100 | <1 | <1 | <1 | 1 | <1 | <1 | <1 | <1 | <1 |

| Parameter | 11-Aug-09 | | | 29-Sep-09 | | | 20-Oct-09 | | |
|---|---|---|---|---|---|---|---|---|---|
| mg/L | 1m | 20m | 30m | 1m | 20m | 30m | 1m | 20m | 30m |
| Total Coliforms CFU/100 | 56 | DGT2 | O.G. with | O.G. with | 13 | O.G. with | DGT2 | DGT1 | DGT1 |
| Background Colonies | DGT200 | DGT200 | | | DGT200 | | DGT200 | DGT200 | DGT200 |
| E.coli CFU/100 | 1 | <1 | 1 | <1 | <1 | <1 | <1 | 1 | <1 |

NOTE: DGT=greater than TNTC= too numerous to count RDL=reported detection limit
OG=overgrown With = with total coliforms

IHA's proposed guidelines for filtration deferral states:

- No more than 10% of raw source water *E. coli* samples should exceed 20 CFU/100mL in any 6 month period (consecutive weekly sampling preferred). and
- No more than 10% of raw source water total coliform samples should exceed 100 CFU/100 mL in any 6 month period (consecutive weekly sampling preferred).

### 2.7.2 Sediment Contaminants – Metals

At an estimated sediment accumulation rate of 2.9 mm/yr in Kalamalka Lake, it would take a decade for 3 cm of new sediments to "seal over" contaminated sediments, assuming no sediment disturbance. This is fortunate because some pesticides used in the past are dangerous and persistent. For example, Walker et al. (1994) found a peak in arsenic and lead in Wood Lake sediments deposited in the 1940's that can be attributed to the use of lead arsenate as a pesticide to control coddling moth damage to fruit orchards. The use of these heavy metals as well as the use of DDT after World War II – 1960's may also explain the decimation of the benthic community of Wood Lake which went from "abundant" (Clemens et al., 1939) to non-existent by 1969 (Saether and McLean, 1972). There was similar tree fruit production around the south end of Kalamalka Lake during 1940 to present, and extensive agriculture was conducted throughout the Coldstream Valley, making it likely that some herbicide/pesticide contamination of Kalamalka Lake sediments occurred.

The contact between the water column and these contaminated sediments that will be buried by approximately >10 cm of recent sediment, should be minimal under normal circumstances. Burrowing fish (e.g. carp) and aquatic insects (e.g.*Mysis*) could disturb these sediments, as could wave and seiche turbulence in shallow areas.

In another study, Walker found slightly increased mercury in recent surface sediments in the Kalamalka-Wood Lake area (Walker et al., 2003). Having re-suspended sediment enter the intake is undesirable. It increases turbidity and possibly introduces small concentrations of contaminants.

The OUC remote sediment sampler was available in 2001, allowing the collection of triplicate cores from 20 m in front of the Lake Country intake and in front of the GVW N-Kal intake. Kalamalka Lake 20 m sediments are a fine silt/clay with moderate organic carbon contents. Recent 0-5 cm sediments contained more phosphorus and organic material than deeper sediments, suggesting increased algal productivity (Table 2.3).

All anthropogenic metals (Zn, Al, Pb, As) in North Arm sediments were 2-3 times the concentration in sediments near the DLC intake because of the greater urban development and agriculture through the Coldstream Valley. They also showed arsenic and lead enrichment, perhaps due to agriculture and the use of leaded gasoline. Zinc was also enriched in surface sediments and serves as a marker for storm water (galvanized pipe is Zn coated) (Table 2.4). Because deeper sediments contain more calcium, it is inferred that marl precipitation events have become less intense in recent years.

**Sediment Contaminants – Bacteria** On September 17, 2009 a remote sampler was repeatedly dropped into the sediment near the intake before retrieving a sample 1 m above the substrate. The intent was to mimic seiche turbulence to see if the sample would account for the turbidity spike that accompanies a seiche. Like the sediment samples from Okanagan Lake, the sediment that is easily stirred up near the DLC Kalamalka intake contained uncountable numbers of coliform bacteria, and non-detectable *E. coli* (Table 2.5). These results indicate that the risk of *E. coli* loading from south end sediments is not significant. Re-suspended sediments do increase turbidity, THM precursors and lower UV transmissivity. The high *E. coli* count in the DLC intake water noted during storms may be the result of storm water entering the southern end of Kalamalka Lake.

### Table 2.4 Sediment Under Kalamalka Lake Intake and Sediment Trap Data

**Sediment Sampling Under Intakes for Microflora - 2009**

| | | 14-Sep | 14-Sep | 17-Sep |
|---|---|---|---|---|
| | frequency data | Ok Lk LC | Kal-GVW | Kal-LC |
| | **DIATOMS** | | | |
| | Asterionella formosa | | L (dead) | L (dead) |
| | Cocconeis | | P | |
| | Cyclotella | | C | C-D |
| | Cymbella sp | L (dead) | L (dead) | L (dead) |
| | Fragilaria capucina | | VL (dead) | |
| | Fragilaria crotonensis | VL (dead) | M (dead) | L (dead) |
| | Melosira italica | P (dead) | L | C (dead) |
| | Navicula sp. | L | L (dead) | P |
| | Stephanodiscus niagarae | VL (dead) | L (dead) | L (dead) |
| | Synedra acus var radians | | | |
| | Synedra ulna | | P (dead) | |
| | Siruriella elegans | | L (dead) | |
| | Tabellaria fenestrata | L (dead) | | P (dead) |
| TOXINS | **BLUE-GREEN ALGAE** | | | |
| x | Aphanocapsa sp. | | | **P** |
| x | Anacystis cyanea | **C-D** | | |
| X | Aphanocapsa sp. | **C** | | |
| X | Planktolyngbya limnetica | **M** | | |
| | Limnothrix redekeii | | | |
| x | Oscillatoria sp. smooth | **L** | | |
| | **OTHER** | | | |
| | micro-flagellates | M | L | VL |
| | Large flagellates | L | C | |
| | bacteria | D | **D** | **C** |
| | detritus | M | **L** | **L** |
| | silt | L | C | D |
| | SUM | | | |

P=Present L= Low M=Moderate C=Common D=Dominant

**Sediment Trap Samples 2009-2010**

**Deployed Sept 14/09 - Collected May 25/10**

(15 cm dia; 175 $cm^2$ surface area)

| | Ok Lk LC | Kal-GVW | Kal-LC |
|---|---|---|---|
| % solids | 0.1 | 0.7 | 0.2 |
| % volatile solids | 19.6 | 13.1 | 15.2 |
| dry weight (g) | 0.222 | 7.250 | 2.503 |
| volatile weight (g) | 0.038 | 0.859 | 0.320 |
| accum rate $g/m^2/yr$ | 1.9 | 62 | 21 |
| volatile accum $g/m^2/yr$ | 0.33 | 7.4 | 2.7 |

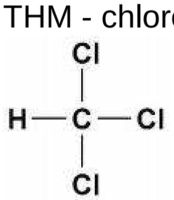
**Photo of Sediment Trap Material from Kalamalka Lake**


The South Kalamalka Lake sediment trap showed a moderate sediment accumulation rate because there was no sediment source such as a stream or a storm water outfall nearby (Table 2.4). The trapped material demonstrated an accumulation rate of 21 $g/m^2/yr$ of which 15.2% was volatile (organic). The sedimentation rate at this site was one third of the rate at the GVW intake in the North Arm because the north site is influenced by the riparian damage along Coldstream Creek.

### 2.7.3 Trihalomethanes THM

Trihalomethanes (THMs) are generated when combinations of total organic carbon, water temperature, contact time and chlorine dose are high (Larratt, 2007). There are many Okanagan water supplies that do not meet the THM criteria. THM's are higher during the summer months when microfloral production is high than they are in the winter months. Almost all of the THM produced in the distribution system will be chloroform ($CHCl_3$). None of the LC Kalamalka Lake intake samples collected to date exceeded the 0.10 mg/L total THM guideline. Total THM samples collected from a "continuous run" site on the Kalamalka Lake source had a total THM of 0.036 mg/L on Nov 9 2006 and 0.042 mg/L on June 12 2007 (Meger et al., 2006; 2007). Further sampling during the three seasons where THM precursors are most likely to occur (spring, summer, fall), taken at location(s) furthest from treatment would confirm the low total THM potential of Kalamalka Lake water and meet filtration deferral requirements.

THM - chloroform



## Table 2.5: Triplicate Sediment Core Results from 20 m Near South Kalamalka DLC Intake 2001

| Sample depth | Al mg/kg | As mg/kg | Ca mg/kg | Cd mg/kg | Fe mg/kg | Pb mg/kg | Sr mg/kg | Zn mg/kg | P % | N % | S % | C % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Set 1 0-5 cm | 6362 | 13.7 | 26.3 | 2.3 | 7152 | 8.3 | 571.3 | 35.1 | 0.05 | 0.40 | 0.44 | 5.02 |
| Set 2 0-5 cm | 5442 | 7.9 | 24.1 | 2.1 | 6779 | 9.5 | 537.2 | 33.6 | 0.05 | 0.43 | 0.37 | 5.08 |
| Set 3 0-5 cm | 6870 | 11.1 | 24.5 | 1.9 | 7438 | 14.0 | 553.7 | 36.6 | 0.05 | 0.43 | 0.40 | 5.03 |
| | | | | | | | | | | | | |
| Set 1 15-25 cm | 5968 | 15.3 | 25.0 | 2.1 | 7653 | 9.0 | 500.6 | 31.5 | 0.03 | 0.33 | 0.55 | 4.56 |
| Set 2 15-25 cm | 6743 | <1.0 | 26.3 | 1.9 | 7999 | 9.0 | 582.5 | 32.6 | 0.03 | 0.30 | 0.59 | 4.32 |
| Set 3 15-25 cm | 7120 | 10.5 | 25.3 | 2.3 | 8349 | 6.2 | 539.5 | 33.4 | 0.04 | 0.33 | 0.63 | 4.55 |
| | | | | | | | | | | | | |
| Set 1 >50 cm | 5218 | <1.0 | 25.0 | 2.0 | 035 | 8.8 | 450.6 | 28.4 | 0.02 | 0.27 | 0.65 | 3.70 |
| Set 2 >50 cm | 6112 | 4.7 | 28.5 | 2.2 | 7595 | <5.0 | 611.8 | 27.7 | 0.02 | 0.25 | 0.66 | 3.29 |
| Set 3 >50 cm | 6280 | 7.4 | 26.3 | 2.0 | 7857 | 5.9 | 535.8 | 19.5 | 0.03 | 0.27 | 0.66 | 3.85 |

| Sample Depth | % sand | % silt | % clay / marl |
|---|---|---|---|
| 0 - 5 cm | 0 | 75 | 25 |
| 15 – 25 cm | 6 | 65 | 29 |
| >50 cm | 6 | 65 | 29 |

## Table 2.5:
## Suspended Sediment beneath South Kalamalka DLC Intake

| Sept. 17 2009 | cfu/100 mL |
|---|---|
| Total Coliforms | overgrown |
| Fecal Coliforms | < 1 |
| *E. coli* | < 1 |

### 2.7.4 Cyanobacteria

Blue-green algae are also called cyanobacteria and they are wide-spread and problematic. With climate change and eutrophication, the frequency and intensity of cyanobacteria growth is increasing in Canada. Many of these genera are known to produce toxins but were not present in Kalamalka Lake in amounts sufficient to cause cyanotoxicity threat (Table 2.6). Like Okanagan Lake, the intake depths are often dominated by low light tolerant filamentous cyanobacteria of the *Lyngbya, Oscillatoria* and *Planktothrix* genera. At least one of the toxins produced by these cyanobacteria (Microcystin) can be degraded by chlorine under specific conditions. The risks from chronic low-dose exposure to cyanotoxins is the subject of much international and local study (Larratt, 2009). In general, Kalamalka Lake should be managed to minimize nutrient loading and intakes should be sited to minimize the quantities of cyanobacteria extracted in the raw water.

**Table 2.6: Toxins Produced by Blue-green Algae (Cyanobacteria)**

| Cyanobacteria | Lyngbyatoxin , plysia-toxin | Aplysiatoxins | lipopolysaccharide | Cylindosper-mopsin | Microcystin | Nodularins | Anatoxins-a and/or -a(s) | Saxitoxins neosaxitoxin | BMAA |
|---|---|---|---|---|---|---|---|---|---|
| Type of toxin | Dermal toxin | Dermal | Dernal | Liver toxin | Liver toxin carcinogenic | Liver toxin carcinogenic | Nerve toxin | Nerve toxin | Nerve toxin carcinogenic |
| LD50 (ug/kg) | | | | 300 | 50–1000 | | 20-5000 | | |
| **Guideline** | | | | | <1 ug/L | | <1 ug/L | | |
| Anabaena | | | Yes | Yes-? | Yes | | Yes | Yes | Yes |
| Anabaenopsis | | | Yes | | Yes | | | | |
| Aphanizomenon | | | Yes | Yes | | | Yes | Yes | Yes |
| Aphanocapsa | | | Yes | | | | | | |
| Cylindrospermopsis | | | Yes | Yes | | | Yes-? | Yes | Yes |
| Gloeotrichia | | | | | Yes | | | | |
| Haplosiphon | | | Yes | | Yes | | | | Yes |
| Lyngbya/ Pleactonema | Yes | Yes | Yes | Yes | | | Yes-? | Yes | Yes |
| Microcystis | | | Yes | | Yes | | | | Yes |
| Nostoc | | | Yes | | Yes | | Yes-? | | Yes |
| Nodularia | | | Yes | | | Yes | | | Yes |
| Oscillatoria | Yes | Yes | Yes | | Yes | | Yes | Yes | Yes |
| Phormidium | Yes-? | | Yes | | Yes | | Yes | | Yes |
| Planktothrix | Yes | Yes | Yes | | Yes | | Yes | Yes | Yes |
| Pseudanabaena | | | Yes | | | | | | |
| Raphidiopsis | | | Yes | Yes | | | Yes | | |
| Schizothrix | Yes | Yes | Yes | | | | | | |
| Synechococcus | | | Yes | | | | | | Yes |
| Synechocycstis | | | Yes | | | | | | Yes |
| Detection technique | | | | HPLC | ELISA HPLC | | HPLC+UV GC/MS | | |

NOTE: Yes-? = Not all authors list this toxin for the cyanobacteria species

Over 2000 – 2009, chlorophyll-a at the surface averaged 1.2 ug/L but at the 20 m intake depth, it doubled to average 2.1 ug/L due to the greater densities of cyanobacteria growing at depth and re-suspension of algal material from the sediments (LC reports). Total Algae counts from LC Kalamalka averaged 400 – 900 cells/mL May-October.

### 2.7.5 Sewage/Septage

Septage routinely carries pathogens, organic matter, nitrates, heavy metals, inorganic salts, pharmaceuticals & personal care products (PPCPs), cleaners, paints, auto wastes, hydrocarbon PAHs and more, hence the need to isolate it from drinking water sources .

Caffeine can be used as a marker for human sewage and septage because no other animal excretes it. A caffeine sample was collected from the intake depth near the Kalamalka Lake intake on September 29 and shipped to ALS Labs Edmonton. The results were below the detection limit of <0.20 ug/L caffeine and suggest that there is no discernable threat from human sewage/septage in the vicinity of the intake under normal lake conditions.

As the septic systems are removed from service by the municipal sewer system, their impact on subsurface drainage should diminish. Hatikvah summer camp and T'ween Lakes campground are on septic tanks/disposal fields. While few problems are anticipated with the Camp Hatikvah system, the T'ween Lake septic system has serious flaws. It is situated on a former wetland infill that causes a high water table. DLC staff have witnessed and documented an incident in 2009 when a motor-home emptied its holding tank into T'ween Lakes septic tank when the tanks and field were underwater during high lake levels. This site is susceptible to flooding during a high water year and servicing traveller's motor-homes raises the risk of pathogen introduction to the lake system. Connection of the T'ween Lakes Campground to the municipal sewer system would be highly desirable.

Flooding events are rare on Kalamalka Lake because the water level is regulated by the control structure in the North Arm. They do occur in years with high freshet and a wet spring when water "backs up" in the lake system. Flooding can increase the impact from old septic fields or informal disposal sites at farms or residences. .

A new sewage lift station and sewer main are located within 100 m of the S-Kal intake. The need for a Gen-set in case of power failures can be determined by DLC Engineering DLC staff are working on updating the District of Lake Country's Liquid Waste Water Management Plan. Currently there is on-site disposal in the area which is not expected to change in the near future.

### 2.7.6 Storm Water Locations

Storm water routinely carries hydrocarbon PAHs, road surface contaminants, salt, pathogens, pesticides and nitrates. It may also carry other contaminants when people illegally dispose of materials down the storm drains. Outfall locations must be distant from the intake and preferably, they should be replaced with soak-away zones. The high *E. coli* count detected during the August 22 2006 storm could well be caused by storm water washing pet and avian feces off adjacent streets and parking lots.

For example, Trask Road that travels up to Kaloya Park is within 11 – 14 m of the lakeshore and has shallow ditches along some stretches. Most road drainage sheets off the road and into the vegetated band separating the road from the lake. This "green belt" offers most of the storm water treatment available. Unfortunately, most land-owners have opened the vegetation to accommodate stairs to a dock or raft. The shorelines have been modified and vegetation cleared, reducing the effectiveness of the infiltration/green belt interception of infiltrated water from the ditches and road flows.

### 2.7.7 Biofilm Development

Warm lake water rich in organic material will develop biofilm in a distribution system. Biofilms in distribution pipelines contain a build-up of precipitated material and microorganisms (bacteria, fungi, yeasts). Biofilms are dislodged from pipe walls during periods of high flow. Most Okanagan water supplies develop biofilms during the summer when the warmer water accelerates bacterial growth.

From 2004 to 2009, the maximum summer temperatures within the DLC distribution system ranged from 10 – 17 $^{o}$C and the normal annual averages ranged from 7.5 – 8.5 $^{o}$C. In a warm summer, the annual average temperature can reach 11 $^{o}$C. The temperatures within the distribution system meet the 15$^{o}$C CDWG guideline except in July. Water temperatures usually rise in October over September because of autumn overturn and reached 16$^{o}$C at the Oyama Office in October 2006 (Hansen et al., 2006).

These temperatures are moderate and although Kalamalka Lake water contains more than 4.0 mg/L TOC, biofilm is not a significant problem in the Lake Country distribution system fed from Kalamalka Lake. Although not strictly a biofilm, the reservoirs need regular cleaning because of a red sediment that accumulates, presumably iron-related bacteria (IRB).

### 2.7.8 Water Infrastructure

Low water levels could theoretically strand the intake's wet well and disrupt service. Because Kalamalka Lake levels are regulated, this could only occur in an extreme drought and is unlikely.

The Kalamalka Lake system was built in 1995/6 and is relatively young. It requires very little maintenance. This system has the added protection of a back-up water supply from Oyama Creek that can supply domestic and limited irrigation water.

### 2.7.9 Monitoring Routine and Emergency Planning

Routine sampling by Lake Country Staff includes sampling for total and free chlorine, conductivity, hardness, pH, color temperature, turbidity, UV transmissivity as well as total coliforms and *E. coli* but these bacterial parameters are invalidated by the chlorine already in the water. A true estimate of the raw water bacterial counts can only be obtained by using a raw water line. Although this intake was equipped with a raw water sample line in the past, it failed and needs replacing. Currently sampling is awkward without the sample line and is conducted once or twice monthly instead of the preferable weekly format.

Monthly monitoring reports are e-mailed to the Interior Health Drinking Water Officer

District of Lake Country has plans in place for releasing water quality advisories and boil water alerts but they do not have a formal emergency response plan that details contacts and procedures in the event of a water emergency. The plan should be developed and could use the GVWU plan as a template.

Vernon's All Hazards Emergency Response Plan was prepared by: Public Safety Consultants Northwest, LLC Seattle, Washington. Vernon's plan follows the guidelines of the BCERMS standards for response and incident management using the Incident Command System. The water utility manager is responsible to review the entire plan on an annual basis, co-ordinating the revision of the plan as needed, maintaining records of the revisions, and administering the overall plan. The emergency plan must include: emergency contact numbers, steps to follow, agencies to notify, protocols to follow for public notice, etc., as per IHA directions.

### 2.8 MODULE 1: Hazard and Contaminant Table – DLC Kalamalka Lake Intake

| Report section | Drinking Water Hazard/Contaminant | Possible Effects | Existing Preventative Measures/Barriers |
|---|---|---|---|
| | **Physical** | | |
| 2.3<br>3.1.1 | Creek plumes | Introduction of TSS, pathogens, nutrients, PPCP, PAHs | Riparian protection through watershed |
| 2.7.2 | Sediment re-suspension from the substrate | Increased turbidity can compromise disinfection treatment potentially causing illness if pathogens, heavy metals are present | 2 m clearance of intake from Kalamalka Lake substrate |
| 2.7.8 | Drought low water levels and shoreline flooding | Wet well stranding is possible if water levels drop below el.389.39; Flooding of septic fields, yards, causes introduction of contaminants | Drought planning outlet flow control, emergency alteration of works if wet well is stranded |
| | **Chemical** | | |
| 2.7.6 | Storm water | Transport of nitrogen, pesticides road surface contaminants, pathogens, salt | Distant from intake, educated residents |
| 2.7.5<br>3.1.3 | Septage (sewage spill, septic fields, boat and RV disposal) | Exposure to: pathogens, organic matter, nitrates, heavy metals, inorganic salts, personal care products cleaners, paints, medications, auto wastes, PAHs | Caffeine analysis was negative |
| 3.1.4 | Hydrocarbons PAHs | Deliberate or accidental spill or use of gas-powered boats, boat launch | Dilution; depth of intake; location of intake |
| 2.5 | Turbidity | Interferes with disinfection; high during marl precipitation | None |
| 2.5<br>2.7.4 | Taste/odor chemicals | Reduced aesthetic; periodic problem usually caused by algae | Increase chlorination |
| 2.7.3<br>3.1.5 | Heavy metals | Bioaccumulation through chronic exposure | None |
| | **Biological** | | |
| 2.7.4 | Cyanobacteria | Chronic low-dose exposure to cyanotoxin; health impacts vary with toxin type, can include hepatic cancer | Depth of intake; chlorination provides some protection; minimize nutrient loading |
| 2.7.3 | THM precursors (algae, organic material) | Organic material (TOC) can react with chlorine to create THMs that are carcinogenic | TOC load is moderate in Kalamalka Lake – never have exceeded 0.1 mg/L Total THM (IMAC) no excessive chlorine. |
| 2.7.5<br>3.1.3 | Viruses –pathogenic | Acute Illness through water-borne exposure | Chlorination |
| 2.7.1<br>2.7.5 | Bacteria (*E. coli*, fecal) | Illness through water-borne exposure | Chlorination |
| 2.7.1<br>2.7.5 | Protozoa -pathogenic | Illness through water-borne exposure | Chlorination |
| 2.7.7 | Biofilm | Shields pathogens from disinfection | Pipeline flushing |

## 3.0 Kalamalka Lake Intake Module 2 Contaminant Inventory

### 3.1 Anthropogenic Potential Water-Borne Hazards to LC Intake

A wide range of human activity occurs within the vicinity of the Lake Country Intake on Kalamalka Lake, including camping, boat-based recreation, lakeshore residential, orchards, a railway, a major highway and low-density residential subdivisions. The degree to which they can affect the intake is based on their proximity and their potential to generate an emergency. The aerial photo in Figure 3.1 has the following features marked: Oyama Canal, a creek plume, LC intake pipeline, LC pipe line inlet, 30 m proposed extended intake site, Hatikvah summer camp, T'ween lakes campground, Highway 97 and the railway.

**Figure 3.1 Features of the South Kalamalka Lake Basin**

### 3.1.1 Major Inflows

Transport for discrete inflows such as creeks or the Oyama Canal enter the layer in Kalamalka Lake with a matching density. Larger inflows such as Coldstream Creek travel as a plume that is still "intact" several kilometres into Kalamalka Lake from the creek mouth. The distance from Coldstream Creek mouth and the LC intake is 14 km and allows extensive dilution of introduced contaminants. Whole-lake effects such as nutrient loading and non-settling particulates such as viruses and bacteria from Coldstream Creek theoretically have the potential to affect the LC Intake.

Figure 3.1 shows a small creek plume in the spring with a deflection to the right (the N hemisphere counter-clockwise Coriolis default direction in the absence of other water currents). Most years, there is only surface inflow during the spring and it is very turbid and probably nutrient-rich. Since it is in an isolated bay from the intake and flow volumes are small, no measurable impact of contaminants on the intake from this wetland creek is expected.

Although it is hard to detect, the Oyama Canal inflow from Wood Lake will also form a plume that seeks the water depth with matching density in Kalamalka Lake (B.C. Research, 1974). For most of the year, the canal inflow is slightly warmer and the conductivity is lower (Table 3.1). The Canal inflow should be buoyant and therefore travel in the upper meters of Kalamalka Lake, affording the intake some protection from this inflow except during seiches. At 20% of the total annual water input to southern Kalamalka Lake, Wood Lake inflow is significant source of nutrients, TOC, chlorophyll-a and cyanobacteria and possibly dilute contaminants (Table 3.1). Algae density near the Lake Country intake tends to be larger when Kalamalka Lake receives large Wood Lake inflows. The volume and direction of the Oyama Canal varies with the water level in both lakes and with wind-induced seiching.

**Table 3.1: Annual Average Water Quality in Wood Lake and South Kalamalka Lake**

| | **WOOD** | 2005 | 2006 | 2007 | 2008 | 2009 | Average |
|---|---|---|---|---|---|---|---|
| TOC | mg/L | 7.6 | 7.6 | 8 | 7.3 | 9.6 | 8 |
| Chlor-a | ug/L | 1.9 | 1.3 | 2.3 | 2.7 | 4.9 | 2.6 |
| Turbidity | NTU | 0.81 | 1.16 | 0.8 | 1.3 | 1.2 | 1.1 |
| UV Trans | % 254nm | 83.6 | 82 | 83.4 | 81.8 | 84.7 | 83.1 |
| Conduct. | mv | 343 | 326 | 337 | 336 | 338 | 336 |
| **SOUTH** | **KAL 0 m** | 2005 | 2006 | 2007 | 2008 | 2009 | Average |
| TOC | mg/L | 4.9 | 5 | 5.3 | 5.3 | 6.3 | 5.4 |
| Chlor-a | ug/L | 1.2 | 0.66 | 1.2 | 1.4 | 1.7 | 1.2 |
| Turbidity | NTU | 0.88 | 0.76 | 0.9 | 0.8 | 0.88 | 0.84 |
| UV Trans | % 254nm | 89.6 | 89 | 89.8 | 88.9 | 90.3 | 89.5 |
| Conduct. | mv | 387 | 389 | 390 | 393 | 396 | 391 |
| **SOUTH** | **KAL 20 m** | 2005 | 2006 | 2007 | 2008 | 2009 | Average |
| TOC | mg/L | 4.8 | 4.3 | 5.1 | 4.4 | 5.6 | 4.8 |
| Chlor-a | ug/L | 2.1 | 1.4 | 1.7 | 2.4 | 2.7 | 2.1 |
| Turbidity | NTU | 1.04 | 0.94 | 1 | 0.7 | 0.75 | 0.89 |
| UV Trans | % 254nm | 88.4 | 90.4 | 89.5 | 89.4 | 91.2 | 89.8 |
| Conduct. | mv | 396 | 401 | 400 | 399 | 401 | 399 |

The Oyama Canal inflow from Wood Lake could also be a significant source of cyanotoxins during a surface algae bloom. These surface blooms occur annually in Wood Lake (but not on Kalamalka Lake) and are occasionally severe. For example, a bloom developed in northern Wood Lake in mid-May 2009 and measured 15.3 ug/L. Accumulated cyanobacterial scums have been measured near the canal that exceed 50 ug/L chlor-a and toxin presence is probable at those densities.

Less likely contaminants that could be transported to the intake area from Wood Lake include re-suspension of toxic materials found in Wood Lake sediments predating 1970's and accidental spills from the railway or Oyama Road that are both immediately adjacent to the Wood Lake shoreline and traverse the canal (Figure 3.1). Boat storage and re-fueling in the canal itself could be a dilute source of PAH hydrocarbons to the Lake Country Intake.

A final method of water-borne contaminant introduction to Kalamalka Lake is via overland flow and subsurface drainage. Land use within several hundred meters of Kalamalka Lake has the highest potential to impact water quality and is covered in Section 3.1-5. Contaminants such as heavy metals, pesticides, PAHs, nutrients and accidental spills can impact the intake area.

### 3.1.2 Storm Water Outfalls

Transport for distributed shoreline sources such as local runoff or storm water outfalls would behave similarly to a creek input (Hayco, 2000). Inflows can pool as a water parcel and travel as a discrete packet of water, diffusing as it travels. Storm water can travel as a unit to the intake depth, particularly during the unstratified winter period. It is therefore not wise to count on dilution with the full volume of the intake bay when water-borne contaminants are considered.

Storm water in the Okanagan region routinely carries large loads of hydrocarbons PAHs and materials released from the paving materials, road salt, pathogens as indicated by *E. coli* and landscaping chemicals including fertilizer and pesticides. Pathogens are a particularly high concern because bacteria levels in stormwater runoff appear to be greater in urban areas than in natural areas and even commercial or industrial zones. One cause may be the high concentration of pets or waterfowl, such as Canada geese, associated with residential areas. Frequently, pets are walked along roadways or near waterways. From such locations, the next rainstorm will quickly flush the animal wastes into the nearest storm sewer (NI-DEP, ND; USEPA 2006). Additionally, some people feel that it is fine to directly dispose of materials into a storm drain and these can include solvents, paint, detergents, waste automotive products, and drug products. Education on the hazards of illegal disposal, landscaping run-off, washing down driveways and not picking up after pets has improved storm water quality in the Kelowna area (M. Toma pers. comm.). Creeks receiving storm water in the City of Kelowna contained *E. coli* from ducks, dogs, songbirds, deer, humans, cows, horses, gulls, and Canada geese (Appendix 3).

The location of storm outfall(s) in the vicinity of the intake is not known. DLC does not have a comprehensive Storm Water Master Plan but they have commissioned storm water studies of discrete areas. There is no formal treatment of storm water, rather, like most locales, it is ditched and infiltrates to the nearest water course. No storm water outfalls should occur that discharge within the Intake Protection Zone. The storm water from paved parking at Kayola Park should be routed away from the intake bay or at least managed by a soak-away treatment. It currently enters the small bay on Kaloya Point.

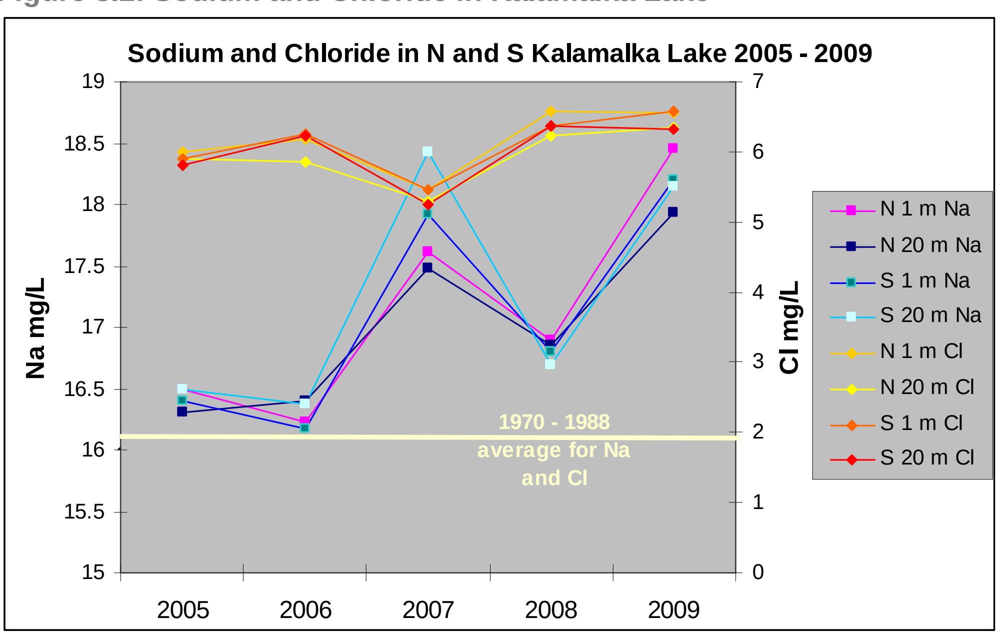
Historically, very little storm water treatment was developed in the Oyama area. Most storm water from older developments reports to the nearest watercourse without treatment. Localized on-site soak-away disposal is now required by DLC. All new development permits require that, "all storm water must be kept on-site". Usually French drains and swales are used to direct storm water to ground and helps preserve predevelopment ground water recharge. Refitting the older developments with swales and with rainwater barrels for roof drains would help limit storm water volumes. Oyama Road (nearest to Wood Lake) has been re-fitted with catch basins and dry wells, replacing the older storm water release to Wood Lake.

**Storm Water Run-off** Storm water runoff will flow directly from the rail line to Kalamalka Lake. The railway is still active and is currently leased to Knighthawk Rail Ltd. It connects with the CN Kamloops Yard. The line carries primarily wood products but chemicals and grain are also hauled. It is common practice for the rail company to store chemical cars on the siding on the Wood Lake and Kalamalka Lake shoreline sidings. Locomotive fuels, oils and lubricants would also be a risk in the event of a derailment on areas of the track that are within 10 meters of Kalamalka Lake. Unpreserved wood products and grain present no threat to water quality, but chemicals could. Depending on the density of the chemical spilled, it could be carried into water deeper than the intake and be diluted before it reached the intake via water currents. The exact behavior of the material would depend on water temperature, winds, recent seiches, etc. and would be impossible to predict the threat it could present to the DLC intake and on what time-frame. For this reason, no poisonous chemicals should ever be transported on this rail line without extensive precautions. A containment boom/cleanup kit suitable for the most deleterious product hauled by train could be purchased by the Railway and the appropriate planning put in place, including track maintenance.

The rail line itself is within 10 m of the water's edge in several places along the southern end of Kalamalka Lake. The entire line is within the riparian area of Kalamalka and Wood Lakes. Direct runoff from the rail bed including creosote is probable. Although a measurable impact on intake water quality is unlikely, it should be noted that positioning a rail bed within 10 m of a lake would never be approved today.

Highway 97 represents a large impervious surface and the storm water from it will carry the same contaminants as municipal storm water, with additional salt from winter abrasive. It also presents the risk of spills and it is located within 150 – 200 m of the lakeshore. This risk of spills will decrease significantly when Hwy 97 is re-routed away from the lake and the current route carries local traffic only. One outfall connecting railway ditching and possibly Hwy 97 runoff to Kalamalka Lake was located. Most runoff from the highway is directed to ditches on both sides of the highway. Seepage to ground from ditches will allow pathogen deactivation and can remove some PAHs but chloride and spilled contaminants may persist.

**Figure 3.2: Sodium and Chloride in Kalamalka Lake**



### 3.1.3 Sewer Infrastructure and Septic Fields

Lake Country has embarked on a sewer system that replaces aging individual residential septic systems. With the high water table in the Oyama area, this is a vital step towards protecting Wood Lake, Kalamalka Lake and the DLC intake.

**Sewer infrastructure** Although sewer is a significant and necessary improvement to the Kalamalka-Wood Lake aquatic ecosystem with the ever-increasing population pressure, the unlikely but the catastrophic consequence of a sewer main or lift station failure to the DLC intake must be considered. The closest lift station to the intake is immediately adjacent to the Kalamalka Lake pump house and wet well (within 100 m). These systems can fail. The Coldstream Creek Sewage Lift Station experienced a power failure, allowing a small raw sewage spill into Kalamalka Lake on February 11, 2009. A back-up generator has since been installed in the lift station.Appropriate containment strategies should be included in the Emergency Response Plan. Consideration should be given to providing back-up power to this lift station given its proximity to the DLC Kal Lk wet well.

The main sewage treatment facility for City of Vernon is the Spray Irrigation program from McKay Reservoir. There may be subsurface flows exiting McKay Reservoir that holds treated sewage effluent. Aspens in wetted hollows have now died back from persistent water-logged soil conditions suggesting increased seepage in recent years. Samples collected by LAC on April 6, 2010 from Bailey Creek in Kekuli Park that receives drainage from the spray effluent program and possibly McKay Reservoir measured 4.16 mg/L nitrate as N and 182 mg/L chloride. Another sample collected from seepage that emerges at the Kekuli Park boat launch measured 11.9 mg/L nitrate as N and 236 mg/L chloride. Both samples indicate significant loading and are well above concentrations found in local natural drainage systems. The risk of effluent seepage reaching the S-Kal intake is very low, however, increasing the nutrient status of the lake con increase algae density.

**Septic Fields and Private Septic Treatment Facilities** According to real estate information, numerous residences around southern Kalamalka Lake are still on septic fields.

A satellite wastewater treatment plant and ground disposal system to service a 27 lot residential subdivision overlooking Kalamalka Lake in was installed recently in Oyama for Amry Developments. It has a similar, low potential for failure like any other septic storage. Their drainage field is tested twice yearly via two monitoring wells as per the municipal sewer regulation. The plant should last a minimum of five years and is at full build-out although only a small number of homes are connected. The future plan is to mothball that plant and bring a line to Winfield wastewater treatment plant (Larsen, pers comm., 2010). Based on the monitoring results supplied to DLC, nutrient and bacterial counts are climbing in Amry effluent and are elevated compared to historic sampling that predates the development (Table 3.2 data supplied by Amry).

**Table 3.2: Amry Effluent Data 2009-2010 and Monitoring Well Data**

| Date and Sample Location | BOD | NO2 + NO3 | Ammonia | Total P | Total Coliforms | Fecal Coliforms |
|---|---|---|---|---|---|---|
| | mg/L | mg/L-N | mg/L -N | mg/L | mpn/100 m | mpn/100 m |
| Monitoring well1 Nov 2002 | <10 | 0.02 | | 1.99 | <3.0 | <3.0 |
| Monitoring well1 Apr 2006 | | 0.22 | | 0.94 | <3.0 | <3.0 |
| Monitoring well1 Apr 2009 | | 1.69 | <0.02 | 0.49 | <3.0 | <3.0 |
| Monitoring well 2 Nov 2002 | <10 | 1.9 | | 2.05 | <3.0 | <3.0 |
| Monitoring well 2 Apr 2006 | | 2.03 | | 0.93 | 3.6 | <3.0 |
| Monitoring well 2 Apr 2009 | | 0.92 | <0.02 | 0.18 | <3.0 | <3.0 |
| | | | | | | |
| Amry effluent Apr 2009 | 10 | 11.29 | 16.1 | 2.27 | >11000 | >11000 |
| Amry effluent Jun 2009 | | | | | | |
| Amry effluent Jul 2009 | 10 | 26.7 | 3.94 | 4.26 | | |
| Amry effluent Aug 2009 | 10 | 16.33 | 12.1 | 9.57 | | |
| Amry effluent Sep 2009 | 10 | 16.6 | 9.57 | 9.05 | 24000 | 9300 |
| Amry effluent Oct 2009 | 10 | 24.93 | 7.55 | 11.1 | 46000 | 15000 |
| Amry effluent Nov 2009 | 12 | 18.87 | 9.79 | 7.91 | 24000 | 11000 |
| Amry effluent Dec 2009 | 11 | 25.52 | 2.71 | 5.42 | >11000 | 4600 |
| | | | | | | |
| Amry effluent Jan 2010 | 10 | 34.11 | 1.36 | 4.42 | 24000 | 430 |
| Amry effluent Feb 2010 | 10 | 30.43 | 1.11 | 4.96 | 24000 | 24000 |
| Amry effluent Mar 2010 | 10 | 32.25 | 1.31 | 5.07 | 11000 | 46000 |

NOTE: Amry Monitoring well 1 is beside the disposal field and well 2 is adjacent to the DLC pumphouse

Properly functioning fields should not release pathogens but they will release nutrients and pharmaceuticals and personal care products (PPCPs) to the groundwater or subsurface flow. Recent research has shown that wastewater treatment plants and septic systems only partially remove pharmaceuticals, so these chemicals end up in groundwater and have been measured in adjacent rivers and lakes (Knox County, ND) In addition to functioning systems, improperly functioning septic systems will allow even greater concentrations of PPCPs to pass. Septic system contamination can severely impact surface and ground water (USEPA, 2007).

Ascertaining the risk from septic systems to the DLC intake would be prohibitively complex and beyond the scope of this report. The best option is to continue on the course of replacing and decommissioning all septic fields with the potential to impact Kalamalka Lake or Wood Lake.

Caffeine can be used as a marker for human sewage and septage because no other animal excretes it. This test is much more definitive if caffeine is detected than if it is below detection because caffeine is broken down by bacteria (Seiler et al., 1999). A caffeine sample was collected from the intake depth near the Kalamalka Lake intake on September 29 and shipped to ALS Labs Edmonton. The results were below the detection limit of <0.20 ug/L caffeine and indicate that there is a low likelihood of threat from human sewage/septage in the vicinity of the intake under normal lake conditions. As the septic systems are removed from service by the municipal sewer system, their impact on subsurface drainage should diminish. A caffeine test was not performed under storm conditions.

### 3.1.4 Moorage, Docks and Powerboat Recreation

Increasing boat traffic on Kalamalka Lake increases the contribution of PAHs including motor oil, gasoline and lubricants. Occasionally the boat traffic near the intake is intense during July and August. A liter of gasoline can contaminate 750,000 liters of water (Kerr Wood Leidel, 2008). Low viscosity fuels such as gasoline can spread rapidly and dispersion is dependent upon temperature and turbulence. Evaporation is less effective on heavier PAHs but remains the single most important weathering process in the first few days following a spill that is not cleaned up appropriately.

Accidental spills during refueling are routine and PAHs accumulate in the sediments near docks, moorage, boat launches and marinas. Because Kalamalka Lake does not have a large public marina (there are 7 "marinas" with more than 6 boat slips on Kalamalka Lake), the risk presented by PAHs to the DLC intake is minimal. No moorage, marinas, boat launches or large dock facilities should ever be contemplated within the Intake Protection Zone. The risks presented by a marina on Wood or Kalamalka Lake must be weighed carefully against the benefits of such a project and include:

- Increased introduction of PAHs during normal motor operation and by accidental spills;
- Increased use of the lakes with boats equipped with on-board septic holding tanks (many of which can be opened at will and verified reports of human feces washed up on shore near houseboat moorage have occurred in the Okanagan);
- Seasonal pump-out stations at marinas can fail – for example the August 14, 2009 spill of raw sewage from the Westbank Yacht Club into Gellatly Bay, Okanagan Lake. Storm water deluged a manhole and overflow of storm water and raw sewage flowed into the lake for 45 minutes (Appendix 1).

A clean-up kit for a PAH spill into Kalamalka Lake should be stored with the Lake Country Fire Department. Spills should be reported and cleaned up in accordance with the Spill Reporting Regulation (B.C. Reg.263/90). Lake Country may wish to consider encouraging non-motorized recreation by planning facilities that promote sailing, kayaking, canoeing, all of which have far less potential to impact intake water quality.

### 3.1.5 Adjacent Land Use

Land use within several hundred meters of Kalamalka Lake has a greater potential to impact water quality than land use distant from the lake. Shoreline properties have the highest potential to impact the lake. Overland flow from these properties is the most serious, followed by subsurface drainage which is slower and offers some in-situ treatment. Both of these routes for contaminant travel are diffuse and are unlikely to impact the intake water quality directly, however, overland flow and groundwater contamination both contribute to the contaminant and nutrient loads reaching the lake. Although shoreline flooding is rare on this regulated lake, toxic materials should not be shored near the high water mark without adequate containment facilities.

Although they do not "grand-father" to older properties, DLC has Development Permit Areas which gives DLC the power to "require works to be constructed to preserve, protect restore or enhance natural water courses or other specified natural features of the environment." A large portion of the Development Permit is an environmental assessment that complies with Riparian Areas Regulations. There should be enforceable (no-build, no-disturb) set-backs from the high water mark and a pesticide ban on lakeshore properties. There are serious examples of private intrusion on

Southern Kalamalka Lake foreshore including in-filling, retaining walls, building cabins on piles over the water and inappropriate storage near the high water mark. Trask Road has many examples of modified shorelines and the shoreline below Hwy 97 has many examples of informal camping or permanent residences on the shoreline. A more recent example was reported by residents as occurring at Crystal Waters where shorefront homes are being built in 20' long creosote-treated pilings (resident, pers. comm.). Reports of hot tubs and swimming pools being drained directly to the lake were also received at the March 25th LC open house. Avenues to encourage private correction of these invasions of the public trust should be considered.

Fortunately, there is no industrial land use and limited commercial land use on the periphery of southern Kalamalka Lake. Near-shore land use is dominated by: residential, tree fruit culture, parks/beaches, Hatikvah children's summer camp and T'ween Lakes RV campgrounds (Figure 3.1). There is a small sawmill-gravel pit complex called the Oyama Industrial Park but it is a kilometer away from the intake.

Like the storm water generated from residential properties, overland flow and seepage to ground can carry fertilizers, pesticides, pathogens, detergents and solvents from residential properties bordering the lake. The impact would be determined by the type volume and the location of the contaminant introduction. Lakeshore owners should be encouraged to preserve a shrub belt between their properties and the lake to intercept drainage. It is illegal to modify the natural shoreline because of its protective value and fisheries value. Best practices management of properties within the Intake Protection Zone is more important to the DLC intake than management of properties remote from the intake, but all are important.

Similarly, parks with lawn areas can also release fertilizers and pesticides to the lake via overland flow in storms or through seepage to groundwater. Washrooms should be connected to sewer or employ small holding facilities. The largest park in the vicinity of the intake is 4.7 ha Kaloya Park and its location on a narrow peninsula near the DLC intake makes proper septage management imperative. The smaller Pioneer Park is located on the shoreline between the pump-house and the intake. Its pit-style outhouse located 45 m from the shoreline has a holding tank that is a fully contained pump-out system.

Tree fruit culture is dependent on a number of sprays and in the past, these have included some very dangerous and currently banned substances including lead arsenate and DDT. The closest orchard is 40 m from Kalamalka Lake and approximately 26 hectares of the lake's western periphery are dedicated to tree fruits (Figure 3.1). Again, the risk posed by this agriculture is proportional to the amount of overland flow, seepage or drift of applied chemicals that reaches the lake and their fate there. Some agricultural chemicals are photo-degraded in lake water, others are persistent. Fertilizer and other soil amendments may also be required periodically. Excess irrigation will increase the subsurface flow reporting to the lake from these orchards. A green belt of riparian trees between the lake and the orchards would be an asset to the lake.

Overall the 10 ha Hatikvah children's summer camp is an asset to Kalamalka Lake. Unlike other forms of development, this camp has preserved the vast majority of its shoreline in pristine condition. Shoreline modification and development has been minimal. Camp Hatikvah is equipped with a tank/disposal field system for septage management. There are extensive grassed areas totaling 8.5 ha of which only a few acres are irrigated. They may donate fertilizer or pesticides to the lake. The seasonal use of this facility further reduces its potential impact.

T'ween Lakes Campground has been built on a former wetland; the water table can be expected to be high on the property. Infilling of the wetland is on-going to provide further boat storage.  Casual and semi-permanent RV camping is provided on its 1.4 hectares. Some of the trailers actually overhang the high water mark along a low retaining wall. The campground road network is gravel and rainfall infiltrates.  Septage from the campground washrooms and pump-out station is managed by a septic tank/disposal field that can be flooded and the system has been used while flooded. Since individual RV's have their own holding tanks, spills should be unlikely but are not impossible. A large dock and moorage slips in the Oyama Canal provide motor boat moorage and both contribute to the potential issues outlined in Sec. 3.1-4  A  small boat launch and re-fueling station (fed by a large fuel tank within 10 m of the shoreline) are located at the dock. Fuel storage is protected by a small enclosure with signage, but no other protective measures were apparent.

One gravel pit is located within 250 m of the lakeshore above Hwy 97 but is unlikely to impact the intake.  A second gravel development by Pier Mac Sand and Gravel on the East side is 500 m from the water but a 80 $m^2$ area has been cleared and leveled on the shore of Kalamalka Lake.

Much of the eastern shore of the lake is protected by the 3700 ha Kalamalka Lake Protected Area, however there are some large undeveloped lots opposite Kaloya Park. There is an old, active sawmill in that area located within 380 m of the lake in what is called Oyama Industrial Park. The extent of other industrial activities on this property is not known.  Should this property be re-developed, detailed impact studies would be needed. Typically, the land under these old sawmills is contaminated.

### 3.1.6 Vandalism

Deliberate spills into Okanagan lakes through ignorance or spite are recorded (Appendix1). For example, 20 gallon pails of hydraulic oil and motor oil were deliberately spilled into Okanagan Lake near Poplar Point in 2009, necessitating an expensive clean-up. While vandalism can be difficult to predict, obvious hazardous targets such as fuel storage or portable outhouses should be protected.  The risk of human activity to Kalamalka Lake is dependent upon the behavior of all Kalamalka Lake residents and users.

### 3.1.7 Open House Public Input

The views of the participants at the DLC open house on lake intakes can be summed up as restricting access.  They identified motor craft of all kinds, and run-off from local developed areas as their key areas of concern.  Many people thought that the water quality on Kalamalka Lake was excellent except for occasional late summer odor, but public confidence in the quality of Okanagan Lake water was lower.  Several people felt that basin-wide education on source protection and water conservation was important.

## 3.2 Natural Contaminants or Factors that Influence Susceptibility of Kalamalka Lake to Contamination

Not even pristine watersheds and lakes provide completely risk-free drinking water. Natural conditions in and near Kalamalka Lake also affect the water quality it provides. The most important of these are covered in this section.

### 3.2.1 Kalamalka Lake Marling

The annual marl events in Kalamalka Lake each summer curb algae production but they also increase turbidity. Turbidity attributable to marl exceeds 1 NTU for more than a month every summer and can reach 2 NTU. Even though this turbidity source is "clean" in the sense that it does not include pathogens, it can still interfere with disinfection.

### 3.2.2 Cyanobacteria in Kalamalka Lake and Imported from Wood Lake

While cyanobacteria densities in the DLC intake water never exceed the WHO and AWWA recommended guidelines, they still allow a chronic low dose exposure to cyanotoxins. Fortunately, one of the most likely cyanotoxins that can be produced by cyanobacteria in Kalamalka Lake is degraded by chlorine but at twice the dose required for disinfection and pH must be near neutral (Hitzfield et al., 2000). UV disinfection is also helpful but again, the UV dose to deactivate microcystins is greater than the dose for water disinfection (Hudnell (ed) 2007).

A larger but infrequent threat is posed by the surface cyanobacteria blooms that periodically develop on Wood Lake. These severe blooms are dominated by *Anabaena, Anacystis*, *Aphanizomenon, and Gomphosphaeria* (Larratt, 2009). *Anabaena, Anacystis and Aphanizomenon* produce a range of undesirable cyanotoxins (Table 2.5).

Severe blooms on Wood Lake are most common in May and November/December. These late fall blooms are unusual, but bloom densities were encountered in December 2006, 2007 and 2008. These very late blooms were probably triggered by the sharp increase in circulating nutrients after the overturn mixed bottom water into the entire water column. Near the Oyama canal, blue-green algae cells accumulate to dangerous levels in the fall based on a chlorophyll-a of 35 ug/L-2006, 10 ug/L-2007 and 2.6 ug/L-2008. (At 50 ug/L chlorophyll-a, the cell count approaches 100,000 cells/mL and cyanotoxicity is probable). The cyanobacteria density in the May 2008 exceeded 100,000 cells/mL where it accumulated along shorelines and that prompted IHA to post signs at beaches and MoE conducted sampling.

These blooms should become less frequent as the nutrient loading to Wood Lake diminishes with the conversion of septic systems to sewer connections. The importance of this program to the ecology of Wood Lake and Kalamalka Lake cannot be overstated.

### 3.2.3 Benthic Algae

No direct research has been completed on the algae that covers rocks on Kalamalka or Wood Lakes, however, a long-time resident reported to the March 25$^{th}$ open house that Wood Lake used to grow attached filamentous green algae and that has gradually shifted to a brown slime (probably diatoms) as the nutrient status of Wood Lake improves. Neither of these algae pose a toxin threat but both are an aesthetic concern.

### 3.2.4 Kalamalka Lake Protected Area – Wildlife

Wildlife are less likely to introduce pathogens to a watershed than humans and their domestic animals, but they can become infected and make an introduced pathogen endemic. The majority of the pathogens donated to watercourses were originally introduced by humans and their pets/domestic animals. Through travel people are exposed to a far wider range of pathogens than animals that live in one locale. Often pathogen and fecal indicator concentrations are higher in domestic animal feces than in wildlife feces (Cox et al, 2005).

Wildlife, particularly rodents, are known carriers of the protozoans *Cryptosporidium* and *Giardia*, and less frequently *Toxoplasma* is encountered. Other infections are possible and every effort should be made to prevent their introduction.

Wildlife that habituate the shoreline such as muskrat, pose the largest risk of shedding pathogens into Kalamalka Lake. Wildlife may contribute to *Cryptosporidium* contamination in the water but may not have major public health significance because they are generally infected with non-human-pathogenic species and genotypes (Feng et al., 2007). However, infectivity studies have demonstrated the potential for cross-transmission exists between rodents and cattle (Donskow et al., 2005). Rodents, because of their close proximity to humans and livestock, pose a potential threat as a maintenance reservoir for *Cryptosporidium* (Zeigler et al., 2007).

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### 3.3 SUMMARY MODULE 2: Contaminant Source Inventory Table

| Contaminant Source and Type | Owner/ Jurisdiction | Location | Distance to intake | Possible Contaminants | Contaminant Transport Mechanism | Comments |
|---|---|---|---|---|---|---|
| Inflows | | | | | | |
| Coldstream Creek plume | n/a | N 50.2243 W119.2636 | 14 km | nutrients bacteria viruses | currents seiches | Very dilute risk at intake |
| Kal-Wood Channel | n/a | N50.1117 W119.3821 | 740 m | nutrients pathogens cyanobacteria spills | currents seiches | Flow direction & volume varies |
| Creek E of Kayola Park | n/a | S of intake | 500 m | sediment nutrients pathogens | Currents | Creek inflow into isolated bay |
| Overland flow flooding | n/a | | | sediment pathogens fertilizers pesticides | currents | Only in storms; flooding rare |
| Sewage | | | | | | |
| Lift Station sewer mains | DLC | near pump-house | 500 m | sewage* | overland flow | Rare event; very high risk |
| Septic fields | various | | | septage* | Subsurface seepage | Very high risk; are being replaced |
| Storm Water | | | | | | |
| Hwy 97 | MoH | W of intake | 870 m | PAH salt pathogens accidental spills; | ditches seepage | Cl- , some PAH travel in seepage |
| Kelowna Pacific Railway | Knight Hawk Rail | W of intake | 680 m | PAH creosote accidental spills | overland flow subsurface | Within riparian area on W shore |
| Municipal storm water | DLC | Ditchs on Trask Rd; | <450 m | PAH salt bacteria nutrients pesticides | ditch seepage overland flow | Outfalls should not occur in IPZ |
| Motorboat | | | | | | |
| Motorboats | various | | | PAH | currents | Risk increasing |
| T'ween Lakes dock/moorage | private | N50.1124 W119.3832 | 730 m | PAH septage | Currents seiches | On-water fueling - tank 8 m from lk |
| Land Use | | | | | | |
| Kayola Park Pioneer Park | DLC | N 50.1124 W119.3832 | 730 m | fertilizers pesticides stored septage | Currents seiches | Shape of Kayola increases risk |
| Hatikvah summer camp | Jewish Society | N50.1149 W119.3767 | 220 m | pesticides fertilizers | Long-shore currents | Risk is minimal; sensitive land use |
| Residential | D.L.C. | | 360 m+ | fertilizers pesticides | Currents | Risk is significant along Trask Rd |
| T'ween Lakes Campground | private | SW of intake | 750 m | fuel storage RV septic storage fertilizers pesticides | Overland flow subsurface seepage | High water table; fuels, trailers within 8 m of lake |
| Orchards | various | W of intake | 700 m + | fertilizers pesticides PAHs fuels | Overland flow subsurface seepage | Historic pesticides may still be in subsurface |
| Natural | | | | | | |
| Kal Lake marl | BC | throughout lake | n/a | turbidity particulates | vertical transport | Can exceed 1 NTU |
| Cyanobacteria | BC | throughout | n/a | cyanotoxins | seiches | May, Nov/Dec |
| Reserve Park | MoTCA | E of intake | 1 km | wildlife pathogens | currents | Low risk |

**Pesticides** includes: herbicides, insecticides, fungicides, rodenticides, and avicides; Many pesticides are highly toxic and are mobile in sub-surface flows

**PAHs** includes: fuels, oil, grease, asphalt (auto wastes also include: transmission fluid, antifreeze, battery acid)

***Septage/sewage** includes: pathogens, organic matter, THM precursors, nitrates, nutrients, heavy metals, inorganic salts, pharmaceuticals, personal care products, cleaners, paints, medications, auto wastes, PAHs

**Pathogens** includes: bacteria, viruses, fungi, protozoan parasites

## 3.4 Summary MODULE 2: Hazard from Contaminants Identification Table

| Contaminant Source and Type | Possible Contaminants | Existing Preventative Measures and Barriers | Possible Preventative Measures and Barriers |
|---|---|---|---|
| Inflows | | | |
| Coldstream Creek plume | nutrients bacteria viruses | Location of Intake distant from creek plume, chlorination | Riparian restoration and better manure handling in Coldstream |
| Kal-Wood Channel | bacteria viruses cyanobacteria spills | Chlorination of supply | Install gauge to monitor direction of flow |
| Creek E of Kayola Park | sediment nutrients pathogens | Creek inflows to discrete bay, isolated from intake | Annual inspection of lower channel for damage activities |
| Overland flow | sediment pathogens fertilizers pesticides | Some riparian preservation, chlorination | Enhance riparian buffers |
| Sewage | | | |
| Lift Station | sewage | Alarms | Spill plan; overflow alarms SCADA, back up power genset |
| Septic Fields | septage | Fields are being replaced | Educate field users on contaminants (esp Tween Lks) |
| Storm Water | | | |
| Hwy 97 | PAH salt accidental spills; | Ditch collection | Replace outfall(s) with infiltration basins, green belts |
| Kelowna Pacific Rail | PAH creosote accidental spills | Spill procedures may be in place | Restrict materials hauled or deactivate and rehabilitate |
| Municipal storm water | PAH salt bacteria nutrients | Some storm water plans are completed for Oyama area | Public education to limit pesticides, fertilizers |
| Motorboat | | | |
| Motorboats | PAH | None | Small number = small risk |
| T'ween Lakes dock/moorage | PAH RV septage ; boat septage | Minimal | Relocate fuel storage and trailers from shoreline, camper education; spill kit on hand |
| Land Use | | | |
| Parks: Kayola Pioneer | fertilizers pesticides stored septage | Restrictions on pesticide use; chlorination of supply | Eliminate use; riparian buffers |
| Hatikvah summer camp | pesticides fertilizers | Use not known, riparian buffer intact in most of the property | Eliminate use; riparian buffers |
| Residential | fertilizers pesticides | Increasing education on dangers | Eliminate use; riparian buffers |
| Tween Lakes Campground | fuel storage RV septic storage fertilizers pesticides | No barriers; fuel tank within 8 m of shoreline | Eliminate use of hazardous materials; riparian buffers proper fuel storage precautions |
| Orchard(s) | fertilizers pesticides PAH's, fuels | None known | Restrict use to biodegradable materials; secure storage |
| Natural | | | |
| Kal Lake marl | turbidity particulates | Particulate monitoring | None possible |
| Cyanobacteria | cyanotoxins | Monthly and emergency monitoring in place | Continue with sewer system; limit nutrient sources |
| Flooding | fertilizers pesticides | Control structure | Automatic lake level monitoring |
| Reserve Park | wildlife pathogens | Riparian Preservation | Riparian Preservation |

**Pesticides** includes: herbicides, insectides, fungicides, rodenticides, and avicides; Many pesticides are highly toxic and are mobile in sub-surface flows
**PAHs** includes: fuels, oil, grease, asphalt (auto wastes also include: transmission fluid, antifreeze, battery acid)
**Sewage** includes: pathogens, organic matter, nitrates, heavy metals, inorganic salts, personal care products cleaners, paints, medications, auto wastes, PAHs
**Pathogens** includes: bacteria, viruses, fungi, protozoan parasites

# 4.0 Kalamalka Lk Intake Module 7: Risk Characterization and Analysis

The intent of Module 7 is to connect the contaminant hazards identified in Modules 1 and 2 with an evaluation of the existing source protection and water treatment barriers. The focus of this report is on the Kalamalka Lake water source itself. Module 7 uses the following set of tables to assign risk.

**Table 4.1: IHA Module 7 Hazard and Risk Tables**

**Qualitative Measures of Hazard**

| Level of Risk | Descriptor | Description | Probability of occurrence within next 10 years |
|---|---|---|---|
| A | Almost certain | Is expected to occur in most circumstances | >90% |
| B | Likely | Will probably occur in most circumstances | 71-90% |
| C | Possible | Will probably occur at some time | 31-70% |
| D | Unlikely | Could occur at some time | 10-30% |
| E | Rare | May only occur in exceptional circumstances | <10% |

**Qualitative Measures of Consequence**

| Level | Descriptor | Description |
|---|---|---|
| **1** | Insignificant | Insignificant impact, no illness, little disruption to normal operation, little or no increase in operating cost |
| **2** | Minor | Minor impact for small population, mild illness moderately likely, some manageable operation disruption, small increase in operating costs |
| **3** | Moderate | Minor impact for large population, mild to moderate illness probable, significant modifications to normal operation but manageable, operating costs increase, increased monitoring |
| **4** | Major | Major impact for small populations, severe illness probable, systems significantly compromised and abnormal operation if at all, high level of monitoring required |
| **5** | Catastrophic | Major impact for large population, severe illness probable, complete failure of systems |

**Qualitative Risk Analysis Matrix**

| **Likelihood** | **Consequences** | | | | |
|---|---|---|---|---|---|
| | **1 Insignificant** | **2 Minor** | **3 Moderate** | **4 Major** | **5 Catastrophic** |
| **A** almost certain | Moderate | High | Very High | Very High | Very High |
| **B** likely | Moderate | High | High | Very High | Very High |
| **C** possible | Low | Moderate | High | Very High | Very High |
| **D** unlikely | Low | Low | Moderate | High | Very High |
| **E** rare | Low | Low | Moderate | High | High |

## Risk Characterization and Analysis

The immediacy of the Kalamalka intake makes it vulnerable to contamination. The risks within the intake protection zone (IPZ) are generally higher than the risks presented by the same hazard occurring outside the IPZ. Tables 4.2 and 4.3 summarize the hazards and assign a risk level based on likelihood and consequence of each hazard, along with existing and proposed improvements to the barrier(s) guarding the DLC Oyama system fed by the Kalamalka Lake Intake. For ease of assessment, the hazards have been grouped as physical, chemical, biological and water system risks. An overview of the protective barriers is presented in the SWOT analysis found in Table 4.4.

**Physical Risks** The physical risks presented by Kalamalka Lake include inflows that can carry contaminants, transport of contaminants within the lake and re-suspension of settled contaminants.

**Chemical Risks** Naturally occurring chemical risks to Kalamalka Lake and the water system involve the marl events that both protect the lake and increase turbidity. Inevitable anthropogenic risks are caused by: storm water, septage and PAHs. Preventable anthropogenic risks include pesticides, fertilizers, manure and accidental spills. Hopefully increasing societal awareness will continue to diminish the risk presented by these chemicals. The most catastrophic human impact on DLC's intake is fortunately extremely unlikely and that is a spill of sewage or toxic chemical within the IPZ.

**Biological Risks** The naturally occurring biological risks to the intake occur throughout Kalamalka Lake and they involve algae blooms and cyanobacterial blooms. These naturally occurring threats are exacerbated by human activities that add nutrients to the lake system. Pathogens are also naturally occurring, but human travel has greatly increased the range of pathogens and their frequency in the Okanagan region.

**Water System Risks** After water from the 22 m depth in Kalamalka Lake enters the Oyama system, it is chlorinated and monitored. All distribution systems are subject to aging, settling of suspended materials, or accidental line breaks. On-going maintenance, repairs and monitoring are vital to any water distribution system. Because this system was constructed in 1995/6 and is relatively new, repairs are minimal. An emergency response plan aids in providing an appropriate and swift response to an emergency.

**Risk Characterization Table: MODULE 7 Part 1: Risks Within Intake Protection Zone**

**Table 4.2 Risks Inside Intake Protection Zone (IPZ) with the Potential to Impact the DLC Kalamalka Intake**

| Drinking Water Hazard | Likelihood Level | Consequence Level | Risk Level | Comments/ Assumptions |
|---|---|---|---|---|
| **Physical** | | | | |
| 1 Sediment re-suspension | **A** | **1** | Mod | Common during seiches; no *E. coli* found in sediment under intake |
| 2 Flooding and subsurface inflow | **D** | **3** | Mod | Kal Lk control structure prevents flooding; subsurface flow more probable |
| 3 Adjacent land use impacts | **A** | **2** | High | Building/storing materials below high water line should be corrected |
| **Chemical** | | | | |
| 4 Natural marl event in summer | **A** | **2** | High | Turbidity will exceed 1 NTU at intake after summer marl event |
| 5 Storm water plume to intake | **C** | **3** | High | Storm water carries many contaminants, no outfalls should occur in IPZ |
| 6 Septage / sewage spill to intake | **E** | **4** | High | Unlikely event but major impact expected when spill occurs within IPZ |
| 7 Hydrocarbons PAHs spill | **D** | **3** | Mod | Unlikely event with moderate impact expected when spill occurs within IPZ |
| 8 THM precursors >0.10 mg/L | **D** | **3** | Mod | All results to date are less than 0.100 mg/L T-THM |
| 9 Heavy Metals (from sediments) | **C** | **2** | Mod | Rototilling or seiche disturbance can release metals to lake water |
| 10 Pesticides (overland /seepage) | **D** | **3** | Mod | Toxicity and persistence of pesticides varies; no storage within IPZ rec'd |
| 11 Fertilizers (overland / seepage) | **C** | **2** | Mod | Localized algae bloom may result, trace metal contamination is possible |
| 12 Accidental spills (rail, boats, homes) | **E** | **4** | High | Depending on spill location and type, emergency response may be needed |
| **Biological** | | | | |
| 13 Algae blooms | **A** | **2** | High | Algae increase TOC, THM precursors, odor, chlorine consumption |
| 14 Cyanobacteria blooms | **B** | **2** | High | Chronic low-dose exposure to cyanotoxins >2000 cells/mL undesirable |
| 15 Viruses- pathogenic | **D** | **3** | Mod | Protect IPZ from septage or boater holding tank spill. Viruses do not settle |
| 16 Bacteria- pathogenic | **D** | **3** | Mod | Protect IPZ from septage or boater holding tank spill. Bacteria slow to settle |
| 17 Protozoa – pathogenic | **E** | **4** | High | Protozoan cysts > 5 microns will settle in calm conditions |
| **Water System** | | | | |
| 18 Physical system failure | **E** | **3** | Mod | Disruption of service probable; may have break/spill reach the lake with Cl |
| 19 Treatment / Monitoring failure | **E** | **3** | Mod | Water quality advisory probable |
| 20 Emergency response plan failure | **B** | **3** | High | No formal Emergency Response Plan is in place; DLC relies on skill of operators to handle and notify appropriate authorities |

**Table 4.3: Risks Outside the Intake Protection Zone (IPZ) with the Potential to Impact the DLC Kalamalka Intake**

| Drinking Water Hazard | Likelihood Level | Consequence Level | Risk Level | Comments/ Assumptions |
|---|---|---|---|---|
| **Physical** | | | | |
| 21 Creek Plumes | **C** | **2** | Mod | Coldstream Creek is 14 km away; Kayola Ck is very small and seasonal |
| 22 Adjacent land use impacts | **A** | **1** | Mod | All Okanagan residents must recognize their responsibility |
| 23 Oyama Canal inflows | **A** | **2** | High | Greater risk of seiche transport of cyanobacteria to the intake in spring/fall |
| 24 Sediment re-suspension | **A** | **1** | Mod | Sediment re-suspension is common but exerts minor impact |
| 25 Flooding / subsurface inflow | **D** | **2** | Low | Flooding, subsurface inflow remote from IPZ is unlikely to exert impact |
| **Chemical** | | | | |
| 26 Natural summer marl event | **A** | **2** | High | Turbidity will exceed 1 NTU at intake after summer marl event |
| 27 Storm water plume to intake | **C** | **2** | Mod | Current transport of storm-water packet to the intake is possible |
| 28 Septage and sewage spill | **C** | **3** | High | Seepage from Tween Lakes would be diluted with pathogen deactivation |
| 29 Hydrocarbons PAHs spill | **C** | **2** | Mod | Fuel tank at Tween Lakes should be relocated; on-water fueling protected |
| 30 THM precursors | **D** | **2** | Low | All results to date are less than 0.100 mg/L T-THM |
| 31 Heavy Metals (from sediments) | **C** | **1** | Low | Sediment disturbance outside IPZ unlike to create measurable impact |
| 32 Pesticides (overland or seepage) | **D** | **2** | Low | Toxicity and persistence of pesticides varies; orchards may donate these |
| 33 Fertilizers (overland or seepage) | **C** | **1** | Low | Large nutrient inflows could increase the algae production of Kal Lake |
| 34 Spills (Hwy 97 railway) | **D** | **4** | High | Depending on contaminant spilled, emergency clean-up needed ASAP |
| **Biological** | | | | |
| 35 Algae blooms | **A** | **1** | Mod | Algae blooms can be transported around lake by currents |
| 36 Cyanobacteria blooms | **C** | **2** | Mod | Concentrated cyanobacteria may travel in from Wood Lake with seiche |
| 37 Viruses – pathogenic | **D** | **2** | Low | Low volume of viral introduction unlikely to impact intake |
| 38 Bacteria- pathogenic | **C** | **2** | Mod | Bacteria can be deactivated or consumed as they travel in lake water |
| 39 Protozoa- pathogenic | **E** | **3** | Mod | Vertical settling of 1 m/day - transport of cysts from N end is unlikely |
| **Water System** | | | | |
| 40 Physical system failure | **E** | **3** | Mod | Disruption of service probable to small population |
| 41 Treatment / monitoring failure | **E** | **2** | Low | Water quality advisory probable |
| 42 Emerg. response plan failure | **B** | **2** | High | No formal Emergency Response Plan is in place |

### 4.1 Condition of Source
Kalamalka Lake provides excellent quality drinking water with no color, moderate hardness, and very rare taste and odor events. Kalamalka Lake is not under the control of the District of Lake Country, but water quality relies on every user of the resource. Moderate population densities and the absence of industrial uses has helped restrict the range of potential contaminants that can reach Kalamalka Lake. Oyama Creek water system represents an alternate supply in the unlikely event that Kalamalka Lake becomes contaminated.

### 4.2 Physical Integrity of Intake, Treatment and Distribution System
The Kalamalka Lake intake was completed in 1995/6 and serves 307 domestic connections and 339 acres of irrigated land. The distribution system is robust and needs little maintenance. Upgrades to the system are performed based on priority. In 2006, the pumps at the Kalamalka Lake pump house were re-packed and new hypo lines were installed. In 2007, the 50 hp pump was removed and rebuilt and the other pumps maintained.

End-of-line low chlorine residuals were resolved with flushing to restore residuals. High iron “color” clears out of the mains during high velocity flushing despite the low iron concentrations in Kalamalka Lake water.

Maintenance involves draining cleaning and chlorine- shocking balancing reservoirs, proactive line flushing, connection checks, etc. DLC employs full-time operators with Level I and Level II training and the water manager has Water Distribution Level III. Operators have additional certifications and receive on-going training from DLC (Meger et al., 2006, 2007).

### 4.3 Risk Assessment for Healthy and Health-compromised Individuals
On the whole, water quality from Kalamalka Lake is enviable and meets the needs of healthy individuals. People with compromised immune systems could profit from another pathogen barrier such as UV disinfection or boiling their drinking water. One area of concern would be the chronic low dose exposure to cyanotoxins for people battling cancer, those with neurological conditions or those with hepatic/renal conditions. Based on in-place monitoring of pathogens and THMs the risk posed by these materials is below the guidelines that themselves usually have a ten-fold safety margin built into them.

### 4.4 Strength/Weakness Opportunities/Threats [SWOT] Analysis

A SWOT analysis provides a summary overview of the balance between the major positive and negative aspects of the DLC Kalamalka Lake Intake as identified in Module 7. Only those aspects with the greatest potential to influence DLC water quality at present and into the future are considered in Table 4.4.

**Table 4.4: Strength/Weakness Opportunities/Threats Analysis Summary of the DLC Kalamalka Lake Intake**

| Strengths | Weaknesses |
|---|---|
| ▪ The large size and depth of oligotrophic Kalamalka Lake helps maintains constant water quality<br>▪ Low concentrations of cyanobacteria most of the year;<br>▪ Urban areas are not close to the intake; land use near IPZ is low-intensity<br>▪ SCADA system includes turbidity (under repair) temperature, free Cl, low wet well etc.<br>▪ Water operators have appropriate training levels and training is on-going<br>▪ Appropriate IHA directed water quality monitoring is reported<br>▪ Alternate supply in Oyama Creek<br>▪ Dedicated DLC staff and council<br>▪ Co-ordination of Kal Lk study between DLC GVWU and MoE, IHA, OBWB<br>▪ Ongoing replacement of septic with sewer esp. important on near-lake properties<br>▪ FIM Foreshore Inventory mapping and SHIM Sensitive Habitat Inventory Mapping are underway for Kal Lk and Coldstream Ck | ▪ The 22 m depth of the intake provides some protection from surface contaminants but seiches regularly deliver surface water to the intake depth in the spring and fall<br>▪ Natural turbidity caused by the marl precipitation interferes with disinfection and deposits in water mains<br>▪ Lack of DLC and GVW control over Kalamalka Lake and adjacent land use<br>▪ Highly inappropriate storage and construction on Riparian Area, particularly T'ween Lakes Resort (including fuel, septic)<br>▪ Lack of DLC control over materials hauled on rail line and Hwy 97<br>▪ Recreational and land development pressures on Wood-Kalamalka Lakes are increasing<br>▪ Small number of connections (307) limits available funds for system improvements<br>▪ Second disinfection barrier not in place |
| **Opportunities** | **Threats** |
| ▪ Apply for License of Occupation over Intake Protection Zone from ILMB<br>▪ Enter into discussions with rail line on chemicals hauled<br>▪ Install raw water sample line on intake<br>▪ Establish no-build, no-disturb setback bylaw for foreshore protection from future development based on 1-100yr storm<br>▪ Develop storm water master plan – relocate untreated storm water from IPZ<br>▪ Funding from grants are available<br>▪ Public Education about Kal Lk as a water source<br>▪ Develop emergency response plan<br>▪ UV disinfection would be effective on this high-quality water<br>▪ Extending the Intake to 30 m would provide better water quality and be more remote from sources of contamination | ▪ Cyanobacteria counts exceeded 2000 cells/mL in the spring and may be increasing with climate change<br>▪ Wood Lake surface cyanobacterial blooms<br>▪ Increasing population pressures for lake recreation, particularly motorized craft<br>▪ Full inventory of storm water outfalls in IPZ is not known<br>▪ Impact of remaining septic systems is not known<br>▪ Inadequate enforcement of recreation polluters and foreshore violations |

# 5.0 Kalamalka Lake Intake Module 8: Recommendations

The summation of Modules 1, 2 and 7 lead to the recommendations to improve DLC Kalamalka Lake Intake – Oyama Water System presented here as Module 8. This section presents three action plans addressing; source protection, the existing water treatment system, and finally future large expenditure system improvements. The hazards from Table 4.2 and 4.3 addressed by each recommendation are shown in the Risk box attached to each recommendation below.

## 5.1 Source Protection Action Plan

The only items worth placing into a source protection action plan are those that can be realistically achieved both from a financial and practical standpoint. Improvements that provide the best cost-benefit for risk reduction are itemized below. Additional protection measures intended to protect unimpaired areas are also provided.

5.1-1 Protect Intake Protection Zone (IPZ)

| Risk | Action | Who? | Cost | Timeframe | Outcome |
|---|---|---|---|---|---|
| 3 4 6 12 7 | Apply for License of Occupation for IPZ | DLC apply to ILMB | Staff time | 2010 | Stronger source water protection |

As the License Holder/Owner of a Drinking Water Intake, DLC could apply to Integrated Land Management Bureau (ILMB) through Front Counter BC for a License of Occupation over the Intake Protection Zone. This License would pre-empt or place limits on future developments (e.g. marinas, house boat moorage) and proposed adjacent uses would be flagged for DLC comment. The License would be in addition to the W1-recreation and W2-marina restrictions in place now. Sections 878 (planning OCP) and 938 (storm water engineering bylaw) of the Local Government Act may also be relevant. The IPZ could be added to the Official Community Plan (OCP) for DLC and that would give the intake further protection.

5.1.2 Bylaw to protect Kalamalka Lake Foreshore

| Risk | Action | Who? | Cost | Timeframe | Outcome |
|---|---|---|---|---|---|
| 2 3 23 21 | Develop foreshore bylaws | DLC | Staff time | 2010 | Kal Lk protection |

The DLC land use planning department has Environmental Development Permit areas in place to protect the foreshore but could also could use other jurisdiction's foreshore policies to draft enforceable (no-build, no-disturb) set-backs from the high water mark and a pesticide ban on lakeshore properties. There are serious examples of private intrusion on Southern Kalamalka Lake foreshore including in-filling, retaining walls, building cabins on piles over the water and inappropriate storage of fuel and landscaping materials near the high water mark. Assist adjacent owners with dismantling structures removing risks, correcting septic problems especially at T'ween Lakes Campground. Sections 878 (planning OCP) and 938 (storm water engineering bylaw) of the Local G overnment Act may also be relevant.

Suggested Buffers 10 m no-build no disturb
15-30 m retain natural vegetation (follow Riparian Areas Regulations)
100 m restrict disturbance; septic storage or disposal
300 m restrict development

### 5.1.3 Storm Water Outfall Exclusion/Improvement

| Risk | Action | Who? | Cost | Timeframe | Outcome |
|---|---|---|---|---|---|
| 5 10<br>11 7 | Exclude storm water outfalls from IPZ | DLC staff and council | unknown | Commence in 2010 | Prevent SW contaminants from reaching IPZ |

Ideally no known storm water outfalls should discharge within the intake protection zone or within two hour's transport during maximum current velocity, whichever is greater. The DLC may need to map the storm water facilities adjacent to the IPZ; currently no outfalls are known in the Trask Road area (e.g. The Kaloya Park parking lot run-off should be directed to swales before it reaches the lake)

### 5.1.4 Storm Water Master Planning

| Risk | Action | Who? | Cost | Timeframe | Outcome |
|---|---|---|---|---|---|
| 5 10<br>11 7 | Staff conference | DLC water & planning staff | Staff time and SWMP | On-going | Position infrastructure to protect DLC intake |

If it is not available, a storm water master plan that would identify all storm water outfalls to Kalamalka Lake is needed. Outfalls within the IPZ (if any) should be replaced with soak-away zones, swales etc. first, followed by the replacement of storm water outfalls outside the IPZ.

### 5.1.5 Mitigate Potential for Sewage/Septage Spill near DLC Pumphouse

| Risk | Action | Who? | Cost | Timeframe | Outcome |
|---|---|---|---|---|---|
| 6 12<br>15 16 | Eng. review of lift stn and Amry tmt field | DLC water & Eng. staff | Staff time | Commence in 2010 | Consider need for back-up power for lift station |

Consideration should be given to providing back-up power to the DLC lift station given its proximity to the Kalamalka Lk wet well. Appropriate containment strategies should be included in the Emergency Response Plan.

### 5.1.6 Public Education

| Risk | Action | Who? | Cost | Timeframe | Outcome |
|---|---|---|---|---|---|
| 3 12<br>7 15 | Continue public education on Kal Lk | DLC and NGO, MoE | low | On-going | Better voluntary control of contaminants to Kal Lk |

Public education through open houses, e-mailings, bill stuffers and other initiatives can help encourage responsible public behaviour and is key to preserving Kalamalka Lake water quality. The newly-formed Society for the Protection of Kalamalka Lake (SPKL) is an example of a focussed, well-organized group that DLC could co-operate with. OBWB provides basin-wide education through their Water Wise program. DLC and OBWB could co-operate to get intake protection better understood by local residents. Signage including maps of the Intake and the IPZ could be posted at parks and boat launches to remind residents that Kalamalka Lake is a drinking water supply.

### 5.1.7 Annual Overview of Changes to South Kalamalka Lake

| Risk | Action | Who? | Cost | Timeframe | Outcome |
|---|---|---|---|---|---|
| 3 12 | 1 day survey, update | DLC | Staff time | annual | Knowledge of changes |

A brief annual survey of South Kalamalka Lake from a boat and an update from the planning department would allow an annual overview of changes to the lake and adjacent land use that have the potential to impact water quality at the intake. They can base their observations on the FIM work completed by Ecoscape, 2010.

5.1.8 Maintain Kalamalka Protected Area

| Risk | Action | Who? | Cost | Timeframe | Outcome |
|---|---|---|---|---|---|
| 3 13 | Maintain park status | Prov of BC | None to LC | On-going | Shoreline protection |

District of Lake Country should petition the Province to encourage the Protected Area's status as a natural park and to encourage a zero-tolerance policy to recreational or land development activities within its boundaries that have the potential to adversely impact water quality.

5.1.9 Discussions with Railway on Goods Transported

| Risk | Action | Who? | Cost | Timeframe | Outcome |
|---|---|---|---|---|---|
| 12 7 5 | Find what railway carries and when | DLC rail line leasee | Staff time | 2010 | Better risk abatement |

DLC should open discussions with Knighthawk Rail on what they carry on the line paralleling Kalamalka Lake shoreline. There may be opportunity to limit what is carried or have the appropriate spill containment measures provided to DLC.

## 5.2 Water Treatment and System Protection Plan

Preventative measures and corrective action for critical hazards to the Kalamalka Lake Intake - Oyama water system are laid out in this section.

5.2-1 Raw Water Sample Line

| Risk | Action | Who? | Cost | Timeframe | Outcome |
|---|---|---|---|---|---|
| 15 16 17 | Replace raw water line | DLC | $15,000 | 2010 | Compliance with IHA filtration deferral |

DLC needs a raw water sample line on the intake for accurate raw water bacteriological sampling and to meet IHA's filtration deferral requirements. It would also allow DLC to not post a Water Quality Advisory when turbidity exceeds 1 NTU provided bacterial counts are acceptable. The intake was originally equipped with this line but it has since failed.

5.2.2 All Hazards Emergency Response Plan

| Risk | Action | Who? | Cost | Timeframe | Outcome |
|---|---|---|---|---|---|
| 18 19 20 | Plan preparation | DLC student | wages | Start in 2010 | Better reaction to emerg. |

Lake Country needs an All Hazards Emergency Response Plan. The plan should include emergency contact numbers, steps to follow, agencies to notify, protocols to follow for public notice, etc. This could be prepared by a Water Quality Tech. summer student using the GVW plan as a guide.

5.2.3 Improve SCADA system

| Risk | Action | Who? | Cost | Timeframe | Outcome |
|---|---|---|---|---|---|
| 19 | DLC | DLC | 7000 | 2011 | Better data, responses |

The Kalamalka Pump-house SCADA system could be upgraded to include continuous temperature (and possibly pH) as well as turbidity monitoring. These SCADA systems are robust. Water temperature will show the correlation between seiches and turbidity. On-line continuous monitoring of turbidity will fulfill IHA's filtration deferral criteria and provide data on all turbidity events. This monitoring will also demonstrate the correlation between marling and turbidity exceeding 1 NTU in a 30 day period during late summer (with UV and chlorine disinfection, GVW is allowed to reach 3.5 NTU without calling a water quality advisory). Currently, monthly turbidity reports are sent to IHA.

### 5.2.4 THM sampling

| Risk | Action | Who? | Cost | Timeframe | Outcome |
|---|---|---|---|---|---|
| 8 18 | Increased THM sampling | DLC | 112.5/sample 225 THM pot | 2010 | Compliance with IHA filtration deferral |

Seasonal THM samples should be collected for three years and then dropped down to once annually during the season when the highest total THMs are expected: Spring, Summer and Fall THM samples should be collected from a location furthest from treatment. (Alternately a sample could be collected during a bloom and chlorinated to normal DLC concentrations and allowed to stand for 7 days in a THM-potential test. (This sampling is expected to meet all criteria i.e. generate a good news outcome.) Additionally THM-potential tests could be added to 20 30 and 40 m for 2010 only.

### 5.2.5 Enhanced water quality sampling at Intake and System

| Risk | Action | Who? | Cost | Timeframe | Outcome |
|---|---|---|---|---|---|
| 19 | More WQ sampling | DLC | (see below) Approx4100.00 | 2010 | Compliance with IHA filtration deferral |

Upgrade current routine sampling to include:
Yearly, schedule A comprehensive ($ 148.00)
Quarterly T-THM ($112.50)
Monthly – protozoa *Cryptosporidium* and *Giardia* (may not need to continue this sampling intensity indefinitely, based on results) $181.90 (MB Labs Richmond 279-0666) (required for filtration deferral but under review, test not fully reliable)
Bi-weekly – alkalinity ($11.70) hardness (in-house), TOC ($36.00)
Weekly - true color ($7.20), UV transmissivity ($10.80) Total & E. coli (25.00)
as per the IHA Filtration Deferral Guidelines - Costs from Caro Labs, Kelowna

| Risk | Action | Who? | Cost | Timeframe | Outcome |
|---|---|---|---|---|---|
| 6 28 | Monitoring of high risk activities | Owner | unknown | 2010 | Leads to corrective action e.g. sewer hook-up |

There is significant risk posed by the T'ween Lakes septic system that is prone to flooding and will report to Kalamalka Lk and the Amry private system on Trask Road that is apparently not dealing with nitrates adequately. Amry has indicated that they will be discontinuing the use of this system. In both cases, the owners should embark on further monitoring and research alternatives, possibly with help from Lake Country and IHA staff.

## 5.3 Future Large Expenditure Improvements to Lake Country System

This final section of recommendations covers the large expenditure items that require extensive preparation and planning.

### 5.3.1 Intake Extension

When all measured physical, chemical and biological parameters are considered, from 2000 to present, the advantages of a 30 m intake extension from the current 22 m intake are:

- Reduced seiche impact, transport of surface contaminants
- Maximum temperature deviation during a seiche would be lowered to <4 – 6 $^{o}$C
- Lower overall water temperature
- Lower turbidity (range in 2008 = 0.1 – 0.7 NTU vs 0.6 – 0.8 NTU at 22 m)
- Lower transmissivity during fall overturn
- Lower algae production (range of chlor-a in 2008 = 1.2 – 2.4 ug/L vs 1.1 – 4.1 ug/L at 22 m)
- Lower total coliforms and possibly pathogens
- Lower pH (range in 2008 = 7.6 – 7.9 versus 7.8 – 8.0 at 20 m)
- A theoretically lower risk of contaminants from land-based activities or Wood Lake input
- Smaller IPZ because lake currents travel slower at 30 m
- Opportunity to give intake better clearance from substrate (minimum 3 m vertically above substrate)

Further water quality improvement would result from extending the intake to 40 m depth and samples will be collected on 6 occasions in 2010. Quantifiable water quality changes are summarized in Table 5.3.

**Table 5.3: Water Quality Change with Current and Extended Intakes - 2009**

| Kalamalka Lake | South 20 m | South 30 m | South 40 m |
|---|---|---|---|
| Distance to pumphouse m | 550 | 755 | 1810 |
| # of seiches exceeding 2 $^{o}$C/yr | 12 | 10 | 4 |
| Max seiche temp.fluctuation $^{o}$C | 10.1 | 5.3 | 2.9 |
| Total organic carbon mg/L | 5.6 | 5.8 | |
| Chlorophyll-a ug/L | 2.7 | 2.3 | |
| Turbidity NTU (IHA limit =1) | 0.75 | 0.44 | |
| UV Transmissivity % | 91.2 | 91.1 | |
| Avg algae counts (cells/mL) | 2402 | 1920 | |

The largest disadvantage to extended intakes is their cost of installation. The distances to a 40 m depth are large, but the distance to 30 m depth for DLC is only 205 m.

| Kalamalka Lake | N end | S end |
|---|---|---|
| Intake extension to 30 m | 553 m | 205 m |
| Intake extension to 40 m | 1510 m | 1175 m |

(minimum distance to proposed intake depth; engineered location may vary slightly)

There is a substantial reduction of risk resulting from an increase in the depth of the intakes (Hayco, 2000). The area that can contribute contaminants to an intake shrinks as the intake depth increases and the Intake Protection Zone would also shrink.

### 5.3.2 Addition of UV Disinfection

The IHA Filtration Deferral document calls for another method of disinfection in addition to chlorination. UV disinfection would be appropriate because the UV transmissivities measured thus far have all been in the acceptable range for UV disinfection. UV-based systems adapt well to small water systems and are cost-effective. The system used by GVW for their Kalamalka Lake Intake could be reviewed for efficiency and costs. With UV and chlorine disinfection, GVW is allowed to reach 3.5 NTU without calling a water quality advisory. UV treatment may also help deactivate several cyanotoxins.

### 5.3.3 Additional Recommendations

Continuing with the replacement of septic fields within 200 m of Kalamalka and Wood Lakes is vital to the long-term health of these important water bodies.

## Overview of Kalamalka Lake Intakes, their Depth and Influences

**The first two columns provide the depths of the Large Kalamalka intakes by sub-basin**
**The last four columns demonstrate the approximate thermal, pathogen, cyanobacterialand turbidity risks as intake depth changes**

| South sub-basin | North Arm | Depth (m) | Thermal Zones | Risk of pathogen | Cyano-bacteria | Turbidity |
|---|---|---|---|---|---|---|
| | | 1 | warm | highest risk | high risk | |
| | | 2 | surface | | of surface | turbidity >1 |
| | | 3 | water | high risk for | cyanobacteria | in freshet |
| | | 4 | | surface water | | and marl |
| | o East GVW Kal | 5 | | contamination | | events |
| | | 6 | | | lower risk | |
| | | 7 | | | of surface | |
| | | 8 | | moderate risk | cyanotoxins | |
| | | 9 | | for surface | | |
| | | 10 | | water layer | | |
| | | 11 | summer | contamination | | |
| | | 12 | thermocline | | | average |
| | | 13 | zone | | significant | turbidity |
| | | 14 | | | growth of | 0.75 - 1 NTU |
| | | 15 | | contamination | low light | |
| | | 16 | active seiches | risk is lower | cyanobacteria | |
| | | 17 | (two per week) | below the | | |
| | | 18 | | thermocline | | |
| | | 19 | 15°C guideline exceeded above this depth | | | |
| | | 20 | | | | |
| | o North GVW Kal | 21 | | | | |
| o DLC South Kal | | 22 | | | | avg turbidity |
| | | 23 | seiches | | | 0.75 NTU |
| | | 24 | diminish | | lower riisk | |
| | | 25 | 5 - 10 °C | | of | |
| | | 26 | temp range | | cyanotoxins | |
| | | 27 | (10-12/yr) | | | |
| | | 28 | | | | |
| | | 29 | | | | |
| | | 30 | | low risk | | |
| | | 31 | | of pathogens | | |
| | | 32 | | | | |
| | | 33 | | | | |
| | | 34 | seiches | | low risk | >30 m |
| | | 35 | diminish | | of cyanotoxins | best range |
| | | 36 | 4 -10 °C | | | to avoid |
| | | 37 | temp range | | | turbidity |
| | | 38 | (4-10/yr) | | | |
| | | 39 | | | | |
| | | 40 | | | | |
| | | 41 | | very low | | |
| | | 42 | low seiche | risk | best range | |
| | | 43 | risk temp | of pathogens | for intakes | |
| | | 44 | range <5°C | | to avoid | |
| | | 45 | (1-4/yr) | | cyanobacteria | |
| | | 46 | | | | |
| | | 47 | | maximum depth for divers | | |
| | | 48 | | | | |
| | | 49 | | | | |
| | | 50 | | | | |
| | | | minimal | | low riisk | |
| | | 60 | seiche | | of | |
| | | | penetrations | | cyanotoxins | |
| | | 70 | | | | |
| | | | | | | re-suspension |
| | | 80 | | suspended | high risk of | very high |
| | | >>> | | detritus | benthic cyanob | turbidity spikes |

COMMENTS: The thermal, pathogen and cyanobacterial risks depicted in this chart are generalized;
every intake is affected by sub-basin and location ( proximity to creek plumes, outfalls, storm water etc.)

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**NEWS**

▼ POPLAR POINT JULY 15 2009

# Waste oil dumped into Okanagan Lake

The Kelowna Fire Department was called early Monday morning to respond to an apparent oil spill in the city's north end.

The oil spill was first spotted at 7:30 a.m. at the Poplar Point area of Okanagan Lake.

On arrival of the initial response crew, the fire department discovered that vandals had taken oil containers and spilled the contents on a barge and in the water around the barge.

With the assistance of the fire department and the Marine Rescue spill response trailer, oil booms and spill pads were distributed along the 200-foot area of the shoreline.

The provincial ministry of environment and the RCMP were also alerted.

Assistant fire chief Bryan Collier said it appears that 20 litre pails of hydraulic oil and motor oil were taken to the area and dumped.

AUG 15 2009

# Sewage leaks into lake

**Raw sewage has leaked into Okanagan Lake at the Westbank Yacht Club boat launch on Gellatly Road in West Kelowna.**

The leak occurred Friday morning during a downpour. 1487

CORD spokesman Chris Radford said that surface water deluged a manhole, causing it to overflow at 9 a.m. Aug. 14. Runoff into Okanagan Lake continued for approximately 45 minutes. "It was a combination of raw sewage and storm water," said Radford.

As a result the boat launch at Gellatly Bay is closed indefinitely. Water samples from the Gellatly Bay boat launch were being taken Friday. As of press deadline Interior Health and the B.C. Ministry of Environment were working to determine when it would be safe to reopen the launch.

For more information, visit www.districtofwestkelowna.ca.

www.kelownacapnews.com — Wednesday, June 23, 2010 capital news A3

**NEWS**

▼ KELOWNA

# Authorities quick to control gasoline leak into lake

SEAN CONNOR/CAPITAL NEWS

**KELOWNA FIREFIGHTERS** work Monday afternoon at Kerry Park to contain a gasoline fuel tank leak into Okanagan Lake.

JENNIFER SMITH
STAFF REPORTER

A gasoline leak from a land-based tank had the City of Kelowna, the fire department and Petro-Canada staff hopping Monday morning as fuel spilled into Okanagan Lake.

It is not known exactly how much gasoline leaked into the water, but city staff say they believe they caught it early and are hoping the damage is minimal.

"We discovered a very small leak, actually in the wall (along the shore)," said Todd Cashin, City of Kelowna's environment division.

To the point where city officials were called in, Cashin said he believes the spill only contained about a water bottle's worth of gasoline, perhaps 200 milliliters; although, all of the details are still under investigation.

The municipality was contacted by concerned citizens who smelled gas in the downtown area at approximately 8 a.m. and city crews were on scene almost immediately.

The Integrated Land Management Bureau, the provincial Ministry of Environment and the federal Ministry of Environment were all contacted as fire crews set up a boom and absorbent pads to contain the spill.

While the exact source of the leak is under investigation, the city could say the spill's source is around a fuel tank used by Kelowna Marina that is buried under Kerry Park. Details on who is responsible for the tank, its maintenance and so forth have yet to be released, though Cashin confirmed the tank itself is a relatively new one.

The site is complicated because it sits on territory once occupied by ferry docks, so the crews working in the area must go slowly to ensure they don't disrupt live infrastructure lines or hit dormant ones once used to service the docks.

A Petro-Can truck was brought in to siphon off the remains of the gas in the tank Monday morning, leaving the tank empty, but crews are still poking around to ascertain whether more fuel leaked into the ground and exactly what caused the leak.

Fire crews used a silly putty-like sealant to damn the leak spilling into the lake upon arrival.

Unfortunately, gasoline, even in small amounts, does diffuse very quickly, meaning a clean up effort will be required.

Kerry Park sits right beside the brand new Stuart Park where the native riparian shoreline is being restored, but the good news Tuesday was that the lake had been entirely protected.

City officials said more information would be forthcoming Wednesday as the exact source of the leak becomes clear.

jsmith@kelownacapnews.com

Fire-Fighting Stormwater Contaminates Mill Creek and City Beach, Kelowna

# Fire's toxic chemical trail leaves questions

Aug 4, 2010

KATHY MICHAELS
CONTRIBUTOR

When fire crews attacked flames overtaking Stewart Centre Saturday night, their focus wasn't on how local waterways would suffer from the toxic mixture of chemicals they unleashed.

Now, as beaches are cordoned off and images of dead fish rising to the top of local streams make the rounds, the environmental impact is front and centre.

"This might be a wake-up call for everyone to step back and look at our procedures and do the things we need to do to protect fish waterways and ensure safe water for wildlife and people," said Patrick Whittingham, vice-president of the Oceola Fish and Games Club.

"That (dead) fish was a canary in the coal mine. We see the fish that have died off, but we don't know enough about the smaller organisms and what impact this will have on them now, and down the road."

Trouble is, as his club co-hort Rick Simpson put it, you're "damned if you do, damned if you don't."

"What were those guys supposed to do, let the whole block burn down?" he said.

According to Jason Brolund, assistant chief of the Kelowna Fire Department, his crews had a good idea about the chemicals they'd be dealing with and their potential hazard, when they headed into the blaze.

"We knew it was going to take water, and that the water would come out contaminated, but the fire department and province at large follows the B.C. emergency response management system," explained.

That set of principles prioritizes the safety of responders first, then the preservation of life, protecting public life, government infrastructure, property, then the environment comes into play.

"The decisions we made that night were tough," he said.

"It was about keeping people safe and fighting the fire—things were flying left, right and centre and we made decisions about protecting exposures on either side… there were 30 to 40 other busineseses that were saved and they could be impacted if we didn't use water to put it out."

With the decision made to deluge flames a call was made to city crews to mitigate the impact of the pesticide, nitrate and glycol mixture that started to trickle into the storm drain system upstream near Lindahl Street, between Springfield Road and Sutherland Avenue.

Their vacuum trucks were on scene, sucking up waste 45 minutes after the first blaze broke.

Unfortunately, they didn't realize they hadn't stopped the flow until the next morning when a resident along Mill Creek noticed the water had changed colour.

Others noticed dead fish on the banks, and as the situation became clear, beaches were closed to swimming.

"In catastrophic situations like that, even the measures the city has in place won't help deal with that volume of water that quickly," said Rick Wagner, environmental emer-

SEAN CONNOR/CAPITAL NEWS

**WADING UP** to his waist in Mill Creek near the entrance to Okanagan lake, an environmental remediation worker inspects and removes debris from the creek after hazardous chemicals from the Stewart Centre fire on Saturday night were washed into the creek through the city's drainage system from the water used to douse the blaze.

SEE TOXIC A4

## Appendix 2: Activities Impacting the Intake Protection Zone Checklist

### Municipal

- Minimize shoreline clearing for beaches especially with adjacent grassed areas (attracts geese)
- Re-locate storm water outfalls to discharge outside of intake protection zone
- Encourage developers to capture and use storm water on their properties
- Stop or limit the use of fertilizers, pesticides on municipal spaces

### Residential 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 or sand for beaches.
- Use paving stones instead of pavement.
- Stop or limit the use of fertilizers, pesticides.
- Don't use fertilizers in areas where the potential for water contamination is high, such as sandy soils, steep slopes, or compacted soils.

### Agriculture

- Locate confined animal facilities away from water bodies and storm water system. Divert incoming water and treat outgoing effluent from these facilities.
- 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.
- 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 stream bank, river or lakeshore and avoid planting crops right up to the edge of a water body.
- Limit the use of fertilizers and pesticides

### Onsite Sewage Systems

- Inspect your system yearly, and have the septic tank pumped every 2 to 5 years
- Use phosphate-free soaps and detergents.
- Avoid septic additives and house-hold cleaning chemicals
- 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 contaminatewaterbodies.
- 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 cleanyour 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 four stroke engines, which are less polluting than two 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
polystyrene (completely contained and sealed in UV-treated material) or washed plastic barrel floats.
• When within 150 m of shore adjust your speed accordingly to prevent waves from eroding banks. Adhere to British Columbia's Universal Shoreline Speed Restriction which limits all power-driven vessels to 10 km/hr within 30 m of shore. Exceptions to this restriction include:• vessels traveling perpendicularly to shore when towing a skier, wakeboard, etc.

-After BC Lake Stewardship Society 2008

## Appendix 3: *E. coli* Source Tracking in City of Kelowna Creeks Receiving Storm Water and at Beaches

City of Kelowna Creeks with Storm Water 2006
*E. coli* Bacterial Source Tracking

| Probable Source | Count | Percent |
|---|---|---|
| Human | 3 | 13 |
| Canine | 6 | 25 |
| Bovine | | 0 |
| Horse | | 0 |
| Song birds | | 0 |
| Gulls | 1 | 4 |
| Duck | 7 | 29 |
| Canada Goose | 1 | 4 |
| Racoon | | 0 |
| Deer | 4 | 17 |
| Unknown | 2 | 8 |
| SUM | 24 | 100 |

City of Kelowna Creeks and Beaches 2006
*E. coli* Bacterial Source Tracking

| Probable Source | Count | Percent |
|---|---|---|
| Human | 8 | 8 |
| Canine | 15 | 14 |
| Bovine | 1 | 1 |
| Horse | | 0 |
| Song birds | 14 | 13 |
| Gulls | 18 | 17 |
| Duck | 20 | 19 |
| Canada Goose | 16 | 15 |
| Racoon | 4 | 4 |
| Deer | 5 | 5 |
| Unknown | 4 | 4 |
| SUM | 105 | 100 |

City of Kelowna Creeks with Storm Water 2008
*E. coli* Bacterial Source Tracking

| Probable Source | Count | Percent |
|---|---|---|
| Human | 3 | 5 |
| Canine | 2 | 3 |
| Bovine | 6 | 9 |
| Horse | 2 | 3 |
| Song birds | 14 | 21 |
| Gulls | 5 | 8 |
| Duck | 7 | 11 |
| Canada Goose | 12 | 18 |
| Racoon | 1 | 1 |
| Deer | 6 | 9 |
| Unknown | 8 | 12 |
| SUM | 66 | 100 |

City of Kelowna Creeks and Beaches 2008
*E. coli* Bacterial Source Tracking

| Probable Source | Count | Percent |
|---|---|---|
| Human | 10 | 5 |
| Canine | 13 | 6 |
| Bovine | 21 | 10 |
| Horse | 11 | 5 |
| Song birds | 44 | 21 |
| Gulls | 18 | 8 |
| Duck | 18 | 8 |
| Canada Goose | 26 | 12 |
| Racoon | 6 | 3 |
| Deer | 19 | 9 |
| Unknown | 28 | 13 |
| SUM | 214 | 100 |

Courtesy of City of Kelowna, Analyses performed at UVic

___________end of report_____________