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Consultants in Hydrogeology and Environmental Science

PHASE 2: SWAN LAKE - LAND USE AND WATER QUALITY ASSESSMENT, VERNON, B.C.

Prepared for:

Regional District of
North Okanagan
9848 Aberdeen Road
Coldstream B.C. V1B 2K9

Prepared by:

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Project: 14-076-02

October 25, 2017

Laura Frank, MA, MCIP, RPP, Regional Planning Projects Manager
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Coldstream, B.C.
V1B 2K9
Via e-mail: laura.frank@rdno.ca

Dear Ms. Frank:

Re: PHASE 2: LAND USE AND WATER QUALITY ASSESSMENT OF SWAN LAKE, NORTH OF VERNON, B.C.

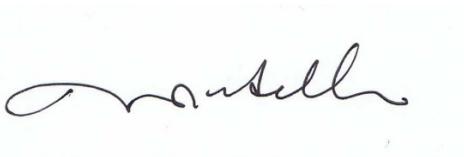
Western Water Associates Ltd. (WWAL) is pleased to provide this report on the Land Use and Water Quality Assessment of Swan Lake. The program aimed to help elucidate the potential sources of water quality impact on Swan Lake.

We undertook a water quality sampling program in the area surrounding Swan Lake. Further, we assessed land use as it relates to potential water quality impact on Swan Lake by apportioning the mass flux of chloride and nutrients entering the lake from the various land uses surrounding the lake.

We trust that the professional opinions and advice presented in this document are sufficient for your current requirements. Should you have any questions, or if we can be of further assistance in this matter, please contact the undersigned.

WESTERN WATER ASSOCIATES LTD.

Reviewed by:



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EXECUTIVE SUMMARY

In 2015 and 2016, WWAL conducted a land use and water quality assessment for the RDNO in and around Swan Lake. The purpose of the study was to assess impacts of the current land uses on groundwater and surface water quality in and around Swan Lake. Further, we provide recommendations related to changes in land use to help maintain or improve water quality in and around the lake.

Water quality, as it relates to land use surrounding Swan Lake, was assessed based on a water sampling program conducted in 2015 and 2016. Further, the assessment included a Swan Lake water budget (balance) approximation, which found that over 75% of the water in Swan Lake is derived from BX Creek inflow, with the remainder comprised of other smaller creeks and springs, overland flow from surrounding land, and a small component of groundwater discharge into the lake. Stream gauging of the in-flowing and out-flowing streams was conducted in 2016 to update and help constrain the surface water components of the water balance. Using chloride as an indicator of water quality impact and estimating chloride mass loading rates from the land uses surrounding Swan Lake, agricultural activities around the lake were found to be the largest contribution to potential water quality impact on Swan Lake. The study scope did not include identifying potential water quality influences on the tributary creeks including BX Creek.

When we compared surface water quality within and around Swan Lake to provincial and federal aquatic life guidelines, we see the quality of water in Swan Lake and at the outlet of Swan Lake (Vernon Creek or Lower BX Creek) is relativity good. With fluoride and ammonia exceeding the Canadian water quality guidelines for the protection of freshwater aquatic life (CCME AL) in Swan Lake and fluoride, along with several metals exceeding guidelines in Vernon Creek. At the creeks, and springs flowing into Swan Lake we see more apparent impact from surrounding land use; specifically, we see elevated metal concentrations and nutrient (nitrate) concentrations at several of the in-flowing tributaries and springs (SE Spring, NE Cowboys Creek, NE Culvert, and SW Spring) exceeded the CCME AL 30-day average (chronic) guideline (3 mg/l). This CCME AL guideline is based on 5 weekly samples collected within a 30-day period. Although our sampling program did not involve weekly sampling for 5 consecutive weeks, based on the consecutively elevated concentrations of nitrate at the SE Spring and at Site 3 (NE Cowboy Creek), both draining the hillside east of Swan Lake, we can infer that the nutrient levels at these locations are elevated above the CCME AL guideline over-time.

When we assess groundwater and near-surface groundwater around the perimeter of Swan Lake by comparing the results to provincial and federal drinking water, livestock watering and irrigation watering guidelines and viewing spatial and temporal trends we are able to provide an assessment of land uses that are likely degrading water quality in Swan Lake. At foreshore waters on the east, north, and southwest shores of Swan Lake, sulphate concentrations were found to be elevated above background concentrations and above federal and provincial water quality guidelines. We interpret the elevated sulphate concentrations to potentially be related to agricultural amendment applications in the area. The operators of agricultural lands above Swan Lake should create and implement Land Application Plans, which aim to reduce the input of sulphate into Swan Lake.

Further, ammonia at high concentrations was observed at two locations on the southeast shore of Swan Lake and is likely related to disposal of on-site wastewater at the shoreline. Given the ongoing measured input of nutrients in surface water and near-surface groundwater along the eastern shoreline of Swan Lake, which we believe is related to domestic wastewater disposal, a collection and treatment of

wastewater from the development along, at least the eastern and northeastern vicinity of Swan Lake. This proposed new infrastructure should be considered in the Master Wastewater Recovery Plan.

1. INTRODUCTION

In September 2014 the Regional District of North Okanagan (RDNO) made a request for proposal to complete water quality monitoring on Swan Lake, located north of the City of Vernon and south of the Township of Spallumcheen, mostly within Electoral Area "B" of RDNO. Based on results of the 2015 water quality monitoring report, the RDNO requested a second year of water quality monitoring at Swan Lake. The RDNO was interested in understanding what influence, if any, adjoining land uses, specifically, existing on-site wastewater systems and storm waters are having on water quality in Swan Lake. Western Water Associates Limited (WWAL) was awarded the contract to assess land use impact and water quality at Swan Lake. Work began on the project in the spring of 2015 and continued into the winter of 2016.

1.1 Project Objectives and Scope of Work

The objective of the water quality assessment was to design and undertake a program to measure the influence of surrounding land uses on water quality in Swan Lake. In the first phase of the work (2015), our scope focused on assessment of the near-surface groundwater entering into Swan Lake to avoid the influence of dilution by surface waters on parameter concentrations. In 2016, five additional surface water sampling locations were included in the program (BX Creek, Storm Drainage Ditch (south), NW Spring, SW Spring and SE Spring) to create a more robust sampling program, which aided in assessing land use impact to the tributaries and springs that feed Swan Lake throughout the year.

It was understood that potential water quality impact to Swan Lake would likely be due to a combination of both point source and non-point source contaminant inputs. Our program method involved identifying the point source and non-point source inputs along the approximately 11.5 km perimeter of Swan Lake. Point source contamination from storm water outfalls and other end of pipe inputs were assessed along with non-point contaminant sources derived from application of agricultural land amendments (fertilizers and/or manure) and operation of on-site wastewater disposal systems.

To identify and quantify point and non-point source nutrient and other contaminant loading into Swan Lake we completed the following tasks:

- Developed a conceptual model of lake water flow by creating a water balance for Swan Lake;
- Performed an initial field reconnaissance to assess potential areas of interest (fall 2014);
- Performed sampling events during high, receding and low lake stages, with a focus on sampling at the areas of interest identified during the field reconnaissance (spring, summer and fall 2015 and 2016); and
- Inventoried land use and estimated mass flux of nutrients entering along the perimeter of the lake.

2. SITE DESCRIPTION, GEOLOGIC, AND HYDROGEOLOGIC SETTING

The following sections summarize the physiographic, geologic, hydrogeologic, and hydrologic information compiled for the area around Swan Lake.

2.1 Site Description

Swan Lake is located north of the City of Vernon and south of the Township of Spallumcheen in the RDNO Electoral Area "B". The lake has an approximate surface area of $4X10^6$ m^2 (400 hectares). The Lake is surrounded primarily by Agricultural Land Reserve (zoned as Country Residential; 75%), and to a far less extent by residential development (16%), recreational commercial development (7%), and general industrial (2%) land use. However, there is significant commercial land use on the east side of Highway 97, which passes close by the east side of Swan Lake. Further, we understand there is a biosolids waste disposal facility located 1.4 km north of Swan Lake.

Qualitative surface water measurements taken at Swan Lake suggest the lake is mesotrophic, exhibiting an intermediate level of productivity (Nordin 1985). Further, there have been anecdotal observations of a plume, assumed to mean an algal bloom between Meadowlark Road and Elmwood Road on the east shore of Swan Lake. A large portion of the perimeter of Swan Lake, more prominently on the east shore, is bordered by wetland vegetation including cattail, willow, bulrushes, and sedges as shown in Photos 1, 2 and 3, below. Appendix C provides photos of all sampled sites the study for reference.

Photo 1: Typical undeveloped riparian area on the east shore of Swan Lake, photo taken at FS-33, July 15, 2015, facing northwest.

Photo 2: Typical riparian area on the east shore of Swan Lake, showing willow photo taken at FS-33, July 15, 2015, facing west.

Photo 3: Typical wetlands area on the east shore of Swan Lake, showing cattails photo taken at FS-45, July 15, 2015, facing west.

2.2 Climate

The climate north of Vernon in the area of Swan Lake is mild. The warm season lasts from June to September with an average daily high temperature above 9°C. The hottest day of the year statistically is July 30, with an average high of 30°C and low of 14°C. The cold season lasts from November to February with an average daily high temperature below 3°C. Unlike nearby larger lakes such as Kalamalka and Okanagan Lake, Swan Lake typically freezes over for at least several weeks each winter (typically

December through February). The average annual precipitation is 487 mm per year. The most recent and available climate normals are provided in Table 1, below.

Table 1: 1981-2010 Climate Normals for Vernon Area

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Daily Average (°C)	-2.8	-0.2	4.2	9.4	13.9	17.4	21	20.5	15.3	7.9	1.8	-2.2	8.8
Rainfall (mm)	11.6	11.7	17	27.2	46.3	49.6	35.4	31.9	32.7	40.7	31.1	9.7	344.9
Snowfall (cm)	40.5	13.5	11.7	1.8	0	0	0	0	0	0.9	26.5	47.3	142.1
Precipitation (mm)	52.2	25.2	28.7	29	46.3	49.6	35.4	31.9	32.7	41.5	57.5	57	487

Data Source: Environment Canada 2016 - Climate Station Number 1128583

2.3 Limnological Information

The following section was provided by Larratt Aquatic (2015) and summarizes the available limnological data available for Swan Lake. Swan Lake is located at the north end of the city of Vernon. The lake has a perimeter of 11.5 km and lies at an elevation of 390 m above sea level (m asl). The lake surface area is 438.3 hectares, with a maximum depth is 9.1 m, and a mean depth of 5.6 m. Swan Lake is classified as a dimictic lake (lake water mixes from surface to bottom twice per year; spring and fall). In three years of sampling, the maximum surface temperatures measured in 2009 and 2011 were 26.5°C (July 30) and 23.0°C (July 7), respectively. The maximum Secchi reading (a measure of lake water turbidity) for all sampling years was 5.4 m and occurred on July 20, 2009. The shallowest Secchi depth measured over the 3-year sampling period was 1.65 m, on May 27, 2009 (BCLSS 2013). Based on the average summer Secchi values, Swan Lake exhibits mesotrophic (3 - 6 m) conditions in all sampling years (Nordin 1985). Anecdotal evidence suggests that Swan Lake experiences algae blooms, and if so, they may be most prominent during the spring and fall overturn periods when nutrient-rich bottom water is circulated throughout the lake. During the 2016 sampling in August and October, the temperature profile of the deepest location of Swan Lake was assessed and the temperature profile shows little variation through the water column, with the lake being so shallow, see the Section 4.2 for the temperature profile results.

Swan Lake is one of the most important wetland habitats in the south-central interior of B.C. and is recognized for its value for staging and breeding waterfowl. The lake is on a major provincial migratory corridor and is an important resting and feeding stop for migratory birds as well as providing essential nesting habitat, including one of the largest urban Great Blue Heron rookeries in western Canada.

Swan Lake is used for fishing, boating, rowing, waterskiing, swimming, flying (floatplanes), and winter ice sports (e.g. skating, ice racing of cars and motorbikes). Additionally, the south end of the lake is popular with birdwatchers. The lake has one boat launch, located about halfway down the lake on the east shore used by local residents and recreational users who visit Swan Lake (BCLSS 2013).

Swan Lake and Lower Vernon Creek (also referred to as Lower BX Creek) are considered well-buffered to acidic inputs, and to have moderate water hardness. In Lower Vernon Creek metals that occasionally exceed criteria include aluminum, iron, and lead. The only known sources of metals to lower Vernon Creek are storm water runoff. Maximum concentrations of ammonia, nitrite, and nitrate were all below criteria. Phosphorus concentrations were high enough to cause excessive algal growths if phosphorus is the limiting factor (BC MoE 1999).

2.4 Surficial and Bedrock Geology

The following section describes the bedrock and surficial geology of the Swan Lake area. The geological Vernon Fault line (a buried bedrock structure) runs through the centre of Swan Lake from north to south, parallel to the valley bottom. Bedrock geology to the east and northeast of the site consists mainly of metamorphic rocks including schist, amphibolite, calc-silicate gneiss, and micaceous quartzite, which formed during the Paleo to Mesoproterozoic era (between 1000 and 2500 million years ago; Thompson et al 2004). The upland areas to the east of Highway 97 are comprised of calcareous quartzite of the Chase Formation and quartz-feldspar-muscovite-biotite schist of the Silver Creek Formation from the Devonian period (approximately 420 to 360 million years ago). Bedrock geology to the west of the Vernon Fault and Swan Lake include siliciclastic and volcanic rocks of the Harper Ranch Group, which formed during the Permian period (300 and 260 million years ago). Predominant metasedimentary and metavolcanic rock types in the formation are siltstone, sandstone, breccia, limestone, tuff, andesite, and skarn (Thompson 2004).

Surficial geology surrounding Swan Lake consists of lacustrine deposit, glacial deposits, and unconsolidated sediments of colluvium and alluvium from the Quaternary period approximately 2.6 million years ago to present (Thompson 2003). Thick lacustrine deposits consist of silt with minor clay and sands (Fulton 1995). These silt deposits underlie the adjoining uplands and were formed during the late glacial period at a time when the valley lake system stood at a higher elevation due to ice dams formed further down-valley (Nasmith 1962). Sediment chemistry for this region taken from uncontaminated lake sediments has shown elevated sulphur and lead; however, sediments are generally low in manganese and magnesium (Reiberger 1992).

2.5 Hydrology and Hydrogeology

There are seven surface water inlets into Swan Lake; all but three are unnamed and primarily ephemeral in nature. The three named tributaries are Greenhow Creek, Malysh Brook and B.X. Creek (MoE 2016). The majority of surface water (and groundwater flow) into Swan Lake occurs from the north and east side of the lake. Swan Lake has one outlet located at the south end of the lake, Vernon Creek (also referred to as Lower BX Creek), which has a regulated outflow structure. Typically, the majority of surface water flow into Swan Lake occurs during the spring freshet (March/April), when snow melt occurs within the valley bottom and during the late spring melt (May/June) when the upper elevations snow melt occur in the headwaters (Silver Star). The remainder of the year, contribution to Swan Lake from the inlet tributaries are typically orders of magnitude lower.

There are three provincially mapped aquifers surrounding the site. Mapped sand and gravel aquifer 348 IIC underlies the site and is classified as low productivity, moderate demand, and low vulnerability (MoE 2016). Bedrock aquifer 358 IIC lies to the northeast and sand and gravel aquifer 349 IIC is located southeast of Swan Lake. The bedrock aquifer is characterized as having low demand, low productivity, and low vulnerability to surface contamination. Sand and gravel aquifer 349 IIC is characterized as having moderate productivity, moderate demand, and low vulnerability to surface contamination. Demand describes local reliance on the groundwater water source, productivity indicates the relative yield of wells completed in the aquifer, and vulnerability describes the potential for contaminants to migrate from the surface into the aquifer.

There are more than 180 wells reported in the vicinity of Swan Lake, with the majority completed in the unconsolidated sand and gravel aquifer (348 IIC). However, we understand that a majority of these wells are not in use, as community water supply is the primary water source throughout the area. Recorded well depths within the sand and gravel aquifer range from approximately 2.7 m (9 ft) to 64 m (212 ft) below ground surface (bgs). Wells that were completed in the bedrock aquifer indicate bedrock depth ranging from 1 m (3 ft) to 50 m (163 ft) bgs (MoE 2016). In 2009 further aquifer characterization was completed for the Okanagan Basin Water Board Groundwater Supply and Demand Study (Golder and Summit 2009). The surficial aquifer was estimated to have approximately 225 $X10^3$ m^3/day of groundwater flow through the aquifer, flowing from northeast to south.

3. METHODS – WATER BALANCE, SITE INVESTIGATION AND MASS FLUX ANAYSIS

The following sections outlines the methods used to create the Swan Lake water balance and complete the site investigation and mass flux estimates.

3.1 Swan Lake Water Balance

The water balance equation of Swan Lake is described as follows:

$$\Delta S = (Q_{in} + P + GW_{in}) - (Q_{out} + E + W_{use} + GW_{out})$$

Where:

- ΔS = Change in storage.
- Q_{in} = Total discharge of tributaries into Swan Lake.
- P = Total precipitation into Swan Lake.
- GW_{in} = Flux of groundwater into Swan Lake.
- Q_{out} = Total discharge of river and streams out of Swan Lake.
- E = Total evaporation from the lake surface.
- W_{use} = Domestic and agricultural water into or from Swan Lake.
- GW_{out} = Groundwater losses from Swan Lake to downgradient aquifers.

The data used in the Swan Lake water balance calculations were derived from several different sources as described and summarized in the table below. The temperature data used to calculate evaporation and the precipitation data were taken from Environment Canada Climate Station No. 1128583, which has record spanning 30 years from 1981 to 2010. The stream flow was recorded during the three sampling events (March, August, and November) in 2016 for all surface water locations with field measurements and calculations of stream discharge following protocol set forth in Part E Section 6.7 of the provincial protocol for *Ambient Freshwater and Effluent Sampling* (BC MoE 2013). Daily stream discharge was then linearly interpolated using the point slope formula and the recorded stream flow measurements collected in the field. The groundwater fluxes used in this report are taken from a 2009 study completed by Golder Associates and Summit Environmental for the Okanagan Basin Water Board (OBWB), which evaluated the groundwater supply and demand for the Okanagan Basin. Due to the relatively static nature of Swan Lake stage, it was suitable to use a 1959 Bathymetric map obtained from the Fisheries Inventory Summary System online data (FISS 1959). Results of the water balance are present in Section 4.1.

Table 2: Water Balance Parameters for Swan Lake

Parameter	Value
Lake Volume (m^3)	24,743,646
Surface Area (m^2)	4,382,745
Shore Line Perimeter (m)	11,478
Max Lake Depth (m)	9
Residence Time (yr.)	1

3.2 Field Investigation

3.2.1 Water Quality Sampling

The field investigation in 2016 remained largely like the routine sampling that occurred in 2015 (WWAL 2015) with the addition of several surface water locations and additional sampling parameters assessed at the outlet of Swan Lake (Vernon Creek): Fecal coliform, Enterococci, *Escherichia coli (E. coli.*), suspended solids, periphyton in chl-a, dissolved oxygen (do in field); and turbidity. In 2016 the additional surface water sites sampled were as follows: Site 5B, Storm Drain, BX Creek, SW Spring, NW Spring, SE Spring and groundwater site FS-104b.

These sampling locations, or areas of interest, are locations where non-point and point source contaminant indicators were found at concentrations markedly above ambient concentrations during the initial field reconnaissance in April 2015. Where ambient (background) concentrations were taken to be represented at MW-3. The indicator species in these areas include electrical conductivity, nutrients (i.e. nitrate, ammonia, and potassium), and other chemical species (i.e. chloride, dissolved sodium, dissolved calcium, sulphate, alkalinity, and uranium).

The initial site reconnaissance, conducted on April 2 and 3, 2015 (during seasonally high groundwater and surface water levels), involved recording field measured electrical conductivity and GPS coordinates at 62 locations along the 11.5 km perimeter of the lake (Figure 2). At 26 locations, water quality parameters listed in Table 3 (initial reconnaissance water quality survey) were assessed. From the 26 locations sampled and further desk top assessment, we identified 21 sampling locations, shown on Figure 1.

The routine sample locations were sampled during two additional events in 2015 and three events in 2016, where water quality parameters listed in Table 3 (routine water quality survey) were assessed. The routine sampling events occurred in 2015 and 2016 July / August (seasonally receding water levels), in October/November (seasonally low groundwater levels) and in March of 2016. Sampling included 14 near-surface groundwater, 3 groundwater, and 11 surface water locations. Table 4 provides a summary of the routine sampled locations, including the following:

- sample location name;
- sample type (groundwater, foreshore (near-surface groundwater) or surface water) ;

- perimeter distance around lake (with kilometer (km) 0 taken to be the outlet of Swan Lake, at the south end of the lake);
- a description of where the samples were taken at each location; and
- dates each location was sampled.

Three wells were monitored during the Swan Lake investigation in 2015 (MW-1, MW-2, and MW-3). The groundwater wells were not sampled in April 2015, as they had not been located and access to the wells had not be granted at the time of the April 2015 initial assessment. Further, sampling at MW-2 was discontinued in 2016 as the water quality at MW-2 was very similar to MW-3 and was considered redundant for sampling in 2016. The three groundwater monitoring wells utilized in this program were selected based on their presence near the lake and permission from land owners to access the wells during the sampling events. The three wells are grouped at the north end of the lake; further, we do not know the actual depth of MW-3, these are both known study limitation. However, sampling of the groundwater wells has provided valuable information with respect to background water quality conditions, taken to be represented at MW-3 and illustrative of water quality impact observed at MW-1.

Well MW-1 is a 2-inch monitoring well located at the north end of the lake, approximately 35 m south of Highway 97 and 20 m west of Greenhow Creek and completed to a depth of 5.2 m (17 ft). Monitored well MW-2 is a drilled well completed to an approximate depth of 24 m (80 ft) and is located just under 900 m north-northeast of the Swan Lake shoreline. MW-2 was in use as a domestic supply source during the initial sampling event in July 2015; however, the property owner has since sold the land and the site is currently under development. Monitored well MW-3 is located approximately 800 m north of Swan Lake and is used as the domestic/commercial water supply for the offices located on that site. The depth of this well is unknown and MW-3 is a drilled 6-inch diameter domestic groundwater supply well.

3.2.1.1 Surface Water Sampling Protocol

Surface water samples were taken as instantaneous grab samples except for the sampling of Swan Lake, which will be described below. All samples were stored in coolers with ice and transported under chain-of-custody protocol to CARO Analytical Services, a laboratory accredited by the Canadian Association for Environmental Analytical Laboratories. Samples were submitted to the laboratory within the required holding time for bacteriological analysis.

Swan Lake was sampled at its deepest point in August and November 2016. Sampling of Swan Lake in August and November 2016 was performed in accordance with the MoE Deep Water sampling guidelines (MoE 2013). A Van Dorn sampling device was utilized for the sampling, further the depth and thermocline were recorded at 1 m intervals. Since no discernable temperature zones were measured (the lake is shallow), the sample was taken in the middle of the water column at the deepest point in the Lake (see Figure 1 for Swan Lake sampled location).

Sample collection was followed by the collection of field pH, temperature, electrical conductivity and turbidity. Field measurements were collected partially by filling a 1 L sample bottle, placing a waterproof PCTester 35 multi-probe at the opening of the bottle and tipping the bottle so that the water access the end of the probe. The probe was calibrated immediately before the measurements were obtained. Turbidity measurements were taken using a LaMotte 2020we/wi Turbidimeter.

3.2.1.2 Vernon Creek (outlet of Swan Lake) Chlorophyll-a Periphyton Sampling Method

Sampling was completed at the Vernon Creek (outlet) site by Trina Koch (B.Sc. R.P.Bio.) and Morgan Jackson B.Sc. of WWAL on August 11, 2016. The chlorophyll-α and periphyton samples were collected from randomly selected rocks that had not been undisturbed. The completion of the chlorophyll-a and periphyton sampling followed the "British Columbia Field Sampling Manual" (MoE 2013). Chlorophyll-a sampling was completed using the following method:

- From across the stream channel, 3 rocks were selected at random, each with a flat side at least as large as a petri dish;
- The petri dish was used to delineate the sample area on each rock;
- A toothbrush was used to scrub the delineated area and a rinse bottle filled with de-ionized water was used to rinse the sample area into a tray;
- The contents of the tray were poured into a pre-labelled jar and the solution volume was recorded on the jar label; and
- Samples were packaged in an iced cooler and delivered under chain-of-custody protocol, to Caro Analytical Services (Kelowna, BC), within a 24-hour period for analysis.

The chlorophyll-α samples were analyzed using the American Public Health Association 10200-H technique. This method involves concentrating the sample by filtrating and grinding algal cells then extracting chlorophyll-a into 90% acetone. The extract is placed in a spectrophotometer and pigment absorbance values are read at 630 nm, 647 nm, 664 nm and 750 nm wavelengths. Chlorophyll-a concentrations were reported in micro grams per liter (ug/L) and the following equation was used to obtain results in mass per unit area (mg/m2):

Chlorophyll a (mg/m^2) =

= (A (µg)/L*1mg/(1000µg)*B mL*1L/(1000 mL))/(C 〖cm^2*($1m^2$)/(10,000 〖cm^2))

3.2.1.3 Groundwater Sampling Protocol

WWAL sampling protocol are based on procedures described in the British Columbia Field Sampling Manual (MoE 2013). To sample from the groundwater monitoring wells MW-1, a bladder or peristaltic pump with new tubing was used to purge water from the wells until parameter stabilization was observed, followed by sample collection directly from the discharge tube into new sample bottles provided by the laboratory. The pump was decontaminated between sample locations. From the domestic wells (MW-2 and MW-3, the dedicated pumps were run till field measured parameters stabilized, at which time the water quality sample was taken. Clean nitrile gloves were worn while purging and sampling.

Sampling events included taking foreshore water samples of the near-surface groundwater, termed "hyporheic zone water", which is the zone of mixing between surface water and groundwater. This near-surface groundwater is the most likely receptor of non-point source contaminants such as septic systems and agricultural input. Our method for sampling the near-surface groundwater involves hand installation of mini-piezometers at the perimeter of the lake. By focusing on sampling near-surface groundwater we avoid dilution of the contaminants via mixing with surface water and we are able to assess water quality of near-surface groundwater at the perimeter of the lake, just before it enters the lake.

All sampled locations were photographed and the GPS coordinates were recorded and Appendix C provides a selection of photos of the sites. Triplicate samples were taken and the relative standard

deviation (RSD) was calculated to help assess quality of the data set, result for the RSD are provided in Section 4.2.3, below and the full QA/QC data set is provided in Appendix A.

Table 3: Summary of Water Quality Parameters for Initial and Routine Sampling

Water Quality Sampling Parameter Lists
Initial reconnaissance water quality survey (Spring 2015): • Field measured dissolved oxygen, temperature, pH, electrical conductivity and oxidation reduction potential; • Ammonia; • Alkalinity; and • Full Ion Chromatography Scan (chloride, bromide, sulfate, nitrate, and ortho-phosphate).
Routine water quality survey (Summer and Fall 2015 and 2016, Spring 2016): • Field measured dissolved oxygen, temperature, pH, electrical conductivity and oxidation reduction potential; • Ammonia; • Alkalinity; • Total Sulfide; • Full Ion Chromatography Scan (chloride, bromide, sulfate, nitrate, and ortho-phosphate); • Fecal Coliform, Total Coliforms & *E. coli* (only once on October 31, 2015); and • Metals (sampled in October 2015, March 2016, August 2016 and November 2016).

Table 4: Sample Location Name, Perimeter (km) around Swan Lake, Description of Location and Dates Sampled.

Location Relative to Swan Lake	Type of Sample (SW, FS or GW)	Location, Perimeter Distance and Locations Description	Dates Sampled
SOUTH	SW	Storm Drainage (km 0), discharges into Vernon Creek just below the outlet of Swan Lake.	28-Mar-16
			11-Aug-16
			2-Nov-16
	SW	Swan Lake (km 0) In 2015, Swan Lake was sampled at the south end of lake near Silver Star R.V. In August and October 2016 the sample was taken from the deepest area of the lake (see Figure 1).	2-Apr-15
			16-Jul-15
			3-Nov-15
			29-Mar-16
			15-Aug-16
			10-Nov-16
	SW	Vernon Creek (Outlet) (km 0), southern most end of Swan Lake - Outlet of Swan Lake (Vernon Creek). Sampled above the weir.	3-Apr-15
			15-Jul-15
			29-Oct-15
			28-Mar-16
			10-Aug-16
			2-Nov-16
EAST	SW	BX Creek (km 0.25), accessed off 20th St on the east side of Hwy 97.	28-Mar-16
			10-Aug-16
			2-Nov-16
	FS	FS-31 (km 0.85). East Shore - south end of lake, downgradient of Silver Star R.V.	2-Apr-15
			16-Jul-15
			3-Nov-15
			29-Mar-16
			10-Aug-16
			3-Nov-16
	FS	FS-104 (km 0.85) and 0.49 km from shoreline. East side, south end of Swan Lake - storm drain (ditch) located at junction of Stickle Road and Pleasant Valley Road.	15-Jul-15
			29-Oct-15
			28-Mar-16
			10-Aug-16
	FS	FS-104b (km 0.85) and 0.59 km from shoreline. SW side of Pleasant Valley Rd and Sickle Rd.	28-Mar-16
			2-Nov-16
	SW	SE Spring (SSRV) (km 1.162)	31-Mar-16
			10-Aug-16
			3-Nov-16
	SW then FS	FS-32 (km 1.215) Originally was surface leachate from an illegal septate dumping pit in 2015. In 2016 the illegal disposal had ended and the sampling occurred from the hyporheic zone. East Shore - south end of lake, just north of the Silver Star R.V. property.	2-Apr-15
			16-Jul-15
			3-Nov-15
			29-Mar-16
			10-Aug-16
			3-Nov-16

Location Relative to Swan Lake	Type of Sample (SW, FS or GW)	Location, Perimeter Distance and Locations Description	Dates Sampled
EAST	FS	FS-33 (km 2.074). East Shore - south end of lake, just south of the south end of Heron Road, downgradient of an unnamed tributary.	2-Apr-15
			16-Jul-15
			29-Mar-16
			11-Aug-16
			3-Nov-16
	FS	FS-3 (km 3.05). East Shore - mid-lake, 500 m north of Meadowlark Road.	2-Apr-15
			15-Jul-15
			29-Oct-15
			29-Mar-16
			10-Aug-16
	FS	FS-101 (km 3.05) and 0.28 km from shoreline. East side of Swan Lake - storm drain (ditch) located on the east side of Hwy 97 north of Meadowlark Road and upgradient to FS-3.	15-Jul-15
			29-Oct-15
			28-Mar-16
			10-Aug-16
			2-Nov-16
	FS	FS-15 (km 3.595). East Shore - north end of lake, downgradient of unknown tributary - just south of Elmwood Road.	2-Apr-15
			29-Oct-15
			29-Mar-16
			29-Mar-16
			29-Mar-16
			11-Aug-16
			8-Nov-16
	SW	Site 3 (NE-Cowboys) (km 4.53). East side and north end of Swan Lake - unnamed tributary sampled east of Hwy 97, behind Cowboys Shop.	3-Apr-15
			28-Mar-16
			10-Aug-16
	FS	FS-45 (km 5.076). East Shore - north end of lake - downgradient of Swan Lake RV.	15-Jul-15
			29-Oct-15
			28-Mar-16
			10-Aug-16
			8-Nov-16
	SW	Site 5 (NE-Culvert) (km 5.378). Northeast end of Swan Lake - culverted Malysh Brook, sampled west of Hwy 97, just north of Swan Lake R.V.	3-Apr-15
			29-Oct-15
			29-Mar-16
			2-Nov-16
	SW	Site 5b (NE-Culvert) (km 5.378). Same as Site 5, but at Silverstone Rd.	28-Mar-16
			10-Aug-16
			2-Nov-16

Location Relative to Swan Lake	Type of Sample (SW, FS or GW)	Location, Perimeter Distance and Locations Description	Dates Sampled
NORTH	FS	FS-103 (km 5.526) and 1.2 km from shoreline. Northeast of Swan Lake - storm drain (ditch) located on the Pleasant Valley Road.	15-Jul-15
			29-Oct-15
			28-Mar-16
			11-Aug-16
			2-Nov-16
	GW	MW-2 (km 5.661) and 1.35 km from shoreline. Northeast of Swan Lake Monitoring well located on TNT property.	16-Jul-15
			29-Oct-15
			28-Mar-16
	GW	MW-3 (km 5.661) and 1.3 km from shoreline. Northeast of Swan Lake Monitoring well located on Kal Tire property. Taken to represent ambient (background) groundwater quality.	16-Jul-15
			29-Oct-15
			28-Mar-16
			10-Aug-16
			3-Nov-16
	SW	FS-43 (SW)(km 5.778). North end of Swan Lake - Greenhow Creek just before it's confluence with Swan Lake.	15-Jul-15
			29-Oct-15
			28-Mar-16
			2-Nov-16
	FS	FS-43 (km 5.778). North end of Swan Lake - on the west side of Greenhow Creek, just before it's confluence with Swan Lake.	3-Apr-15
			15-Jul-15
			29-Oct-15
			28-Mar-16
	GW	MW-1 (km 5.788) and 0.05 km from shoreline. North end of Swan Lake - Monitoring Well - near FS-43 and FS-43 (SW).	15-Jul-15
			29-Oct-15
			28-Mar-16
			10-Aug-16
			2-Nov-16
WEST	GW	FS-21 (km 6.772). West Shore - north end of lake, downgradient of hobby farms.	2-Apr-15
			15-Jul-15
			29-Oct-15
			31-Mar-16
			3-Nov-16
	SW	NW Spring (km 6.925). Northwest side of Swan Lake, Ephemeral spring, only flowing in spring 2016.	31-Mar-16
	FS	FS-28 (km 9.42). West Shore - south end of lake, downgradient of hobby farms.	2-Apr-15
			15-Jul-15
			29-Oct-15
			28-Mar-16
			10-Aug-16
			8-Nov-16
	SW	SW Spring (km 10.144).Southwest side of Swan Lake, Ephemeral spring, only flowing in spring 2016.	31-Mar-16
	FS	FS-29 (km 10.277). West Shore - south end of lake, along a perched water pond, downgradient of hay fields and at the edge of Swan Lake.	2-Apr-15
			15-Jul-15
			29-Oct-15
			28-Mar-16
			10-Aug-16
			8-Nov-16

Note: SW - Surface waters, FS - Foreshore waters (near-surface groundwater) and GW - deeper groundwater. FS and GW are both considered to be groundwater.

3.3 Land Use Inventory and Mass Flux of Anthropogenic Impact Indicators

Impact of anthropogenic (human) pollution on fresh water bodies can come from both point source and non-point source inputs. A point source input is derived from the end of a pipe, like storm water outfalls or a community wastewater discharge system. Non-point source input is derived from a diffuse source such as agricultural runoff or multiple private on-site wastewater systems dispersed across a landscape. Some of the potential pollution sources for Swan Lake include input from human and animal waste matter, fertilizers from agricultural practices, industrial waste, and road salting practices. There are many chemicals that can contribute to the degradation of water or are indicators of anthropogenic input. Some of these anthropogenic indicator parameters are nutrients, which contribute to eutrophication of surface water bodies such as nitrogen and phosphorus or indicate anthropogenic input like chloride and sulfur, along with other metals associated with different land use practices. Urban and agricultural runoff, in turn, can contribute different mixtures of these constituents via storm flow in ditches as well as overland flow and through groundwater (on-site wastewater systems).

Chloride concentrations are of particular interest and form the focus of the land use and mass flux estimates for several reasons. Firstly, chloride serves as a useful indicator of anthropogenic influence/ impacts due to its conservative properties within the hydrosphere and its association with human and animal effluent as well as fertilizers, primarily in the form of potassium chloride. Secondly, the salinization of fresh water can lead to acidification, mobilization of toxic metals (Kaushal *et al*., 2005), and ultimately decreased water quality.

Chloride is introduced into the environment by way of natural and anthropogenic sources. Some of the natural sources include atmospheric deposition, and the natural weathering of bedrock, soil, and surficial materials. Typically, in pristine or unaffected fresh waters chloride concentrations are less than 3 mg/l. The primary anthropogenic inputs include surface runoff related to agricultural practices, industrial activities, on-site wastewater, and road salting.

The following sections describe the methods used to estimate the chloride mass loading into Swan Lake in two ways. The first mass flux estimate is based on land-use partitioning and the second is based on groundwater flow and the results from the foreshore water quality sampling. Both estimates are first order approximations and based on assumptions explained in the sections to follow.

3.3.1 Chloride Loading Based on Land-Use

In order to establish theoretical loading rates for chloride as it enters Swan Lake, the surrounding basin area was partitioned into four main land uses that contribute to the majority of the chloride loading. These included the following categories: Wetlands, Agricultural Lands (corn, grassland, hay, and hobby farm), Residential, Industrial and Roadways surrounding Swan Lake (Figure 1). Using both literature values and actual application rates provided by land users, average input values per unit area were estimated and used to calculate theoretical annual chloride mass flux into Swan Lake.

3.3.2 Chloride Loading Based on Groundwater Discharge and Water Quality

As will be seen in the water balance section below for Swan Lake, surface water contribution from BX Creek is significant; whereas, groundwater discharging via the alluvial aquifer associated with BX Creek accounts for a relatively small portion of the recharge to Swan Lake. Groundwater recharge (flow) into Swan Lake can transport with it, anthropogenic pollutants. To estimate ambient chloride concentration in the aquifer sampling location MW-3, 300 m northeast of the lake was used as a measure of 'background' chloride concentrations. The foreshore samples taken on the east and north shores of Swan Lake were used as an indication of the increase in chloride concentrations due to the different land-use practices upgradient of the lake. The ambient chloride concentrations used in this study is 16 mg/l. The geometric annual mean of the foreshore sampling on the east shoreline was calculated to be 154 mg/l. Using these measured chloride concentrations and the aquifer discharge into Swan Lake, an annual flux of chloride loading into Swan Lake was made. Further, an estimate of chloride mass flux into Swan Lake assuming no anthropogenic impact was calculated.

The groundwater recharge equation for an unconfined aquifer to Swan Lake is characterized by Darcy's Law and the equation is as follows:

$$Q = -K * i * A$$

Where:

Q = Discharge into Swan Lake (length^3/time);
k = Hydraulic conductivity (length/time);
i = Hydraulic gradient (length/length); and
A = Cross sectional area (aquifer width (length) * saturated thickness (length)).

4. RESULTS

The following sections summarize the results of the land use and water quality assessment of Swan Lake. Sections below include results on the following aspects of the study:

- Swan Lake seasonal water budget;
- Water quality assessment including temporal and spatial results along with assessment of water quality exceedances; and
- Estimates of mass flux of water quality indicator parameters.

4.1 Swan Lake Water Balance

The following section discusses the seasonal water budget for Swan Lake which utilized measured stream discharges assessed during the 2016 sampling events. The major components in the calculation included precipitation, evaporation, stream and spring inputs, and output, gains and losses from groundwater and surface water use. Table 5 summarizes the stream gauging measurements made during the sampling events in 2016. Table 5 is a monthly breakdown of the Swan Lake water budget estimates.

Swan Lake has a volume of approximately 24,744,000 m^3 (FISS, 2013), dividing the Volume of the inputs (0.72 m2/sec or 22,678,000 m^3/year), Swan Lake has a calculated residence time of approximately 1 year. The primary influx of water into Swan Lake is from BX Creek which enters at the south end of the lake and accounts for over 75% of total input. BX Creek is derived primarily from higher elevation snowmelt, with 70% of the flow arriving during freshet in the months of April, May, and June (Figure 3).

There are three smaller creeks at the north end of the lake:

- Site 3 (Cowboys Creek);
- Malysh Creek Site 5 (Culverted Stream); and
- Greenhow Creek (FS 43 (SW)).

All three smaller inflowing tributaries are potentially ephemeral and can stop flowing completely in the summer, fall, and winter. During baseflow (late summer, fall, and winter), for example, Greenhow Creek was reduced to no flow in August 2016 and returned to flowing in November 2016 (Table 5).

Along with the three streams, the following three springs were sampled in 2016 (see Figure 1 for locations):

- SE Spring (Culverted);
- NW Spring (Culverted); and
- SW Spring (Culverted).

With the SE Spring flowing throughout 2016 (Table 5). Small tributaries and springs accounted for the second largest input into Swan Lake at 16% of the total estimated inputs.

Precipitation accounted for 10% of the total influx. Seasonally, most of the precipitation occurs during the winter and late fall and enters the lake in early spring.

Groundwater contributions to Swan Lake was estimated at about 1%, with an annual average estimated to be 0.006 m^3/sec and is primarily from the unconfined aquifer that sees most of the in-flow from the east. The aquifer formation consists chiefly of lacustrine deposits on the order of 60 m thick (Golder and Summit, 2009). The primary groundwater flow direction is from north to south through the Spallumcheen aquifer and to a lesser extent from east to southwest from the BX Creek associated aquifer. For this first order approximation of the water budget estimates, we assume that the groundwater flow into Swan Lake is constant throughout the year.

The primary water output from Swan Lake is at the south end of the lake primarily through Vernon Creek (also referred to as Lower BX Creek), just 200 metres west of where BX Creek enters the lake (Figure 2). Annual output flows total 0.764 m^3/sec, accounting for 94% of total output. Seasonally, the output via Vernon Creek mirrors the seasonal inputs from BX Creek with the majority of the flow occurring in the spring.

Total evaporation was calculated to average 0.036 m^3/sec annually and was estimated using average monthly temperatures as per recommendation of the latest Okanagan Basin Evaporation Study (Schertzer, 2009). A search of the MoE database revealed only 2 registered surface water licenses on Swan Lake. Of these two, only one reported the allowed quantity of 0.0064 m^3/sec. For the water balance calculations, it was assumed that the total allowed consumption was used, for a potential annual extraction of 0.01 m^3/sec.

There is a difference of 11% between outputs and inputs, which would translate to a 0.65 m drop in lake level during the 2016 season. Some potential reasons for this difference may include the following: a fluctuation in the lake level of 0.65 meters from one year to the next, an under estimation of evaporation, losses to groundwater likely occurring out the south end of the lake to the downgradient aquifer, losses from BX Creek to the underlying aquifer between the point where it leaves Swan Lake at Vernon Creek, and where the stream flow data was collected.

Table 5: Summary of Steam Gauging at the Swan Lake Tributaries and Springs in 2016

In / Out	Stream Gauging Site Location Name	Discharge m³/sec		
	Date	29-Mar-16	11-Aug-16	02-Nov-16
Inflow	BX Creek	1.429	0.042	0.335
	Site 3 (Cowboys Creek)	0.002	0.00003	0
	Site 5 (Culvert Stream – Malysh Creek)	0.061	0.0013	0.024
	FS 43 (SW) (Greenhow Creek)	0.172	0	0.0035
	SE Spring	0.0078	0.004	0.007
	NW Spring	0.0009	0	0
	SW Spring	0.0002	0	0
Outflow	Storm Drainage - Inflow into Vernon Creek	0.005	0.004	0.010
	Vernon Creek (also called lower BX Creek)	2.271	0.158	0.100

Table 6: 2016 Water Balance, Monthly Inputs and Outputs for Swan Lake

	INFLOW					OUTFLOW				
Month	Precip.	Groundwater	BX Creek	Small Creeks and Springs	Total In	Vernon Creek	Evaporation	Water Use	Total Out	Change is Storage (Sum In – Sum Out)
Jan	0.088	0.006	0.29	0.35	0.735	0.4	0	0.0102	0.45	0.284
Feb	0.043	0.006	0.73	0.13	0.906	1.12	0	0.0102	1.13	-0.227
March	0.049	0.006	1.26	0.22	1.533	2	0.02	0.0102	2.03	-0.495
April	0.049	0.006	1.25	0.21	1.515	2	0.03	0.0102	2.04	-0.520
May	0.078	0.006	0.97	0.16	1.214	1.57	0.04	0.0102	1.62	-0.409
June	0.084	0.006	0.62	0.10	0.817	1.04	0.05	0.0102	1.11	-0.290
July	0.060	0.006	0.32	0.05	0.438	0.58	0.07	0.0102	0.67	-0.230
August	0.054	0.006	0.09	0.01	0.158	0.19	0.07	0.0102	0.27	-0.111
September	0.055	0.006	0.17	0.02	0.247	0.13	0.05	0.0102	0.19	0.057
Oct	0.070	0.006	0.28	0.03	0.390	0.12	0.03	0.0102	0.15	0.238
Nov	0.097	0.006	0.27	0.03	0.400	0.02	0.02	0.0102	0.05	0.348
Dec	0.096	0.006	0.12	0.06	0.277	0.00	0	0.0102	0.01	0.266
Annual Averages	**0.069**	**0.006**	**0.530**	**0.115**	**0.719**	**0.764**	**0.036**	**0.01**	**0.810**	**-0.091**
Percentage of Total Input or Output	**10%**	**1%**	**74%**	**16%**	**100%**	**94%**	**4%**	**1%**	**100%**	**-11%**

Note: all fluxes are presented in units of m³/sec.

4.2 Additional Vernon Creek and Swan Lake Sampling

In 2016 additional sampling was made at the outlet of Swan Lake (Vernon Creek) to assess a more robust list of periphyton in chlorophyll-a along with pathogenic bacteria (Fecal coliform, Enterococci, *Escherichia coli (E. coli.)*), suspended solids and dissolved oxygen. Section 3.2.1.2 describes the method used to sample and calculate the periphyton in chloraphyll-a at the outlet of Swan Lake. The chlorophyll-a at Vernon Creek (outlet of Swan Lake) was estimated to be 108.1 mg/m^2; which is above the MoE Water Quality Criteria for Nutrients and Algae guidelines, short-term maximum (MoE 2017) for the protection of aquatic life in streams of 100 mg/m^2. These guidelines apply province-wide to ambient water quality for variables that are important for surface waters of British Columbia. More specifically, this criterion is designed to protect fish habitat and changes in communities of organisms such as invertebrates. The criteria are to protect water resources from degradation caused by excessive amounts of algae, which may impair human use of lakes and streams. Typically, increased concentrations of algae occur due to an oversupply of nutrients such as phosphorus or nitrate.

In 2015 and spring 2016 sampling of Swan Lake were taken at the shoreline as a grab sample. In August and November 2016 Swan Lake was sampled from a boat where the lake is the deepest as was detailed in the Bathometric survey (FSS 1959) (shown in 5 feet increments on Figure 2) with the location sampled indicated on Figure 1. Table 7 provides a summary of the depth, thermocline and field measured water quality data (temperature, dissolved oxygen and electrical conductivity). The Van Dorn sampler was used to take a bid-basin sample based on the depth profile and the thermocline. Water quality results from the Swan Lake sampling in 2015-16 will be discussed below, along with the other sampled locations.

Table 7: Summary of Swan Lake Thermocline and Field Measured Water Quality Data

Date Sampled	Depth (m Below Water Surface)	Temperature (°C)	DO (mg/L)	EC (µS/cm)
15-Aug-16	1	25	9.78	479
	2	24.96	9.72	479
	3	24.92	9.72	479
	4	**24.15**	**9.72**	**479**
	5	24.13	9.71	479
	6	24.13	9.71	479
	7	24.13	9.71	479
10-Nov-16	0	9.6	10.9	488
	1	9.6	10.43	488
	2	9.5	10.32	488
	3	**9.4**	**10.27**	**485**
	4	9.6	10.21	490
	5	9.8	10.15	497

Note: Bolded value is the depth is where sample was taken with Van Dorn Sampler.

4.3 Water Quality Assessment

The following section provides discussion on the water quality in and around Swan Lake and how it relates to land use surrounding the lake. Our analysis of potential anthropogenic (human caused) impacts on the receiving environment (groundwaters and surface waters in and around Swan Lake) employs two main approaches:

- direct comparison of results to applicable water quality guidelines; answering the question "does a problem exist" from existing land use; and
- trend analysis, what does the input from land use around the lake look like over time and spatially.

Our findings can then be used to inform decisions about future monitoring priorities as well as provide insight to the RDNO as to what areas should be prioritized for centralized wastewater treatment. Sometimes, the results are inconclusive, pointing to the need for more data.

Recall that the objective of the current study is to assess potential impact to the receiving environment from land use surrounding Swan Lake. The receptors of concern are Swan Lake itself, hyporheic waters (shallow groundwater discharging into the lake), tributaries and springs feeding the lake and Vernon Creek (outlet of Swan Lake). Land use around the lake consists primarily of domestic homes, light industrial and agriculture. The area around the lake is serviced by municipal water supply; however, any property owner could install a water well, which could be used for drinking, irrigation, or livestock watering. Therefore, the 2015-16 water quality results were compared to the following applicable provincial and federal guidelines:

- Guidelines for Canadian Drinking Water Quality - Aesthetic Objectives (GCDWQ AO);
- Guidelines for Canadian Drinking Water Quality - Maximum Acceptable Concentrations (GCDWQ MAC);
- BC Approved Water Quality Guidelines for drinking water (BCAWQG DW);
- BC Approved Water Quality Guidelines for irrigation (BCAWQG I);
- Working Water Quality Guidelines for British Columbia for irrigation (BCWWQG I);
- BC Approved Water Quality Guidelines for livestock (BCAWQG L); and
- Working Water Quality Guidelines for British Columbia for livestock (BCWWQG L).

Further, surface waters were compared to the following federal and provincial aquatic water guidelines:

- Canadian water quality guidelines for the protection of freshwater aquatic life. (CCME AL);
- BC Approved Water Quality Guidelines for freshwater aquatic life (BCAWQG AL);
- BC Approved Water Quality Guidelines for freshwater aquatic life (30-day average) (BCAWQG ALA); and
- Working Water Quality Guidelines for British Columbia for freshwater aquatic life (BCWWQG AL).

As discussed above, the purpose of sampling at foreshore locations is to assess concentrations of septic indicator parameters in the hyporheic zone (zone of mixing between groundwater and surface water) just before groundwater discharges into Swan Lake. Concentrations of indicator parameters may vary in the hyporheic zone depending on the dynamics of groundwater and surface water interaction. During spring freshet, the lake stage (level) could be higher than the adjacent groundwater level, creating a water table that is at surface (flooding), at the perimeter of the lake. During the fall sampling, there is less dilution of

the groundwater caused be snowmelt runoff in the spring, this time of year is referred to as baseflow. Concentration of contaminates can be higher during baseflow due to the lack of dilution which can occur in the spring.

To help our spatial assessment of the water quality results, the perimeter of the lake was linearized, with kilometer (km) zero being set as Vernon Creek (the outlet of Swan Lake). The increasing lineal distance moves counter-clockwise, from southeast to northeast and around the northwest to southwest ending at Vernon Creek (the outlet of Swan Lake (km 11.5)). The linearized perimeter distance for each sampled location is provided in Table 4, above. The perimeter plots provided in the figures attached show the averaged values for the parameters assessed. The time-series plots provide select parameter concentrations over the sampling period. Spatial and time-series plots are provided for the waters sampled in 2015-16 (Figures 4-21, attached), for the following select anthropogenic indicator parameters:

- Electrical Conductivity (Figures 4 and 5);
- Chloride (Figures 6 and 7);
- Sulphate (Figures 8 and 9a and 9b);
- Fluoride (Figure 10 and 11)
- Ammonia (Figures 12 and 13);
- Nitrate (Figures 14 and 15);
- Sodium (total for surface waters and dissolved for groundwaters) (Figures 16 and 17); and
- Uranium (total for surface waters and dissolved for groundwaters) (Figures 18 and 19).

Please note that water quality results below the reportable detection limit are displayed as one-half the reportable detection limit on the Figures attached.

For the relevant land uses around Swan Lake, we provide lists of exceedances for surface water results by guideline (Table 8) and by parameter (Table 9) and for groundwaters by guideline (Table 10) and by parameter (Table 11). Appendix A provides the full water quality database for all locations sampled in 2015-16. Appendix B contains the water quality laboratory reports for all sampling events.

Owners of domestic wells were notified by WWAL of any exceedances of the GCDWQ MAC.

Table 8 Exceedances of Surface Water Quality Results by Guideline

Sampling	Guideline	Exceedances
BX Creek	BCAWQG AL	Selenium (total)
	BCAWQG ALA	Selenium (total)
	GCDWQ AO	Temperature [F]
	BCAWQG DW	Phosphorus (total, APHA 4500-P), Phosphorus (dissolved, APHA 4500-P), Temperature [F]
	CCME AL	Aluminum (total), Selenium (total)
FS-43 (SW)	BCAWQG ALA	Chloride
	BCWWQG AL	Uranium (total)
	GCDWQ MAC	E. coli (MPN), Fecal coliforms (MPN), Total coliforms (MPN)
	GCDWQ AO	Temperature [F]
	BCAWQG I	Chloride
	BCWWQG I	Conductivity [F], Conductivity, Uranium (total)
	BCAWQG DW	E. coli (MPN), Fecal coliforms (MPN), pH [F], Phosphorus (total, APHA 4500-P),Temperature [F]
	CCME AL	Aluminum (total), Chloride, Fluoride, Uranium (total)
NW Spring	BCWWQG I	Conductivity
	CCME AL	Fluoride
SE Spring	BCAWQG AL	Selenium (total)
	BCAWQG ALA	Nitrate (as N), Nitrate + Nitrite (as N) (calculated), Selenium (total)
	BCWWQG AL	Chromium (total), Uranium (total)
	GCDWQ MAC	Uranium (total)
	BCWWQG I	Conductivity [F], Conductivity, Uranium (total)
	BCAWQG DW	Phosphorus (total, by ICPMS/ICPOES)
	CCME AL	Chromium (total), Fluoride, Nitrate (as N), Nitrate + Nitrite (as N) (calculated), Selenium (total), Uranium (total)
Site 3 (NE-Cowboys)	BCAWQG AL	Temperature [F]
	BCAWQG ALA	Nitrate (as N), Nitrate + Nitrite (as N) (calculated), Temperature [F]
	BCWWQG AL	Uranium (total)
	GCDWQ MAC	Uranium (total)
	GCDWQ AO	Iron (total), Temperature [F]
	BCAWQG I	Chloride
	BCWWQG I	Conductivity [F], Conductivity, Uranium (total)
	BCAWQG DW	Phosphorus (total, APHA 4500-P), Temperature [F]
	CCME AL	Aluminum (total), Copper (total), Fluoride, Iron (total), Nitrate (as N), Nitrate + Nitrite (as N) (calculated), Uranium
Site 5 (NE-Culvert)	BCAWQG ALA	Nitrate (as N), Nitrate + Nitrite (as N) (calculated)
	GCDWQ MAC	E. coli (MPN), Fecal coliforms (MPN), Total coliforms (MPN)
	GCDWQ AO	Iron (total), Manganese (total)
	BCAWQG I	Chloride, pH [F]
	BCWWQG I	Conductivity [F], Conductivity
	BCAWQG DW	E. coli (MPN), Fecal coliforms (MPN), pH [F], Phosphorus (total, by ICPMS/ICPOES)
	CCME AL	Aluminum (total), Copper (total), Fluoride, Iron (total), Nitrate (as N), Nitrate + Nitrite (as N) (calculated), pH [F],
Site5b (NE-culvert)	BCAWQG AL	Arsenic (total), Copper (total), Iron (total), Manganese (total), Silver (total), Temperature [F], Zinc (total)
	BCAWQG ALA	Arsenic (total), Cobalt (total), Copper (total), Iron (total), Lead (total), Manganese (total), Silver (total), Temperature
	BCWWQG AL	Barium (total), Beryllium (total), Chromium (total), Uranium (total)
	GCDWQ MAC	Arsenic (total), Barium (total), Chromium (total), Lead (total)
	GCDWQ AO	Iron (total), Manganese (total), pH, Temperature [F]
	BCAWQG L	Aluminum (total), Arsenic (total)
	BCWWQG L	Chromium (total)
	BCAWQG I	Aluminum (total), Chloride
	BCWWQG I	Chromium (total), Conductivity [F], Conductivity, Manganese (total), Uranium (total)
	BCAWQG DW	Arsenic (total), Lead (total), pH, Phosphorus (total, by ICPMS/ICPOES), Phosphorus (total, APHA 4500-P), Phosphorus
	CCME AL	Aluminum (total), Arsenic (total), Cadmium (total), Chloride, Chromium (total), Copper (total), Fluoride, Iron (total),
Storm Drainage	BCAWQG AL	Copper (total), Iron (total), Selenium (total), Zinc (total)
	BCAWQG ALA	Copper (total), Iron (total), Selenium (total), Zinc (total)
	BCWWQG AL	Antimony (total), Chromium (total)
	GCDWQ MAC	Antimony (total)
	GCDWQ AO	Iron (total), Manganese (total), Temperature [F]
	BCWWQG I	Chromium (total), Conductivity [F], Conductivity
	BCAWQG DW	Phosphorus (total, by ICPMS/ICPOES), Temperature [F]
	CCME AL	Aluminum (total), Chromium (total), Copper (total), Fluoride, Iron (total), Selenium (total), Zinc (total)
SW Spring	BCAWQG AL	Sulphate
	BCAWQG ALA	Nitrate (as N), Nitrate + Nitrite (as N) (calculated), Sulphate
	GCDWQ AO	Sulphate
	BCAWQG I	Chloride
	BCWWQG I	Conductivity [F], Conductivity
	BCAWQG DW	Phosphorus (dissolved, by ICPMS/ICPOES), Sulphate
	CCME AL	Fluoride, Nitrate (as N), Nitrate + Nitrite (as N) (calculated)
Swan Lake	BCAWQG AL	Temperature [F]
	BCAWQG ALA	Temperature [F]
	GCDWQ MAC	Total coliforms (MPN)
	GCDWQ AO	Temperature [F]
	BCAWQG DW	Phosphorus (total, by ICPMS/ICPOES), Temperature [F]
	CCME AL	Ammonia (total, as N), Fluoride
Vernon Creek (Outlet)	BCAWQG AL	Iron (total), Temperature [F]
	BCAWQG ALA	Copper (total), Iron (total), Temperature [F]
	BCWWQG AL	Chromium (total)
	GCDWQ MAC	E. coli (MPN), Fecal coliforms (MPN), Total coliforms (MPN)
	GCDWQ AO	Iron (total), Manganese (total), pH [F], Temperature [F]
	BCAWQG L	E. coli (MPN), Enterococcus (MPN), Fecal coliforms (MPN)
	BCAWQG I	E. coli (MPN), Enterococcus (MPN), Fecal coliforms (MPN)
	BCWWQG I	Chromium (total)
	BCAWQG DW	E. coli (MPN), Enterococcus (MPN), Fecal coliforms (MPN), Phosphorus (total, APHA 4500-P),Temperature [F]
	CCME AL	Aluminum (total), Chromium (total), Copper (total), Fluoride, Iron (total), Selenium (total), Zinc (total)

[F] = Field Result(s)

Table 9 Exceedances of Surface Water Quality Results by Parameter

Parameters	BX Creek	FS-43 (SW)	NW Spring	SE Spring	Site 3 (NE-Cowboys)	Site 5 (NE-Culvert)	Site5b (NE-Culvert)	Storm Drainage	SW Spring	Swan Lake	Vernon Creek (Outlet)
Field Results											
Conductivity		X		X	X	X	X	X	X		
pH		X				X					X
Temperature	X	X			X		X	X		X	X
Lab Results											
General											
Chloride		X			X	X	X		X		
Conductivity		X	X	X	X	X	X	X	X		
Fluoride		X	X	X	X	X	X	X	X	X	X
pH							X				
Sulphate									X		
Microbiological											
E. coli (MPN)		X				X					X
Enterococcus (MPN)											X
Fecal coliforms (MPN)		X				X					X
Total coliforms (MPN)		X				X				X	X
Nutrients											
Ammonia (total, as N)										X	
Nitrate (as N)				X	X	X			X		
Nitrate + Nitrite (as N) (calculated)				X	X	X			X		
Nitrite (as N)							X				
Phosphorus (dissolved, by ICPMS/ICPOES)		X			X			X	X	X	
Phosphorus (total, by ICPMS/ICPOES)				X		X	X	X		X	X
Phosphorus (total, APHA 4500-P)	X	X		X	X	X	X	X		X	X
Phosphorus (dissolved, APHA 4500-P)	X	X		X	X	X	X	X		X	X
Total Metals											
Aluminum (total)	X	X			X	X	X	X			X
Antimony (total)								X			
Arsenic (total)							X				
Barium (total)							X				
Beryllium (total)							X				
Cadmium (total)							X				
Chromium (total)				X			X	X			X
Cobalt (total)							X				
Copper (total)					X	X	X	X			X
Iron (total)					X	X	X	X			X
Lead (total)							X				
Manganese (total)						X	X	X			X
Selenium (total)	X			X				X			X
Silver (total)							X				
Uranium (total)		X		X	X		X				
Zinc (total)						X	X	X			X

Table 10 Exceedances of Groundwater Quality Results by Guideline

Sampling Location	Guideline	2016 Exceedances	2015 Exceedances
FS-3	GCDWQ MAC	Uranium (dissolved)	E. coli (MPN), Fecal coliforms (MPN), Fluoride, Total coliforms (MPN), Uranium (dissolved)
	GCDWQ AO	Manganese (dissolved), Temperature [F]	Manganese (dissolved), pH [F], Sulphate, Temperature [F]
	BCAWQG L		E. coli (MPN), Fecal coliforms (MPN), Fluoride, Sulphate
	BCWWQG L		Sulphate
	BCAWQG I		Chloride, E. coli (MPN)
	BCWWQG I	Conductivity [F], Conductivity, Manganese (dissolved), Uranium (dissolved)	Conductivity [F], Manganese (dissolved), Uranium (dissolved)
	BCAWQG DW	pH [F], Phosphorus (total, APHA 4500-P), Temperature [F]	E. coli (MPN), Fecal coliforms (MPN), Fluoride, Sulphate, Temperature [F]
FS-15	GCDWQ MAC	Fluoride, Uranium (dissolved)	E. coli (MPN), Fecal coliforms (MPN), Fluoride, Selenium (dissolved), Total coliforms (MPN), Uranium (dissolved)
	GCDWQ AO	Chloride, Iron (dissolved), Manganese (dissolved), Sodium (dissolved), Sulphate, Temperature [F]	Chloride, pH [F], Sodium (dissolved), Sulphate
	BCAWQG L	Fluoride, Molybdenum (dissolved), Sulphate	Fluoride, Molybdenum (dissolved), Selenium (dissolved)
	BCWWQG L	Sulphate	Uranium (dissolved)
	BCAWQG I	Chloride, Fluoride, Molybdenum (dissolved)	Chloride, Fluoride, Molybdenum (dissolved), pH [F], Selenium (dissolved)
	BCWWQG I	Conductivity [F], Conductivity, Manganese (dissolved), Uranium (dissolved)	Conductivity [F], Uranium (dissolved)
	BCAWQG DW	Aluminum (dissolved), Chloride, Fluoride, Phosphorus (dissolved, by ICPMS/ICPOES), Phosphorus (total, APHA 4500-P), Phosphorus (dissolved, APHA 4500-P), Sulphate, Temperature [F]	Chloride, E. coli (MPN), Fecal coliforms (MPN), Fluoride, pH [F], Selenium (dissolved), Sulphate
FS-21	GCDWQ MAC	Uranium (dissolved)	E. coli (MPN), Fecal coliforms (MPN), Total coliforms (MPN), Uranium (dissolved)
	GCDWQ AO	Manganese (dissolved), Sodium (dissolved), Sulphate	Manganese (dissolved), pH [F], Sodium (dissolved), Temperature [F]
	BCAWQG L	Sulphate	E. coli (MPN), Fecal coliforms (MPN)
	BCWWQG L	Sulphate	
	BCAWQG I		pH [F]
	BCWWQG I	Conductivity [F], Conductivity, Manganese (dissolved), Uranium (dissolved)	Conductivity [F], Manganese (dissolved), Uranium (dissolved)
	BCAWQG DW	Phosphorus (dissolved, by ICPMS/ICPOES), Phosphorus (total, APHA 4500-P), Phosphorus (dissolved, APHA 4500-P), Sulphate	E. coli (MPN), Fecal coliforms (MPN), pH [F], Temperature [F]
FS-28	GCDWQ MAC	Arsenic (dissolved), Uranium (dissolved)	E. coli (MPN), Fecal coliforms (MPN), Total coliforms (MPN), Uranium (dissolved)
	GCDWQ AO	Iron (dissolved), Manganese (dissolved), pH, Sulphate, Temperature [F]	Manganese (dissolved), pH [F], Temperature [F]
	BCAWQG L		E. coli (MPN), Fecal coliforms (MPN)
	BCAWQG I		E. coli (MPN)
	BCWWQG I	Conductivity [F], Conductivity, Manganese (dissolved), Uranium (dissolved)	Conductivity [F], Manganese (dissolved), Uranium (dissolved)
	BCAWQG DW	Arsenic (dissolved), Phosphorus (dissolved, by ICPMS/ICPOES), Phosphorus (total, APHA 4500-P), Phosphorus (dissolved, APHA 4500-P), Sulphate, Temperature [F]	E. coli (MPN), Fecal coliforms (MPN), Temperature [F]
FS-29	GCDWQ MAC	Uranium (dissolved)	E. coli (MPN), Fecal coliforms (MPN), Total coliforms (MPN), Uranium (dissolved)
	GCDWQ AO	Manganese (dissolved), Sodium (dissolved), Sulphate, Temperature [F]	Manganese (dissolved), Sulphate, Temperature [F]
	BCAWQG L	Molybdenum (dissolved), Sulphate	E. coli (MPN), Fecal coliforms (MPN), pH [F], Sulphate
	BCWWQG L	Sulphate, Uranium (dissolved)	Sulphate
	BCAWQG I	Molybdenum (dissolved)	E. coli (MPN), Fecal coliforms (MPN), pH [F]
	BCWWQG I	Conductivity [F], Conductivity, Manganese (dissolved), Uranium (dissolved)	Conductivity [F], Manganese (dissolved), Uranium (dissolved)
	BCAWQG DW	Phosphorus (dissolved, by ICPMS/ICPOES), Phosphorus (total, APHA 4500-P), Phosphorus (dissolved, APHA 4500-P), Sulphate, Temperature [F]	E. coli (MPN), Fecal coliforms (MPN), pH [F], Sulphate, Temperature [F]
FS-31	GCDWQ MAC	Arsenic (dissolved)	E. coli (MPN), Fecal coliforms (MPN), Total coliforms (MPN)
	GCDWQ AO	Iron (dissolved), Manganese (dissolved), pH [F], Temperature [F]	Iron (dissolved), Manganese (dissolved), Temperature [F]
	BCAWQG L	pH [F]	E. coli (MPN), Fecal coliforms (MPN)
	BCAWQG I	Chloride, pH [F]	Chloride
	BCWWQG I	Conductivity [F], Conductivity, Manganese (dissolved), Uranium (dissolved)	Conductivity [F], Manganese (dissolved)
	BCAWQG DW	Arsenic (dissolved), pH [F], Phosphorus (dissolved, by ICPMS/ICPOES), Phosphorus (total, APHA 4500-P), Phosphorus (dissolved, APHA 4500-P), Temperature [F]	E. coli (MPN), Fecal coliforms (MPN), Phosphorus (dissolved, by ICPMS/ICPOES), Temperature [F]
FS-32	GCDWQ MAC	Uranium (dissolved)	E. coli (MPN), Fecal coliforms (MPN), Total coliforms (MPN)
	GCDWQ AO	Chloride, Iron (dissolved), Manganese (dissolved), pH, Sodium (dissolved), Temperature [F]	Manganese (dissolved), pH [F], Temperature [F]
	BCAWQG L	Molybdenum (dissolved)	E. coli (MPN), Fecal coliforms (MPN)
	BCAWQG I	Chloride, Molybdenum (dissolved)	Chloride, E. coli (MPN)
	BCWWQG I	Conductivity [F], Conductivity, Manganese (dissolved), Uranium (dissolved)	Conductivity [F], Manganese (dissolved), Uranium (dissolved)
	BCAWQG DW	Chloride, Phosphorus (dissolved, by ICPMS/ICPOES), Phosphorus (total, APHA 4500-P), Phosphorus (dissolved, APHA 4500-P), Temperature [F]	E. coli (MPN), Fecal coliforms (MPN), Phosphorus (dissolved, by ICPMS/ICPOES), Temperature [F]
FS-33	GCDWQ MAC	Uranium (dissolved)	
	GCDWQ AO	Manganese (dissolved), pH [F], Temperature [F]	pH [F], Temperature [F]
	BCAWQG I	Chloride	Chloride
	BCWWQG I	Conductivity [F], Conductivity, Manganese (dissolved), Uranium (dissolved)	Conductivity [F]
	BCAWQG DW	Phosphorus (total, APHA 4500-P), Temperature [F]	Temperature [F]
FS-43	GCDWQ MAC	Uranium (dissolved)	E. coli (MPN), Fecal coliforms (MPN), Total coliforms (MPN)
	GCDWQ AO	Chloride, Sodium (dissolved), Sulphate, Sulphide (total, as S)	Chloride, pH [F], Sulphate, Temperature [F]
	BCAWQG L	Sulphate	Sulphate
	BCWWQG L	Sulphate	Sulphate
	BCAWQG I	Chloride	Chloride
	BCWWQG I	Conductivity [F], Conductivity, Uranium (dissolved)	Conductivity [F], Uranium (dissolved)
	BCAWQG DW	Chloride, Phosphorus (dissolved, by ICPMS/ICPOES), Sulphate	Chloride, E. coli (MPN), Fecal coliforms (MPN), pH [F], Phosphorus (dissolved, by ICPMS/ICPOES), Sulphate, Temperature
FS-45	GCDWQ MAC	Uranium (dissolved)	E. coli (MPN), Fecal coliforms (MPN), Total coliforms (MPN), Uranium (dissolved)
	GCDWQ AO	Manganese (dissolved), Sulphate, Temperature [F]	Manganese (dissolved), Temperature [F]
	BCAWQG L	Molybdenum (dissolved)	
	BCAWQG I	Molybdenum (dissolved)	
	BCWWQG I	Conductivity [F], Conductivity, Manganese (dissolved), Uranium (dissolved)	Conductivity [F], Manganese (dissolved), Uranium (dissolved)
	BCAWQG DW	Phosphorus (total, APHA 4500-P), Phosphorus (dissolved, APHA 4500-P), Sulphate, Temperature [F]	E. coli (MPN), Fecal coliforms (MPN), Temperature [F]
FS-101	GCDWQ MAC	Uranium (dissolved)	Fecal coliforms (MPN), Total coliforms (MPN)
	GCDWQ AO	Sodium (dissolved), Sulphate, Temperature [F]	pH [F], Temperature [F]
	BCAWQG L	Sulphate	
	BCWWQG L	Sulphate	
	BCWWQG I	Conductivity [F], Conductivity, Uranium (dissolved)	Conductivity [F], Uranium (dissolved)
	BCAWQG DW	Phosphorus (dissolved, by ICPMS/ICPOES), Phosphorus (total, APHA 4500-P), Phosphorus (dissolved, APHA 4500-P), Sulphate, Temperature [F]	Fecal coliforms (MPN), Phosphorus (dissolved, by ICPMS/ICPOES), Temperature [F]
FS-103	GCDWQ MAC		E. coli (MPN), Fecal coliforms (MPN), Total coliforms (MPN)
	GCDWQ AO	Manganese (dissolved), pH, Temperature [F]	pH [F], Temperature [F]
	BCAWQG I		Chloride
	BCWWQG I	Conductivity [F], Conductivity, Manganese (dissolved)	Conductivity [F], Uranium (dissolved)
	BCAWQG DW	Phosphorus (total, APHA 4500-P), Phosphorus (dissolved, APHA 4500-P), Temperature [F]	E. coli (MPN), Fecal coliforms (MPN), Temperature [F]
FS-104	GCDWQ MAC		E. coli (MPN), Fecal coliforms (MPN), Total coliforms (MPN)
	GCDWQ AO	Manganese (dissolved), Temperature [F]	pH [F], Temperature [F]
	BCAWQG L		pH [F]
	BCAWQG I	Chloride	pH [F], Selenium (dissolved)
	BCWWQG I	Conductivity [F], Conductivity, Uranium (dissolved)	Conductivity [F], Uranium (dissolved)
	BCAWQG DW	Phosphorus (dissolved, by ICPMS/ICPOES), Phosphorus (total, APHA 4500-P), Phosphorus (dissolved, APHA 4500-P), Temperature [F]	E. coli (MPN), Fecal coliforms (MPN), pH [F], Selenium (dissolved), Temperature [F]
FS-104b	GCDWQ MAC	Uranium (dissolved)	
	GCDWQ AO	Manganese (dissolved)	
	BCAWQG I	Selenium (dissolved)	
	BCWWQG I	Conductivity [F], Conductivity, Uranium (dissolved)	
	BCAWQG DW	Phosphorus (dissolved, by ICPMS/ICPOES), Phosphorus (total, APHA 4500-P), Phosphorus (dissolved, APHA 4500-P), Selenium (dissolved)	
MW-1	GCDWQ MAC	Uranium (dissolved)	Total coliforms (MPN), Uranium (dissolved)
	GCDWQ AO	Chloride, Iron (dissolved), Manganese (dissolved), Sodium (dissolved), Sulphate	Chloride, Manganese (dissolved), pH [F], Sodium (dissolved), Sulphate
	BCAWQG L	Sulphate	Sulphate
	BCWWQG L	Sulphate	Sulphate
	BCAWQG I	Chloride	Chloride
	BCWWQG I	Conductivity [F], Conductivity, Manganese (dissolved), Uranium (dissolved)	Conductivity [F], Manganese (dissolved), Uranium (dissolved)
	BCAWQG DW	Aluminum (dissolved), Chloride, Phosphorus (dissolved, by ICPMS/ICPOES), Phosphorus (total, APHA 4500-P), Phosphorus (dissolved, APHA 4500-P), Sulphate	Chloride, Phosphorus (dissolved, by ICPMS/ICPOES), Sulphate
MW-2	GCDWQ AO	Manganese (dissolved)	Manganese (dissolved), Temperature [F]
	BCAWQG DW		Temperature [F]
MW-3	GCDWQ AO	Iron (dissolved), Manganese (dissolved), Temperature [F]	Manganese (dissolved), Temperature [F]
	BCAWQG DW	Phosphorus (dissolved, by ICPMS/ICPOES), Phosphorus (total, APHA 4500-P), Phosphorus (dissolved, APHA 4500-P), Temperature [F]	Temperature [F]

[F] = Field Result(s)

Table 11: Exceedances of Groundwater Quality Results by Parameter

Parameter	FS-3	FS-15	FS-21	FS-28	FS-29	FS-31	FS-32	FS-33	FS-43	FS-45	FS-101	FS-103	FS-104	FS-104b	MW-1	MW-2	MW-3
Field Results																	
Conductivity	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
pH	X	X	X	X	X	X	X	X	X		X	X	X		X		
Temperature	X	X	X	X	X	X	X	X	X	X	X	X	X			X	X
Lab Results																	
Dissolved Metals																	
Aluminum (dissolved)		X													X		
Arsenic (dissolved)				X		X											
Iron (dissolved)		X		X		X	X								X		X
Manganese (dissolved)	X	X	X	X	X	X	X	X		X		X	X	X	X	X	X
Molybdenum (dissolved)		X			X		X			X							
Selenium (dissolved)		X											X	X			
Sodium (dissolved)		X	X		X		X		X		X				X		
Uranium (dissolved)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
General																	
Chloride	X	X				X	X	X	X			X	X		X		
Conductivity	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
Fluoride	X	X															
pH				X			X					X					
Sulphate	X	X	X	X	X				X	X	X				X		
Sulphide (total, as S)									X								
Microbiological																	
E. coli (MPN)	X	X	X	X	X	X	X		X	X		X	X				
Fecal coliforms (MPN)	X	X	X	X	X	X	X		X	X	X	X	X				
Total coliforms (MPN)	X	X	X	X	X	X	X		X	X	X	X	X		X		
Nutrients																	
Phosphorus (dissolved, by ICPMS/ICPOES)		X	X	X	X	X	X		X		X		X	X	X		X
Phosphorus (total, APHA 4500-P)	X	X	X	X	X	X	X	X		X	X	X	X	X	X		X
Phosphorus (dissolved, APHA 4500-P)		X	X	X	X	X	X			X	X	X	X	X	X		X

4.3.1 Quality Control / Quality Assurance of Water Quality Data

The quality control/quality assurance for this project consisted of the following components:

- Provincially prescribed standard methods were utilized for sample acquisition and transport;
- Field data were digitized and then reviewed prior to input into the water quality database;
- A triplicate sample was taken at FS-15 on March 29, 2016 and the relative standard deviation was below 20% for all parameters above detection limits; except for antimony, cadmium and nitrate, at 21.7%, 33.3%, and 36.5%, respectively and these were all close to detection limits. See Appendix A for replicate sampling analysis; and
- Use of a Database Manager, where the data is stored and can be queried.

The data is overall acceptable and suitable to form a basis for study findings.

4.3.2 General Water Quality Characteristics

Overall, all foreshore (near-surface groundwater) locations along with groundwater monitoring well MW-1 showed anthropogenic impact; with evidence of impact observed as exceedances of applicable water quality guidelines for chloride, electrical conductivity, nitrate, sodium, sulphate, ammonia, uranium, and phosphorus.

Surface waters, in general and as expected, showed lower concentrations of water quality impact parameters; however, anthropogenic impact was observed at all monitored surface water locations to some degree. Specifically, at the outlet of Swan Lake periphyton – chlorophyll-a was found to be above the MoE Water Quality Criteria for Nutrients and Algae guidelines (MoE 2017). Further, nitrate was above the provincial 30-day average guideline of 3 mg/l for protection of aquatic life at four surface water locations (SE Spring, Site 3 (Cowboys Creek), Site 5 (NE Culvert), and the SW Spring. Ammonia was found to exceed CCME AL in Swan Lake in August 2016. Further exceedances will be discussed below.

The following sections will discuss the applicable water quality guideline exceedances along with spatial and temporal trend assessment of key indicators of impact.

East Shore

The foreshore sites at the southeast end of the lake (FS-31 and FS-32) along with the SE Spring, show impact likely derived from operation of on-site wastewater systems as is evident from the extremely elevated ammonia, chloride, sulphate, sodium, alkalinity, and potassium concentrations. Further, along the mid-east bank of Swan Lake, FS-33, FS-3, and FS-15 along with the ditch waters at FS-101, FS-103, and FS-104 consistently showed very high levels of indicator parameters compared to background (MW-3).

FS-3 and the foreshore north and south of FS-3 indicated extremely elevated electrical conductivity and sulphate in the spring of 2015; however, subsequently measured sulphate levels came down by orders of magnitude (Figure 9a). From conversation with fertilizer suppliers in the area (Patterson 2015), we understand there is application of sulphate rich agricultural amendments applied on the orchards upgradient of FS-3.

FS-15 is the discharge zone for relatively large catchment area compared to the other foreshore sites, located downgradient of an unnamed, often ephemeral, tributary (Figure 1). Likely, FS-15 is receiving waste streams (non-point source inputs) from upgradient land-uses which are primarily agriculture and residential on-site wastewater.

FS-45, located directly down gradient of Swan Lake RV Park, showed elevated sodium, sulphate, uranium and fluoride compared to background (MW-3). However, concentrations of indicator parameters (chloride, sodium, nitrate, sulphate, ammonia, alkalinity, fluoride, potassium, uranium, and calcium) were lower than at the following locations (MW-1, FS-3, FS-15, FS-21, FS-32, FS-31, FS-43(SW), FS-43, FS-28, FS-101 and FS-103).

Site 3 (NE-Cowboys), is an ephemeral stream, present during the April 2015, March 2016 and November 2016; however, it was not present in July or October 2015 or August 2016, showed relatively high concentrations for most of the indicator parameters.

Site 5 (NE-Culvert) and Site 5b(NE-Culvert) are both culverts which drain Malysh Creek and the area to the northeast of Swan Lake into Swan Lake. Both locations showed high levels of water quality indicator parameters (chloride, sodium, nitrate, sulphate, ammonia, alkalinity, fluoride, potassium, uranium, and calcium), see Appendix A for all results. Site 5b(NE-Culvert) showed the highest number of water quality exceedances (Table 10, below) and this sampled location is likely seeing influence from the highway runoff and from the operation of on-site wastewater systems and agriculture fertilizers.

Nitrate, present in the hyporheic ditch waters above the east shore of Swan Lake at FS-101, FS-104 and FS-104b was shown to be elevated. However, all sampled foreshore locations downgradient of these ditches showed nitrate concentrations less than 1.15 mg/l. The overall reduction of nitrate from ditches to the foreshore water is likely the result of uptake of nitrogen by the riparian vegetation present along most of the eastern Swan Lake shoreline.

North Shore

The groundwater at MW-3, located to the northeast of Swan Lake (Figure 1), represent ambient (background) conditions. Whereas groundwater at MW-1, surface water at Greenhow Creek (FS-43 (SW)), and foreshore water at FS-43 show high levels of the following indicator parameters: chloride, sodium, sulphate, uranium and calcium. Based on the fact that these indicator parameters are low at MW-3 and high at MW-1, FS-43(SW) and FS-43, we believe there is significant anthropogenic input from upgradient land-uses which includes agriculture, road salting on the highway, and a biosolids disposal site (located about 1.4 km north of Swan Lake).

West Shore

Three routine foreshore samples were taken on the west shore of Swan Lake at FS-21, FS-28, and FS-29 along with two additional surface water locations were added on the west shore in 2016 (NW Spring and SW Spring) sampled in the spring of 2016 (both were dry the rest of 2016) (Figure 1). FS-21 and FS-28 are both located downgradient of agricultural land (small hobby farms) and showed a moderate degree of impact. Of note, at FS-21 the sodium level is elevated above all other sampled locations. The source of the elevated sodium may be agricultural in origin. FS-29 is located at a perched pond, on the edge of Swan Lake, downgradient of agricultural land. FS-29 showed elevated water quality indicator parameters; specifically, ammonia and sulphate were high relative to the other sites. FS-28, sampled downgradient of

rural residence (small hobby farms) showed concentrations of indicator parameters above background (MW-3). Of impact of the surface waters sampled, SW Spring showed generally, the highest degree of impact; however, as mentioned above the locations was only sampled once, due to it being ephemeral. SW Spring drains the agricultural lands between Raven Road and Old Kamloops Road.

South Shore and Swan Lake

The three samples taken at the south end or middle of the lake are surface water samples: Storm Drainage, Vernon Creek (outlet of Swan Lake) and Swan Lake (grab sample at south end in 2015 and spring 2016 and mid-basin sample summer and fall 2016. The Swan Lake mid-basin sample (August 2016) exceeded for ammonia. Vernon Creek, sampled at the outlet of Swan Lake, showed elevated chloride, periphyton-chlorophyll-a, and pathogenic bacteria. The other water quality parameter levels are low at the outlet of Vernon Creek, likely due to dilution from BX Creek or Swan Lake. Based on the indicator parameters assessed, Swan Lake shows signs of nutrient loading as it flows into Vernon Creek (also referred to as lower BX Creek).

4.3.3 Water Quality Assessment (Exceedances, Spatial and Temporal Trends)

The following sections provide a discussion of the results above the applicable water quality guidelines, listed above. The guideline values and notes associated with the guidelines, for each parameter, are provided in the water quality database, found in Appendix A, attached. The database has been grouped by sample type, i.e. sampled groundwater and surface water sites. To help assess the large data set, the exceedance summary tables (below) are grouped by sample type (surface water or groundwater) and by guidelines and parameter as follows:

- Table 8: Exceedances of Surface Water Quality Results by Guideline;
- Table 9: Exceedances of Surface Water Quality Results by Parameter;
- Table 10: Exceedances of Groundwater Quality Results by Guideline; and
- Table 11: Exceedances of Groundwater Quality Results by Parameter.

4.3.3.1 Field (electrical conductivity, pH, and temperature)

Almost all the sampled locations exceeded for field measured temperature, pH and electrical conductivity. Exceedances of field measured temperature and pH are not believed to be relevant in the current discussion regarding land-use impacts as they were almost ubiquitous at the sampled locations; therefore, no insight into land-use impacts can be assessed from pH and temperature exceedances.

4.3.3.1.1 Electrical Conductivity (EC)

Exceedances of electrical conductivity, measured both in the field and confirmed in the laboratory (in 2016) are relevant to land use impact. Electrical conductivity exceeded the working provincial irrigation water quality guideline (700 µS/cm) at all locations except the following: MW-2, MW-3, BX Creek, NW Spring, Swan Lake and Vernon Creek.

Electrical conductivity at the sampled surface waters varied from an average of 456 µS/cm (BX Creek) to 2,260 µS/cm (SW Spring) (Figures 4 and 5). The next highest surface water averaged EC's are at Site 3 (Cowboy Creek) (1,152 µS/cm), which is relatively stable over the sampling period and FS 43 (SW Greenhow Creek) (866 µS/cm) which is quite variable over-time (from 300 µS/cm to 1,400 µS/cm), showing the lowest levels in the spring, due to dilution. With the rest of the surface water sites sampled falling below 866 µS/cm.

Electrical conductivity at the sampled groundwater sites varied from an average of 477 µS/cm (MW-3) to 6,423 µS/cm (FS-3) (Figures 4 and 5). With FS-3 varying over-time, showing higher levels in the spring. The next highest groundwater averaged EC's are at MW-1 (4,742 µS/cm), which is relatively stable over the sampling period (varying between about 3,000 µS/cm and 5,000 µS/cm). Followed by FS-21 (2,745 µS/cm) and FS-15 (2,442 µS/cm), with the remains groundwater sites falling below 2,000 µS/cm.

This almost ubiquitous exceedance of electrical conductivity is indicative of the overall anthropogenic influence on the near-surface groundwater and tributaries and springs surrounding Swan Lake. The locations where EC is notability higher (Site 3, Greenhow Creek, MW-1, FS-3, FS-15 and FS-21) indicate a higher degree of impact compared to the other sampled sites.

4.3.3.2 General (chloride, sulphate, fluoride, pH and electrical conductivity)

Electrical conductivity and pH were discussed in the field parameters above.

4.3.3.2.1 Chloride

Chloride is highly soluble and conservative, meaning, once it enters the environment it remains mobile and concentrations in water are primarily affected by dilution and not by chemical or biological reactions. Because of its anthropogenic origins and conservative properties, chloride is an important ion for identifying land use impacts to the receiving environment. Natural sources of chloride in aquatic systems include naturally-occurring saline lakes and groundwater discharges from aquifers enriched in chloride, as well as naturally occurring salt deposits. However, such natural sources are not observed in the vicinity of Swan Lake. Again, groundwater well MW-3 is taken to represent background (ambient) water quality and chloride levels at MW-3 were less than 20 mg/l.

Chloride at the sampled surface waters varied from an average of 10 mg/l (NW Spring) and 112 (SW Spring) (Figures 6 and 7). With the next highest averaged chloride levels at FS 43 (SW Greenhow Creek) (91 mg/l). With averaged chloride at the Storm Drainage, Site 3 (Cowboy Creek), Site 5 and 5b and SE Spring ranging from 40 mg/l to 69 mg/l and Vernon Creek, Swan Lake, BX Creek and NW Spring ranging from 16 mg/l to 32 mg/l.

Chloride at the sampled groundwater sites varied from an average of 21 mg/l (MW-3) to 392 mg/l (MW-1) (Figures 6 and 7). The next highest chloride levels were at FS-15 (256 mg/l), FS-43 (235 mg/l), and FS-32 (205 mg/l), all others averaging below 1,100 mg/l. With FS-31, FS-104, FS-33, FS-3, and FS-28 average chloride concentrations falling between 57 mg/l and 95 mg/l and FS 104b, FS-101, MS-2, FS-103, MW-3, FS-21, and FS-29 average chloride concentrations falling between 21 mg/l and 45 mg/l. Most of the chloride levels were relatively stable over-time except for FS-43, FS-15 and FS-32, which showed significant variance over the sampled period.

Nine groundwater sites and five surface water sites exceeded at least one of the provincial guidelines. These exceedances indicate that intensive anthropogenic input is occurring along the east and even more so at the north end of Swan Lake. Section 4.3, below, provides estimates of chloride loading into Swan Lake, based on land-use practices surrounding the lake.

4.3.3.2.2 Sulphate

Sulphate exceeded applicable guidelines at one surface water locations (SW-Spring) and nine groundwater locations (FS-3, FS-15, FS-21, FS-28, FS-29, FS-43, FS-45, FS-101, and MW-1), see Tables 8 and 10 for specific guideline exceedances.

Sulphate at the sampled surface waters varied from an average of 32 mg/l (Site 5 – NE Culvert) to 898 mg/l (SW Spring) (Figures 8 and 9a and 9b). The SW Spring drains the agricultural lands located between Raven Road and Old Kamloops Road. The next most elevated average sulphate concentrations were found at NW Spring (221 mg/l), Site 3 (NE- Cowboys) (114 mg/l), Greenhow Creek (FS-43 (SW)) (109 mg/l), and Site 5b (103 mg/l). All other surface water site average sulphate concentrations are found below 65 mg/l.

Sulphate at the sampled groundwater sites varied from an average of 49 mg/l (MW-2) mg/l to 2,544 mg/l (MW-1) (Figures 8 and 9). Sulphate concentrations at MW-1 remained relatively consistent over-time. The next highest averaged sulphate levels were at FS-3 (2,344 mg/l), and FS-21 (1,161 mg/l). With the remainder of groundwater sampled sites falling below 750 mg/l; FS-29 (751 mg/l), FS-43 (650 mg/l), FS-101 (663 mg/l), FS-15 (463 mg/l), FS-45 (281 m/l), FS-28 (233 mg/l), FS-103 (123 mg/l), FS-33 (178 mg/l) and FS-32 (190 mg/l). The remaining sites, FS-104, FS-31, FS-104b, MW-3 and MW-2 all fell below 70 mg/l. In general, we see that sulphate concentrations over-time follow a different pattern, compared to some of the other indicator parameters, with more elevated concentrations occurring in the spring, during the freshet.

On the east shore of Swan Lake, sulphate exceeded at FS-3, FS-15, FS-45 and FS-101. FS-3 showed an extremely elevated sulphate concentration of 10,500 mg/l during the April 2, 2015 sampling (Figure 9a). We did not interpret this result as erroneous, because the field measured electrical conductivity was also extremely elevated (13,320 µS/cm), thereby validating the sulphate laboratory results. During the subsequent five sampling events between July 2015 and November 2016 sulphate concentrations were orders of magnitude lower, yet still elevated compared to background (ambient) MW-3 (average of 67 mg/l over the sampled period). We interpret these results to be indicative of impact from upgradient agricultural land-use, with the April 2015 sample having captured a peak concentration prior to dilution.

At FS-15, located downgradient of an unnamed tributary and just south of Elmwood Road, we see a large quantity of water quality exceedances. The elevated sulphate concentration at FS-15 is thought to be of different origin than at FS-3, as the temporal variation of concentrations at FS-3 and FS-15 are substantially different. We see a similar temporal trend to FS-15 at FS-32, FS-103 where we see the peaks at different times during the sampling person compared to FS-3. Other locations that show similar temporal trend to FS-3 are FS-21, FS-28, FS-29, FS-43, FS-45, FS-101 (Figure 9b). Similar to at FS-3, we interpret these results to be indicative of impact from upgradient agricultural land-use.

4.3.3.2.3 Fluoride

Fluoride exceeded the provincial livestock watering guideline at two groundwater locations (FS-3 and FS-15), both located on the east shore of Swan Lake. Further, fluoride exceeded the CCME AL at all surface waters sampled except BX Creek.

Fluoride at the sampled surface waters varied from an average of 0.09 mg/l (BX Creek) to 0.71 mg/l (SW Spring) (Figures 10 and 11). The next highest average flouride concentrations are found at Site 3 (Cowboys) (0.65 mg/l), NW Spring (0.53 mg/l), Site 5b (0.4 mg/l), Greenhow Creek (FS-43 (SW)) (0.4 mg/l), SE Spring (0.32 mg/l) and Site 5 (0.31 mg/l). With average fluoride at Swan Lake, Vernon Creek, Storm Drainage and BX Creek all below 0.2 mg/l.

Averaged fluoride concentrations at the sampled groundwater locations varied from 0.14 mg/l (MW-2) to 1.78 mg/l (FS-15) (Figures 10 and 11). Average fluoride at FS-15 is almost double the next highest

average fluoride concentrations and varied significantly between 1.2 mg/l and 2.3 mg/l over the sampled time period. The next most elevated average fluoride concentrations in the groundwaters, which varied between 1mg/l and 0.92 mgl were all on the east side of the lake at FS-3, FS-33, FS-101, FS-45, with all other sites showed average fluoride concentration's below 0.4 mg/l.

There are anthropogenic sources of fluoride, such as agricultural fertilizers (contaminated rock-phosphate fertilizer), industrialization, and urbanization. High fluoride concentrations in Okanagan groundwater are typically associated with crystalline rocks containing fluorine-rich minerals, especially granites and volcanic rocks. Further, shallow aquifers in arid areas experience strong cyclic evaporation, which can increase fluoride concentrations. At this point, the origin of excessive fluoride at FS-15 an FS-3 is unclear. Likely, there is naturally occurring fluoride, as a result the local surficial geology. However, FS-15 and FS-3 show elevated electrical conductivity, chloride, sodium, and sulphate; parameters associated with anthropogenic input; therefore, fluoride at these two locations is likely also anthropogenic in origin.

4.3.3.3 Microbiological (E. coli, Enterococcus, fecal coliforms and total coliforms)

Limited microbiological sampling occurred in the current study as the focus of the project was to assess land use effects on the water quality. Microbiological parameters in and around Swan Lake can be influenced by avian activity; therefore, they are not an ideal indicator of anthropogenic impact. At the request of the RDNO *E. coli.*, Fecal coliforms and Total coliforms were sampled once in 2015 at the routine sample locations; further, *E. coli.*, Fecal coliforms and Total coliforms were sampled at Vernon Creek in August and November 2016. Enterococcus was sampled once, at the outlet of Swan Lake (Vernon Creek), in November 2016. Microbiological results are provided in the Water Quality Database (Appendix A) and summarized in Table 12 below. In general, deeper groundwater was low in pathogenic bacteria; whereas, the near-surface groundwater pathogenic bacteria varied from negligible to >110,000 MPN/100 ml. Greenhow Creek appeared to have significantly lower pathogenic bacteria compared to what was measured at the outlet of Swan Lake (Vernon Creek). Enterococcus was sampled once at the outlet of Swan Lake (Vernon Creek) in the current study and was measured at 290 MPN/100 ml.

Table 12: Summary of Microbiological (Pathogenic Bacteria) Results

Date Sampled	Sampling Location	E. coli (counts)	Fecal coliforms (MPN)	Total coliforms (counts)	Enterococcus (MPN)
	Guidelines	MPN/100 mL	MPN/100 mL	MPN/100 mL	MPN/100 mL
	BCAWQG AL	N [1.1]	N [1.5]	NG	N [1.3]
	BCAWQG ALA	N [2.1]	N [2.5]	NG	N [2.3]
	GCDWQ MAC	0 [3.1]	0 [3.4]	0 [3.5]	NG
	BCAWQG L	200 [4.1]	200 [4.5]	NG	50 [4.3]
	BCAWQG I	385 [5.1]	1000 [5.5]	NG	100 [5.3]
	BCAWQG DW	0 [6.1]	0 [6.5]	NG	0 [6.3]
29-Oct-15	FS-3	*430*	*430*	930	
29-Oct-15	FS-15	36	36	150	
29-Oct-15	FS-21	*230*	*230*	24000	
29-Oct-15	FS-28	*930*	*930*	3900	
29-Oct-15	FS-29	*>110000*	*>110000*	>110000	
3-Nov-15	FS-31	*230*	*230*	1200	
3-Nov-15	FS-32	*430*	*430*	>110000	

29-Oct-15	FS-43	91	91	46000	
29-Oct-15	FS-43 (SW)	9.1	23	1200	
29-Oct-15	FS-45	9.1	9.1	2400	
29-Oct-15	FS-101	<3.0	36	>110000	
Date Sampled	**Sampling Location**	**E. coli (counts)**	**Fecal coliforms (MPN)**	**Total coliforms (counts)**	**Enterococcus (MPN)**
29-Oct-15	FS-103	3.6	3.6	15	
29-Oct-15	FS-104	3.6	3.6	46000	
29-Oct-15	MW-1	<3.0	<3.0	3.6	
29-Oct-15	MW-2	<3.0	<3.0	<3.0	
29-Oct-15	MW-3	<3.0	<3.0	<3.0	
29-Oct-15	Site 5 (NE-Culvert)	23	23	430	
3-Nov-15	Swan Lake	<3.0	<3.0	73	
10-Nov-16	Swan Lake	<1	<1	<1	
29-Oct-15	Vernon Creek (Outlet)	*430*	*430*	2400	
10-Aug-16	Vernon Creek (Outlet)	*1100*	*1100*		
2-Nov-16	Vernon Creek (Outlet)	*460*	*460*		*290*

Guidelines notes (1.1, 2.1, 3.1, 4.1 and 5.1) are provided in Appendix A Water Quality Database, some do not apply for the current study.

4.3.3.4 Nutrients (ammonia (total, as N), nitrate and phosphorus)

4.3.3.4.1 Ammonia

The only exceedance of the provincial freshwater aquatic life guideline for ammonia occurred during the August 2016 Swan Lake sampled from the Swan Lake mid-basin. Site 5b (NE Culvert) showed a significant increase during the November 2016 sampling (Figure 13). Ammonia at near-surface groundwater (foreshore) locations FS-31 (27 mg/l) and FS-32 (16.9 mg/l) showed extremely elevated concentrations, which varied significantly over the sampling period (Figures 12 and 13). FS-31 and FS-32 are both located in the vicinity of commercial and residential land uses and the ammonia exceedances may be due to the operation of on-site wastewater systems nearby. FS-29 showed the next highest average ammonia concentration (0.91 mg/l). FS-29 is a near-surface groundwater (foreshore) sample taken at the southwest end of the lake, higher concentrations of ammonia are likely associated with agricultural activities upgradient of the FS-29 location.

4.3.3.4.2 Nitrate

In general, we see higher nitrate levels in the surface waters compared to the near-surface groundwater locations (Figures 14 and 15). Nitrate exceeded the provincial and federal freshwater aquatic life guidelines of 3 mg/L at the following four surface water sample sites: SE Spring, Site 3 (NE-Cowboys), SW Spring (only sampled once in spring 2016, as it was dry later in 2016) and Site 5 (NE-Culvert); with average nitrate concentrations of 8.6 mg/l, 6.13 mg/l, 6.46 mg/l and 0.282 mg/l, respectively. Note, Site 5 (NE-Culvert) only exceeded once during the sampling period, in April 2015 (Figure 15).

The highest averaged nitrate levels were observed at FS-104b (8.32 mg/l), FS-101 (3.02 mg/l and FS-104 (1.95 mg/l) with all other groundwater average nitrate levels were below 1 mg/l. FS-104b, FS-101 and FS-104 are all located within ditches on the east side of Swan Lake, samples taken downgradient of these

ditch waters showed significantly lower nitrate concentrations (Figures 14 and 15), indicating that between the ditches and Swan Lake there is significant nutrient removal by vegetative uptake and denitrification of nitrate within the near-surface groundwater. Given the locations of the elevated nitrate are predominantly on the east side of the lake, downgradient of substantial residential home land-use, we interpret the elevated nitrate on the eastern shore to be primarily due to operation of on-site wastewater disposal systems.

4.3.3.4.3 Phosphorus

Orthophosphate (dissolved, as P) was assessed during virtually all dates in the sampling period, except August and November 2016 and typically values were less than 0.02 mg/l. For August and November 2016, the following parameters were sampled:

- Phosphorus (dissolved, by ICPMS/ICPOES) or Phosphorus (dissolved, APHA 4500-P); or
- Phosphorus (total, by ICPMS/ICPOES) or Phosphorus (total, APHA 4500-P).

Total phosphorus at FS-43, SW Spring and NW Spring were not sampled as they were dry during the August and November 2016 sampling. Total phosphorus analyzed with APHA 4500-P produced the highest values for all locations sampled and are listed from highest to lowest in Table 13, below. FS-101 (1.8.5 mg/l), FS-103 (17.1 mg/l) and FS-31 (9.72 mg/l) were the highest total phosphorus (PHA 4500-P) concentrations measured; all three located on the eastern shore of Swan Lake and these levels are associated with on-site wastewater and agricultural input.

Table 13: Summary of Phosphorus (total, APHA 4500-P) (mg/l) Results

Sampled Location (GW and SW)	Phosphorus (total, APHA 4500-P) (mg/l)	Sampled Location (GW and SW)	Phosphorus (total, APHA 4500-P) (mg/l)
FS-101	18.5	FS-21	0.499
FS-103	17.1	FS-33	0.492
FS-28	15.1	FS-3	0.378
FS-31	9.72	BX Creek	0.192
FS-29	2.88	Storm Drainage	0.153
FS-15	1.92	FS-104b	0.119
FS-104	1.64	Vernon Creek (Outlet)	0.108
FS-32	1.25	Site 5 (NE-Culvert)	0.06
FS-45	1.11	FS-43 (SW)	0.057
Site5b (NE-culvert)	1.07	SE Spring	0.038
MW-1	0.851	MW-3	0.036
Site 3 (NE-Cowboys)	0.753	Swan Lake	0.018

4.3.3.5 Metals total and dissolved (Aluminum, Arsenic, Iron, Manganese, Molybdenum, Selenium, Sodium, Uranium (total and dissolved) and Others)

Metals were sampled in the fall of 2015 and during the three 2016 sampling events. In general, sampled groundwaters show fewer metal exceedance compared to the surface waters sampled (Tables 10 and 11). However, the main location where metals exceeded the applicable guidelines was Site 5b (NE-Culvert). Site 5b (NE-Culvert) drains Malysh Creek and runoff from Highway 97, which runs just to the east of Site 5 and Site 5b. Likely Site 5b is draining more highway runoff as there are considerably more exceedances of metals at Site 5b compared to Site 5 and both drain the Malysh Creek basin.

One major source of metals in urban runoff is related to road runoff, which picks up motor vehicle exhaust emissions that precipitate onto the roads, tire wear, oil and grease, metal corrosion byproducts and breakdown of road surface. Wear particles from tires and brake linings and corrosion of metal parts contribute zinc, copper, chromium, cadmium, nickel and lead. Pigments in paints and stains used on the exterior of buildings and lane markers contain chromium, cadmium, nickel and lead. Road salt contains a wide range of potentially toxic pollutants including chloride, zinc, nickel, chromium, lead and cyanides (used as an anti-caking ingredient). Other potential sources of metal include atmospheric deposition from industrial sources, illicit dumping and poor waste disposal (BC Environment 1992). Additionally, a few metals including selenium, aluminum, iron and manganese are known to be ubiquitous in Vernon area creeks and are likely transported from groundwater (Jensen 2005, WWAL 2016).

4.3.3.5.1 Molybdenum, Iron and Others

Molybdenum exceeded provincial irrigation and livestock watering water quality guidelines, concentration of 0.05 mg/l at the following four foreshore (near-surface groundwater) locations: FS-15, FS-32, FS-45 and FS-29. Three of which (FS-15, FS-32, and FS-45) are draining into the eastern shoreline of Swan Lake. FS-29 drains the agricultural fields at the southwestern shore line of the lake.

Iron above the applicable provincial and federal drinking water and/or freshwater aquatic life guidelines at the following locations: FS-15, FS-28, FS-31, FS-32, MW-1, MW-3, Site 3 (NE-Cowboys), Site 5 (NE-Culvert), Site5b (NE-Culvert), Storm Drainage, Vernon Creek (Outlet), see Tables 8 and 9.

Zinc exceeded at the following four surface water sites: Site 5 (NE-Culvert), Site5b (NE-Culvert), Storm Drainage and Vernon Creek (Outlet). These sites are likely influenced by road runoff.

Site 5b is where the following total metal exceedances occurred during sampled period: aluminum (total), arsenic (total), barium (total), beryllium (total), cadmium (total), chromium (total), cobalt (total), copper (total), iron (total), lead (total), manganese (total), silver (total), uranium (total), and zinc (total). With the following metals only exceeding at Site 5b (NE -Culvert): arsenic (total), barium (total), beryllium (total), cadmium (total), cobalt (total), lead (total), and silver (total).

4.3.3.5.2 Likely Naturally Occurring Metals (aluminum, copper, selenium and manganese)

Aluminum exceeded the CCME AL at the following surface water sites: BX Creek, FS-43 (SW), Site 3 (NE-Cowboys), Site 5 (NE-Culvert), Site5b (NE-Culvert), Storm Drainage, Vernon Creek (Outlet) and aluminum exceeded BCAWQG DW at two groundwater sites (FS-15 and MW-1).

Copper exceeded provincial and federal aquatic life guidelines at the following surface water sampled locations: Site 3 (NE-Cowboys), Site 5 (NE-Culvert), Site5b (NE-Culvert), Storm Drainage and Vernon Creek (Outlet).

Selenium exceeded the applicable guidelines (Tables 8 and 10) at the following locations: FS-15, FS-104, FS-104b, BX Creek, Greenhow Creek (FS-43 (SW)), NW Spring, SE Spring, Site 3 (NE-Cowboys), Malysh Creek (Site 5 (NE-Culvert) and Site5b (NE-Culvert)), Storm Drainage, SW Spring, Swan Lake, and Vernon Creek (Outlet of Swan Lake).

Manganese exceeded the GCDWQ AO concentration of 0.05 mg/ l at the following locations: FS-3, FS-15, FS-21, FS-28, FS-29, FS-31, FS-32, FS-33, FS-45, FS-103, FS-104, FS-104b, MW-1, MW-2, MW-3, Site 5 (NE-Culvert), Site5b (NE-Culvert), Storm Drainage, and Vernon Creek (Outlet). Further, manganese

exceeded the BCWWQG I of 0.2 mg/l at the following locations: FS-3, FS-15, FS-21, FS-28, FS-29, FS-31, FS-32, FS-33, FS-45, FS-103, MW-1, and Site5b (NE-culvert).

Sulphide only exceeded at one location, FS-43, the foreshore of Greenhow Creek.

4.3.3.5.3 Sodium

Sodium exceeded the federal (GCDWQ AO) guideline of 200 mg/l at seven groundwater locations but no surface water sampled locations: FS-15, FS-21, FS-29, FS-32, FS-43, FS-101 and MW-1. The highest total sodium averaged concentrations were found at SW Spring (115 mg/l), FS-42 (SW) (Greenhow Creek) (56 mg/l) and Site 3 (Cowboys Creek) (46 mg/l) (Figure 16). All other averaged total sodium surface water sampled locations were below 40 mg/l. Except at Site 5b (NE- Culvert), surface water total sodium concentrations were consistent over the sampling period (Figure 17); Site 5b varied from below 20 mg/l to over 60 mg/l.

In general, average dissolved sodium concentrations in the groundwater were significantly higher than observed in the surface waters. With MW-1 (334 mg/l) showing the consistently highest levels, followed by FS-21 (280 mg/l), all other average dissolved sodium groundwater locations were below 200 mg/l (Figure 16). Averaged dissolved sodium at FS-15, FS-101, FS-32, FS-43, FS-29, FS-31 and FS-28 fall between 100 mg/l and 2000 mg/l (Figure 16) whereas FS-33, FS-104, FS-3, FS-104b, FS-103, MW-2 and MW-3 fell below 100 mg/l. The lowest average dissolved sodium was found at MW-2 (10 mg/l) and MW-3 (18 mg/) and represents ambient (background) groundwaters. Over-time, we see that dissolved sodium at MW-1 and FS-101 is relatively consistent; whereas, at FS-21, FS-29, FS-15, FS-32 and FS-101, we see significant variance over the sampling period. The difference in the seasonal pattern suggest that dissolved sodium is derived from different sources at MW-1 and MW-101 compared to the other sites. Specifically, MW-1 is likely seeing predominately impact from the upgradient biosolids composting facility located 1.2 km north of the lake; whereas, the other sampled groundwaters are likely seeing influence from on-site wastewater and agricultural input. Note, elevated sulphate concentrations at MW-1 are likely an indication that the land-use impacts at MW-1 are a result of agricultural input and the biosolids composting, both upgradient land-uses.

4.3.3.5.4 Uranium

Figures 18 and 19 provide the spatial and temporal concentrations of uranium at the sampled in the current study. Within the surface waters, uranium averages ranged orders of magnitude, from 0.0018 mg/l (Site 5 (NE-Culvert) to 0.037 mg/l (SW Spring). The next highest average uranium concentration in surface water was found at the SE Spring (0.0241 mg/l), followed by Site 3 (NE Cowboys Creek) (0.0174 mg/l), Greenhow Creek (FS-43(SW) (0.0095 mg/l). The rest of the surface water sites (Storm Drainage, Swan Lake, Vernon Creek, BX Creek, Site 5 and Site 5b) displayed uranium concentrations below 0.01 mg/l.

Note that the CCME Canadian water quality guidelines for the protection of freshwater aquatic life provide both a Long-Term Exposure guideline, and Short-Term Exposure guidelines for uranium. The Long-Term Exposure guideline was used in this report, which is µg/l (0.015 mg/l). The guidelines are for total recoverable, unfiltered analyses. Uranium exceeded the following applicable guidelines, at the specified locations (from Tables 8 and 10):

- BCWWQG AL (0.0085 mg/l) FS-43 (SW), SE Spring, Site 3 (NE-Cowboys), Site5b (NE-culvert), SW Spring;
- CCME AL (0.015 mg/l) FS-43 (SW), SE Spring, Site 3 (NE-Cowboys), SW Spring;

- BCWWQG I (0.01 mg/l) at FS-3, FS-15, FS-21, FS-28, FS-29, FS-31, FS-32, FS-33, FS-43, FS-43 (SW), FS-45, FS-101, FS-103, FS-104, FS-104b, MW-1, SE Spring, Site 3 (NE-Cowboys), Site5b (NE-culvert), SW Spring;
- GCDWQ MAC (0.02 mg/l) at FS-3, FS-15, FS-21, FS-28, FS-29, FS-32, FS-33, FS-43, FS-45, FS-101, FS-104b, MW-1, SE Spring, Site 3 (NE-Cowboys), and SW Spring; and
- BCWWQG L (0.2 mg/l) at FS-15 and FS-29.

Uranium is naturally occurring within sediments throughout the Okanagan Valley. Note, ambient groundwater in the area, represented at MW-3, showed a low average uranium concentration of 0.0005 mg/l. As mentioned above, there were no foreshore locations sampled, which appear to be unaffected by anthropogenic input. There appears to be a relatively strong correlation between uranium and calcium along with uranium and chloride (as summarized in the table below), with a second order polynomial regression analysis providing an r^2 value of 0.6 for the surface waters sampled. Other researchers have seen a similarly strong correlation between uranium, calcium, and to a lesser degree between uranium and chloride (Drage and Kennedy 2013 and Dong et. al. 2005). If the surficial deposits in the vicinity of Swan Lake are of similar origin and MW-3 is representative of ambient groundwater conditions, it is possible that anthropogenic input of calcium and chloride, via road salting, agricultural activity, operation of onsite wastewater systems, and other anthropogenic sources is influencing the solubility of uranium present in the surficial deposits, thus mobilizing uranium into the foreshore (near-surface) waters surrounding Swan Lake.

Data	Uranium and Calcium Correlation Coefficient (r^2)	Uranium and Chloride Correlation Coefficient (r^2)	Count
All Results	0.2	0.3	89
Surface Waters	0.6	0.6	29
Groundwaters	0.1	0.3	60

4.4 Land Use Inventory and Mass Flux of Anthropogenic Impact Indicators

Since chloride is a conservative ion, not subject to biological or geochemical sequestering and is derived primarily from human activity, it can be used as a measure of anthropogenic impact on the environment. The following section focuses on apportioning of chloride and other nutrients (sulphate) by land use as a means of quantifying the relative impact each land use category could have on water quality in Swan Lake. The apportioning of chloride was estimated by two methods. The first estimation method was based on assigning chloride mass flux values to land use and the second estimate of chloride mass flux was based on groundwater discharge to the lake and concentrations of chloride physically measured during the foreshore sampling for this project. The chloride flux estimate are first order approximations and assumptions for the calculations are stated.

4.4.1 Chloride Loading Based on Land Use Practices

The following section presents the apportioning of chloride to the various land uses classified around Swan Lake. As mentioned earlier, these land uses include the following categories: Agricultural Lands, Residential, Industrial, and Roadways surrounding Swan Lake (Figure 20). These main categories were then subdivided further into more specific land-uses that are described below. Table 14 summarizes the chloride loading from the various land uses.

Road Salts

Standard road salt applications for British Columbia are between 60 to130 kilograms/kilometer for a two lane highway with the average of 42.5 kg/lane/km. Average conditions for application include early day application, when the surface temperature is -4°C and rising under snow, sleet or freezing rain conditions (Ministry of Environment, 1998). For the purpose of this study it was assumed that application only occurred on days that received greater than 5 cm of snow. Based on these calculations and assumptions an estimated total of **21,384 kg/year** of chloride is introduced to the ground surface and roadside ditches from road salting. It should be noted that in the northeast end of Swan Lake there is a road salt storage facility with a storage capacity of 1000 m^3.

Upon inspection there was evidence of brine runoff into adjacent ditches. Although, it was not possible to investigate further into this matter due to property access restriction, this potential source of chloride contamination should be further assessed in the future. It could be seen, from off-site, that potential monitoring wells do exist on the salt-storage site and have likely been sampled in the past. Access to this data would help to improve the value of the apportioning of chloride aspect of this current study.

Agriculture

The four main subcategories for agriculture derived chloride around Swan Lake include the following: cherry and apple orchards, corn crops, irrigated grasslands, and hobby farms. The average chloride input from agricultural practices is estimated at 5,392 kg/km^2 (Mullaney, et al. 2009). Using satellite imagery and site visits the total area around Swan Lake used for the different types of agriculture was estimated at 12.7 km^2. Using these simplified estimates, agricultural practices potentially contribute a total of **65,633 kg/year** of chloride to the land.

Residential

The residential contribution of chloride to Swan Lake was estimated using the average loading of septic effluent per lot or unit, with a chloride concentration of 70 mg/l and the total area of all the different residential subdivisions (Katz, *et al.* 2011). It was assumed that all the residences were using septic fields as effluent disposal since they are not connected to the City of Vernon infrastructure and that the condition of the septic systems varies greatly depending on age. In total, an estimate of 780 units (or homes with septic fields) in the area was made, contributing approximately **3,739 kg/year** of chloride to the soil.

Industrial

Industrial inputs for the desktop study were based on the average amount of effluent produced per employee per day and standard concentrations of chloride (70 mg/l) obtain from previously completed studies (Katz, *et al.* 2011). Based on averages obtained from several of the larger industrial outfits in the area, we estimated 500 employees work full time in the area, amounting to **703 kg/year** of potential chloride input to septic fields and holding tanks. Note that several properties east of Swan Lake have holding tanks which are pump and haul systems and the Christian school has a sand mound type system.

Biosolids Disposal Facility

There is a bio-solid disposal site located approximately 1.2 km north of Swan Lake. Unfortunately, very little is known about the Operational Permit associated with this facility or the influence that the operation may have on the near-surface groundwater or downgradient surface water (Swan Lake). Inquiries were made by WWAL staff to the B.C. Ministry of Environment in 2015; however, no information was made available regarding the permit. We recommend further inquiry be made into whether groundwater monitoring downgradient of the facility is occurring. Despite this lack of information, operation of the biosolids disposal facility is an important part of the chloride and nutrient balance of Swan Lake and is a data gap in the current study and should be considered further.

Table 14: Summary of Potential Chloride Loading into Swan Lake Estimated from Land-Use.

	Total Area (km2)/ Length (km)	Number of Homes/ units/Employees	Concentration NaCl/Loading Rates	Chloride Loading (kg/yr)	Chloride loading (% of Total)
Roads/Highways	26.5		42 (kg/lane/km/snowday)	**21384**	**23**
Agricultural			5393 (kg/km2)		
Apple/Cherries	2.63		5394 (kg/km2)	14184	16
Corn	1.49		5395 (kg/km2)	8036	9
Irrigated Grasslands	2.54		5396 (kg/km2)	13698	15
Hobby Farms	5.51		5397 (kg/km2)	29715	32
Total	12.17		5398 (kg/km2)	**65633**	**72**
Residential					
Trailer Parks/Camping	0.1	269	1.3 kg/unit/year)	349.7	0
Country residential	1.44	498	6.77 kg/unit/year)	3371.46	4
Total	1.55	767		**3721**	**4**
Industrial	0.43	500	70 mg/l at 55 liters/day	**703**	**1**
Natural Grasslands	6.39			Retention	
Wetlands	1.25			Retention	
Total Chloride loading (kg/yr)				**91,441**	**100**

Chloride is associated with almost all land-use around Swan Lake. Based on land use, a total of 91,441 kg of chloride (more than 90 metric tonnes) is estimated to be introduced to the land around Swan Lake every year. Without considering the biosolids processing facility at the north end of the lake, the greatest source of chloride is apportioned to agricultural practices. With agricultural land use accounting for an estimated 65,633 kg/year or 72% of the total. More specifically, hobby farms may contribute 29,715 kg/year or 32% of the overall loading of chloride to the lake. This is followed by orchards and irrigated grassland, contributing 16% and 15%, respectively. The next largest contribution of chloride is estimated to be coming from road salting. Road salt amounts to 21,384 kg/year or 23% of the total chloride loading to the lake. To a lesser extent, residential areas and industrial practices contribute an estimated 4 % and 1%, respectively.

4.4.2 Chloride Loading Based on Groundwater Discharge and Water Quality

The lithology beneath Swan Lake is characterized as being a layered sequence of sediments. At the surface there is an unconfined sand and gravel aquifer with a saturated thickness of about 13 metres, underlain by a clay aquitard. Below this lies a deep, confined 40 to 60 meter thick sand and gravel aquifer (Golder and Summit, 2009). For the purposes of this study it is assumed that only the top 4 meters of the upper, unconfined aquifer is interacting with Swan Lake. The 'Swan Lake' Aquifer covers 6.28 km^2 and has an average hydraulic gradient (i) of 0.1 with an estimated hydraulic conductivity (k) of $1x10^{-5}$ m/s. The length of aquifer that is assumed to interact with Swan Lake is about 4,200 meters (OBWB 2009 and Smerdon

2009). The primary flow direction of the groundwater within the aquifer is from the east and a smaller portion from the north (OBWB 2009). Approximately 500 m north of Swan Lake a bedrock outcrop acts as a groundwater divide and is assumed to be a groundwater no-flow boundary separating the Swan Lake Aquifer from the larger Spallumcheen aquifer, which flows from north to south entering Okanagan Lake at the head of the lake.

Well logs for wells located north of Swan Lake indicate extensive clay and silt in the upper stratigraphy and bedrock below (MoE Well Plate Numbers 18089 and 62562). However, it is likely that immediately north of the lake (0 - 200 m) there is localized groundwater flow from the north flowing into Swan Lake or beneath Swan Lake. Accurately characterizing groundwater flow from the north is challenging due to a lack of information.

Using the assumed discharge of groundwater into Swan Lake, the chloride concentrations found in the background well (MW-3), and an average of the chloride concentrations from the foreshore samples the yearly loading of chloride was calculated. As seen in Table 15 the ambient loading of chloride amounts to 8,556 kg/year, while the loading of chloride based on the foreshore samples was calculated to be 81,589 kg/year. This is a difference of 73,033 kg/year of chloride attributed to human impact.

Table 15: Summary Table of Chloride Loading based on Groundwater Discharge and Measured Water Quality Results.

Parameter	Value Used in Estimate of Cl Mass Flux
Aquifer thickness – assumed to be discharging into Swan Lake	4 m
Aquifer Length	4,200 m
Area (a)	16,800 m^2
Gradient (i)	0.1
Hydraulic Conductivity (k)	0.00001 m/s
Groundwater discharge to Swan Lake	529,800 m^3/year
Background Cl Concentration (from MW-3)	16 mg/l
Average Foreshore Cl Concentration	154 mg/l
Background Cl Loading	8,556 kg/year
Foreshore Chloride Loading	81,589 kg/year

Note: all values in Table 10 are from Golder Summit 2009, except chloride concentrations which are from the current study.

Estimating the actual chloride flux into Swan Lake based on measured concentrations of chloride at the lake's foreshore provided results within the same order of magnitude as that calculated from the land use apportioning of chloride, 82,000 kg/year compared to 91,000 kg/year, respectively.

4.4.3 Sulphate Loading Based on Land Use Practices

Recall that sulphate concentrations on the east shore of the lake at FS-3 measured over 100,000 mg/l in April 2015 and still elevated, but at a much lower concentration in July and October 2015. Due to the elevated concentration of sulphate above background (70 mg/l at MW-3), we investigated the potential sources of sulphate further. Through personal communication with a local fertilizer supplier, it was determined that sulphate is applied to the apple and cherry orchards located primarily on the east side of

the lake as well as a small area at the north end. According to our conversation with a local supplier, approximately 2,445 to 4,890 kg/km^2/year of sulfur is applied in the spring (Pers. Com. Patterson, July 2015). Based on land area and the application rate we calculated an estimated loading rate of **6,428 to 12,871 kg/year** of sulfur loading to the near-groundwater on the perimeter of Swan Lake.

5. CONCLUSIONS

After completing a second year of study on the Swan Lake land-use and water quality assessment, we provide the following conclusions:

C1 Swan Lake is a mesotrophic lake located on the northern fringes of the Vernon urban area and is surrounded by largely agricultural lands, along with light-industrial, commercial and residential land-uses; with a major transportation corridor on its east side (Hwy 97) and localized higher density commercial and residential development such as RV Parks along the lake shore. We estimate the residence time of Swan Lake is about one year.

C2 The 2016 Swan Lake water budget (balance) was completed and we estimate that 75% of the water flowing into Swan Lake is derived from BX Creek inflow and 16% is from the smaller inflowing tributaries (Greenhow Creek, Malysh Creek, etc.).

C3 Water quality impacts from land-use surrounding Swan Lake were assessed in 2015-16 through a water quality sampling program and through apportioning of chloride by land-use around the lake.

C4 Foreshore (near-surface groundwater) waters surrounding the entirety of Swan Lake are anthropogenically impacted from upgradient land-uses. From the 2015-16 sampling program, we see elevated levels of groundwater quality indicator parameters within all the foreshore waters sampled compared to background (ambient) water quality (taken to be represented in the groundwater at MW-3). Conclusions C5 through C11 provide a summary of the most pertinent water quality results. Swan Lake is mesotrophic, moderately productive; therefore, it will act as a natural sink for metals and nutrients and other contaminants, whereas rapid flushing of the lake will result in the loss of chloride.

C5 Sampling locations at the north end of Swan Lake (FS-43, Greenhow Creek (FS-43 (SW)), and MW-1) showed the highest levels of chloride compared to the other sample sites (expect at FS-15). The source of the chloride is likely from a combination of road-salting, agriculture and biosolids composing. Further investigation would be required to assess the relative contribution of chloride from the biosolids disposal facility, located about 1.2 km north of the lake.

C6 Average ammonia, a reduced state of nitrogen, was present at elevated concentrations at two foreshore (near-surface groundwater) locations at the southeast shore of Swan Lake (FS-31 and FS-32). Both locations are thought to be affected by septic effluent. FS-29 was also elevated in ammonia and is likely influenced by agricultural land-use. Swan Lake (August 2016, mid-basin sample) exceeded the aquatic life water quality guidelines for ammonia. This area could be a focus for centralized wastewater treatment.

C7 Nitrate, present in the hyporheic ditch waters above the east shore of Swan Lake at FS-101, FS-104, FS 104b and Site 5 and Site 5b (NE-Culvert) were shown to be elevated, likely due to operation of on-site wastewater systems in the densely populated area along with some

agricultural input. However, all sampled foreshore locations at the lake shoreline showed nitrate concentrations less than 1 mg/l. The overall reduction of nitrate from the ditches to the foreshore water is likely the result of uptake of nutrients (nitrogen) into the riparian vegetation present along a majority of Swan Lake's east shoreline.

C8 Sulphate concentrations were found to be elevated during the spring (April 2015) sampling of foreshore waters on the east, north, and southwest shores of Swan Lake. Concentrations were above 10,000 mg/l at FS-3 (east) and above 1,000 mg/l at FS-43 (north), MW-1 (north), and FS-29 (west). During subsequent sampling events, we see that sulphate was quite elevated in the spring of 2016; however, sulphate at FS-3 never reached over 10,000 mg/l again during the sampling period. Land-use upgradient of the foreshore consists of light industrial, commercial, residential and agricultural land; specifically, apple and cherry orchards. From personal communication with an agricultural fertilizer supplier in the area, we were able to estimate the application of sulphate to the orchards above the affected east foreshore area to be on the order of 6,428 to 12,871 kg/year.

C9 Uranium was present at all foreshore (near surface groundwater) locations sampled around Swan Lake at concentrations above the provincial irrigation water and drinking water guidelines of 0.01 and 0.02 mg/l, respectively. Uranium exceeded applicable guidelines at four locations (FS-34 (SW), SE Spring, Site 3 (NE–Cowboys), Site 5b (NE- Culvert). Pearson correlation analysis showed a 0.6 r^2 between uranium and chloride and uranium and calcium in the surface waters; r2 for uranium and chloride and uranium and calcium were less correlated with an r^2 of 0.3. Based on research in other geographic areas, it is possible that the impact from land-use surrounding Swan Lake, specifically input of calcium and chloride, have changed the solution chemistry of the near-surface groundwater, resulting in increased solubility of uranium present in the parent rock. Specifically, from the one sampling event, completed in the fall of 2015, we see concentrations of dissolved uranium within the foreshore (near-surface groundwater) of Swan Lake at concentrations two to three orders of magnitude above background (ambient) levels observed in the groundwater at MW-3.

C10 Chloride can be used as an indicator of anthropogenic input into the environment. By apportioning chloride to the land uses surrounding Swan Lake, we estimated chloride mass loading rates and found that agricultural activities around the lake form the largest contribution to the chloride budget.

C11 Periphyton- chlorophyll-a at Vernon Creek (outlet of Swan Lake) was estimated to be 108.1 mg/m2; which is above the MoE Water Quality Criteria for Nutrients and Algae guidelines, short-term maximum (MoE 2017) for the protection of aquatic life in streams of 100 mg/m^2. This chlorophyll-a exceedance indicates that Swan Lake is discharging relatively nutrient rich water into Vernon Creek. Nutrients are derived from adjacent land-use (agricultural and on-site wastewater systems) with likely minor influence from avian activities.

C12 The following data gaps were recognized in the current study:

- The above-mentioned uncertainties with regard to the water budget; and
- Unable to assess potential contribution from the biosolids disposal facility located north of the lake due to lack information provided by government on permitted volumes or other aspects of the disposal operation.

6. RECOMMENDATIONS

Based on the conclusions of the Swan Lake area water quality and land use study completed in 2015-16, we provide the following recommendations:

R1 Given the measured impact of nutrients at Swan Lake, Vernon Creek, FS-31, FS-32, SE Spring, Site 3 (NE – Cowboys) and other locations on the east side of the Swan Lake, collection and treatment of wastewater from commercial and residential land-uses, which surround Swan Lake, should be considered in a Master Wastewater Recovery Plan.

R2 Given the significant contribution of sulphate around the perimeter of the Swan Lake, farmers operating around Swan Lake should be encouraged to create and implement Land Application Plans, which aim to reduce the input of sulphate into the near-surface groundwater along the shore of Swan Lake.

R3 Due to the input of both naturally occurring and anthropogenic derived calcium and chloride from the various land uses around Swan Lake, we believe the solubility of uranium into the foreshore waters is increased. A strategy to reduce uranium input into Swan Lake foreshore waters, with an overall reduction in anthropogenic derived calcium and chloride, should be implemented. This strategic plan to reduce calcium and chloride input should involve recommending that the various land users surrounding the lake reduce application of chemicals containing calcium and chloride.

R4 We observed a notable reduction of nitrate concentrations between the ditch (and storm drainage) waters and the foreshore waters on the east side of the lake. We see this as good evidence that the riparian zone is effective in reducing nutrient loading to the lake. Therefore, the land owners at the perimeter of the lake should be encouraged and/or be provided incentive to maintain and cultivate planting of willow and cattails within at least 10 m of the lake, in the riparian zone to help improve water quality of Swan Lake. Further, the stream entering Swan Lake on the east shore of Swan Lake (SE Spring, Site 3, Site 5 and 5b) which show elevated nitrate above the aquatic life guidelines should be diverted into constructed wetlands prior to entering the lake to help reduce nutrient loading into Swan Lake.

R5 Upon inspection there was evidence of brine runoff into adjacent ditches. Although, it was not possible to investigate further into this matter due to property access restriction, this potential source of chloride contamination should be further assessed in the future. It could be seen, from off-site, that potential monitoring wells do exist on the salt-storage site and have likely been sampled in the past. Access to this data would help to improve the value of the apportioning of chloride aspect of this current study. We recommend further inquiry into the status of monitoring the biosolids composting operation be made; specifically, inquire as to whether groundwater monitoring downgradient of the facility is occurring. Despite this lack of information, operation of the biosolids disposal facility is an important part of the chloride and nutrient balance of Swan Lake and is a data gap in the current study and should be considered further.

R6 Currently the City of Vernon is engaged in a three-year baseline water quality assessment of Vernon Creek. Data sharing from this study should be provided to the City of Vernon for consideration in their baseline study.

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Figures

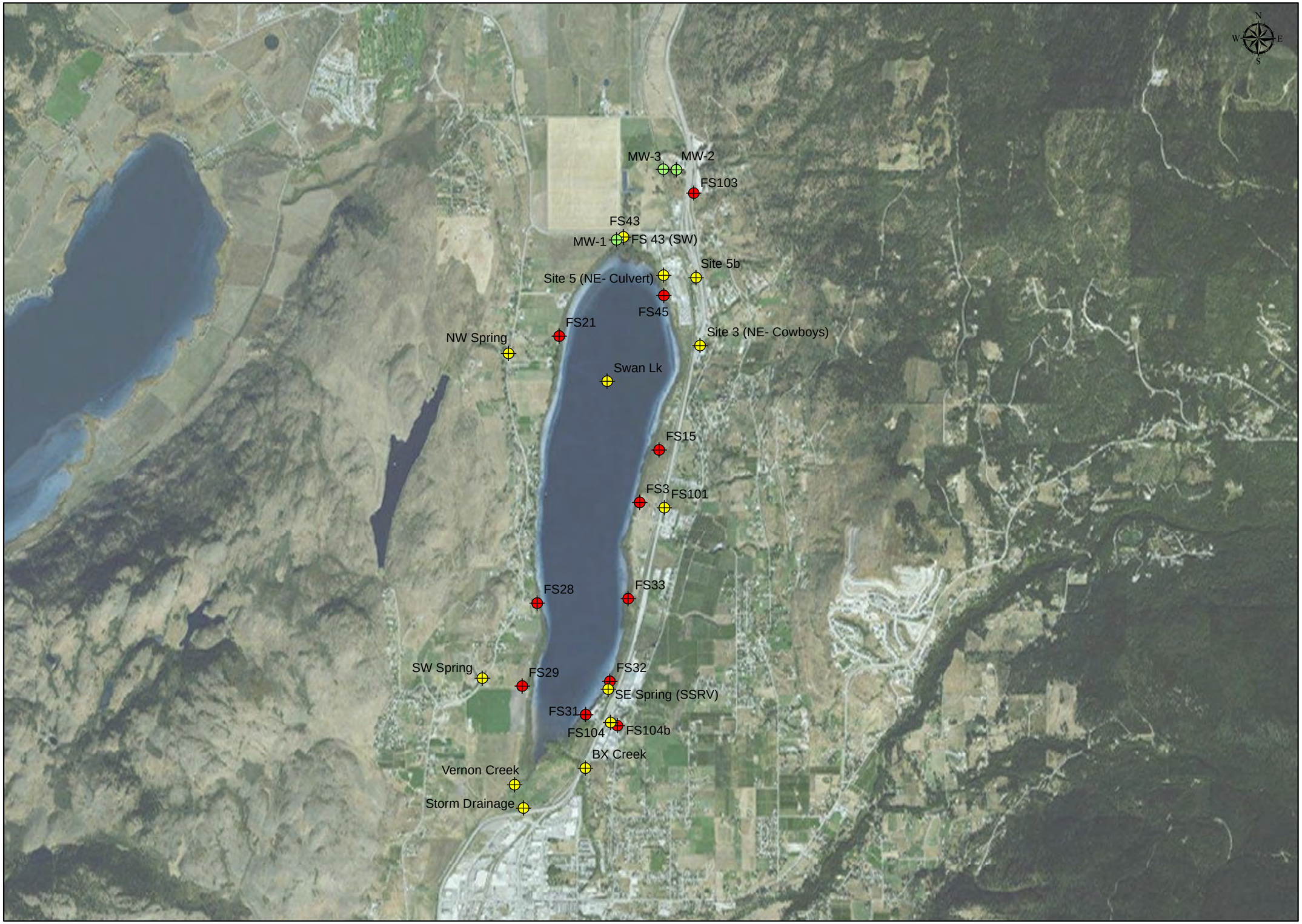


Figure 1 - Swan Lake Site Overview.

Legend

- Groundwater Locations
- Surface Water Locations
- Foreshore Locations (Near surface groundwater locations)

0 495 990 1,980
Meters

western water ASSOCIATES LTD
Consultants in Hydrogeology and Water Resources Management

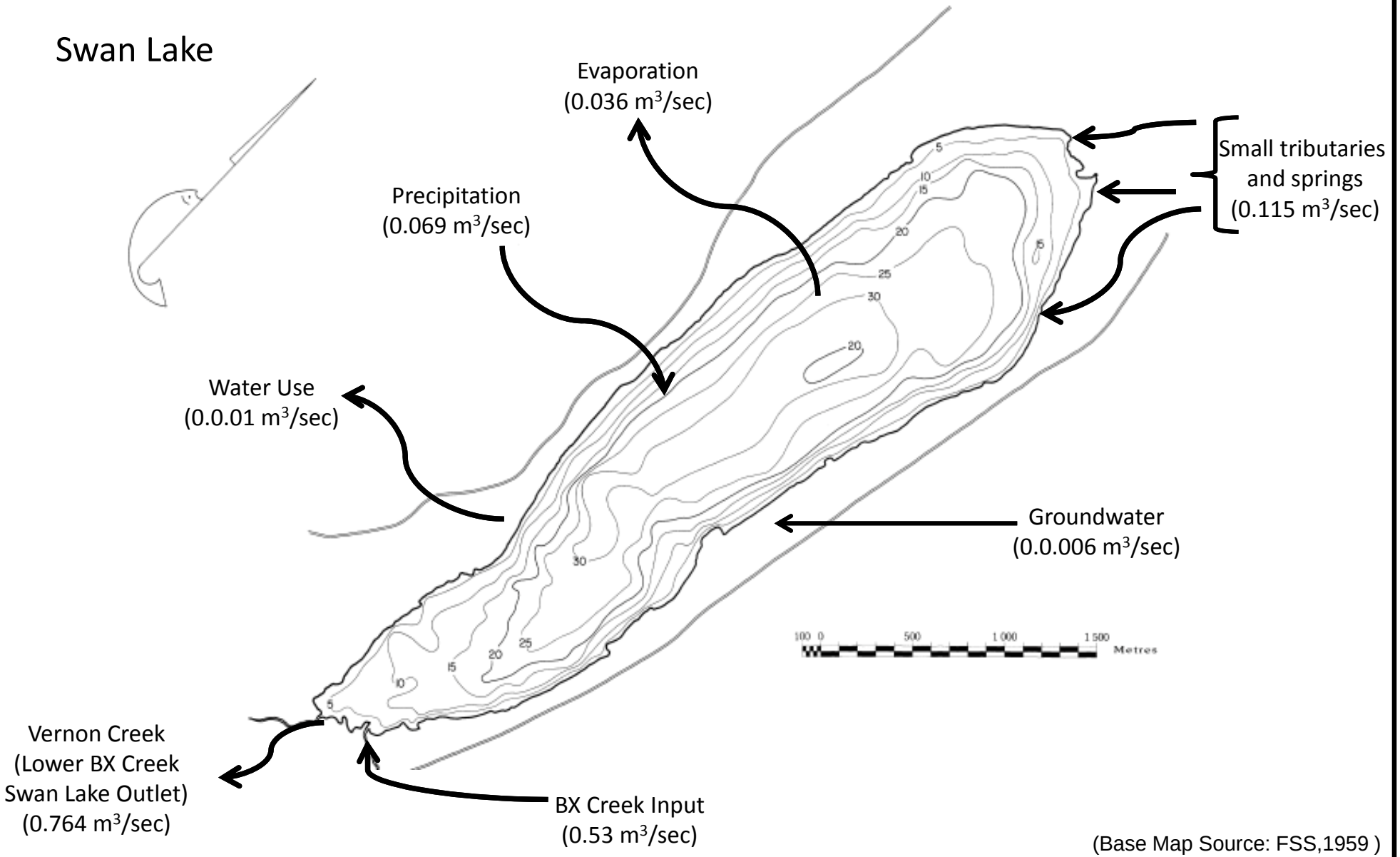
Reference

Client: RDNO.
Project Number: 14-076-01
Date: November 1, 2016
Drawn by: Nathan Whitling
Checked by: Bryer Manwell

Digital data and orthophotos provided by RDNO and MOE

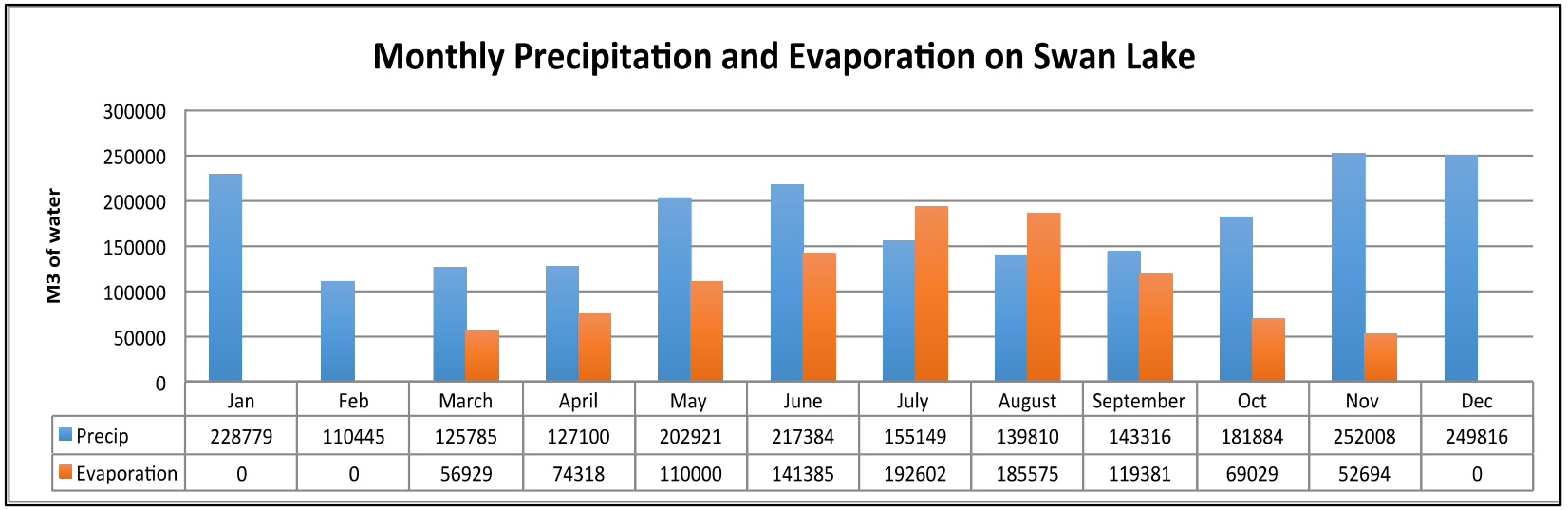
Coordinate System: NAD 83 UTM Zone 11

Key Map

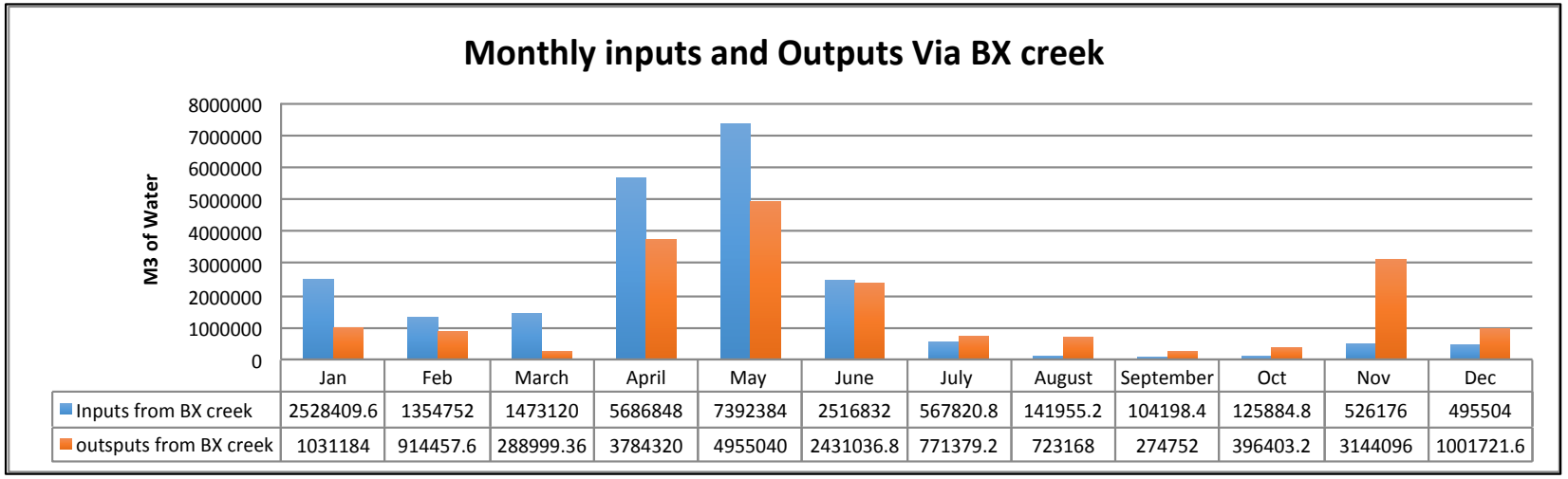


(Base Map Source: FSS,1959)

Regional District of North Okanagan	TITLE **Figure 2**: Bathymetric Map and 2016 Water Balance Estimates (average annual inflows and outflows).		
western water ASSOCIATES LTD	DRAWN MJ	DATE June 2017	PROJECT NO. 14-076-02
	CHECKED BM	SCALE	DWG. NO. na
	REVIEWED	FILE NO.	FIGURE NO. 1



	Jan	Feb	March	April	May	June	July	August	September	Oct	Nov	Dec
Precip	228779	110445	125785	127100	202921	217384	155149	139810	143316	181884	252008	249816
Evaporation	0	0	56929	74318	110000	141385	192602	185575	119381	69029	52694	0



	Jan	Feb	March	April	May	June	July	August	September	Oct	Nov	Dec
Inputs from BX creek	2528409.6	1354752	1473120	5686848	7392384	2516832	567820.8	141955.2	104198.4	125884.8	526176	495504
outsputs from BX creek	1031184	914457.6	288999.36	3784320	4955040	2431036.8	771379.2	723168	274752	396403.2	3144096	1001721.6

Regional District of North Okanagan

TITLE **Figure 3:** Monthly Precipitation and Evaporation (upper), Monthly Inputs and Outputs via BX Creek**.**

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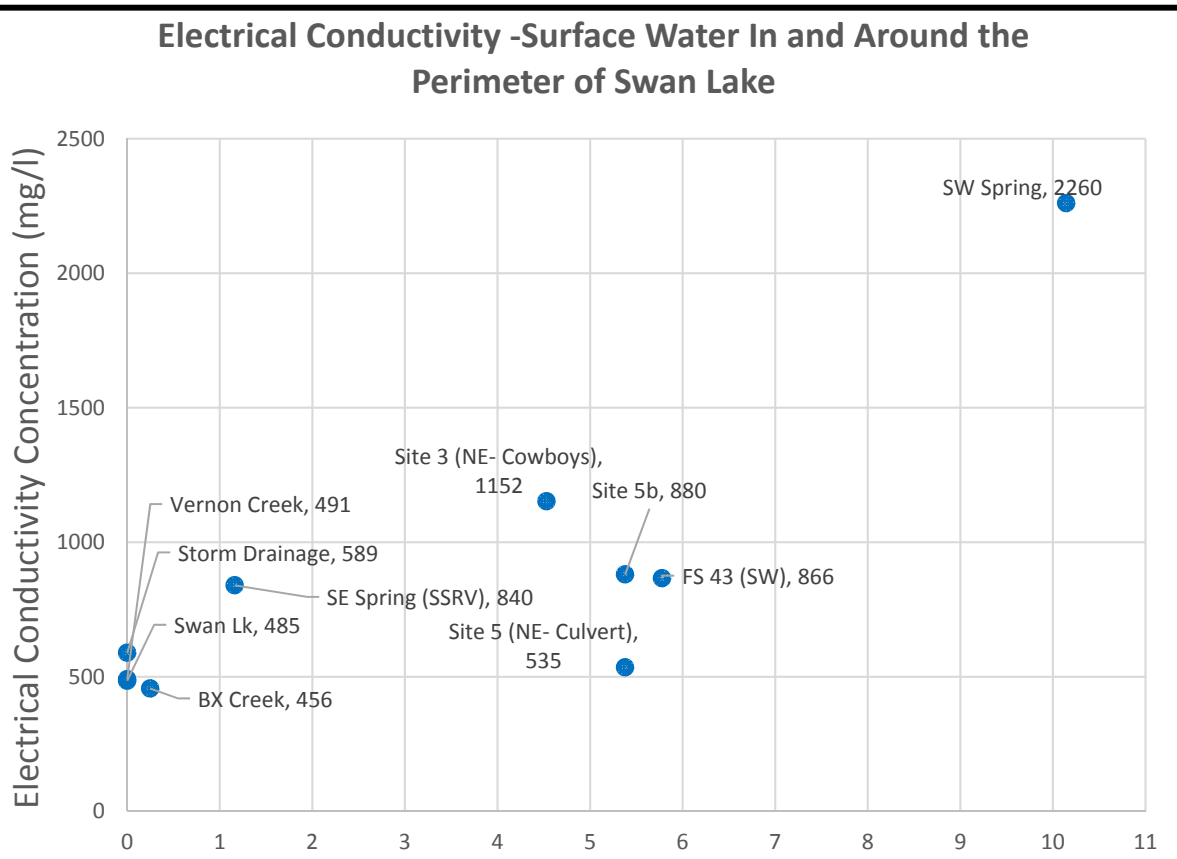
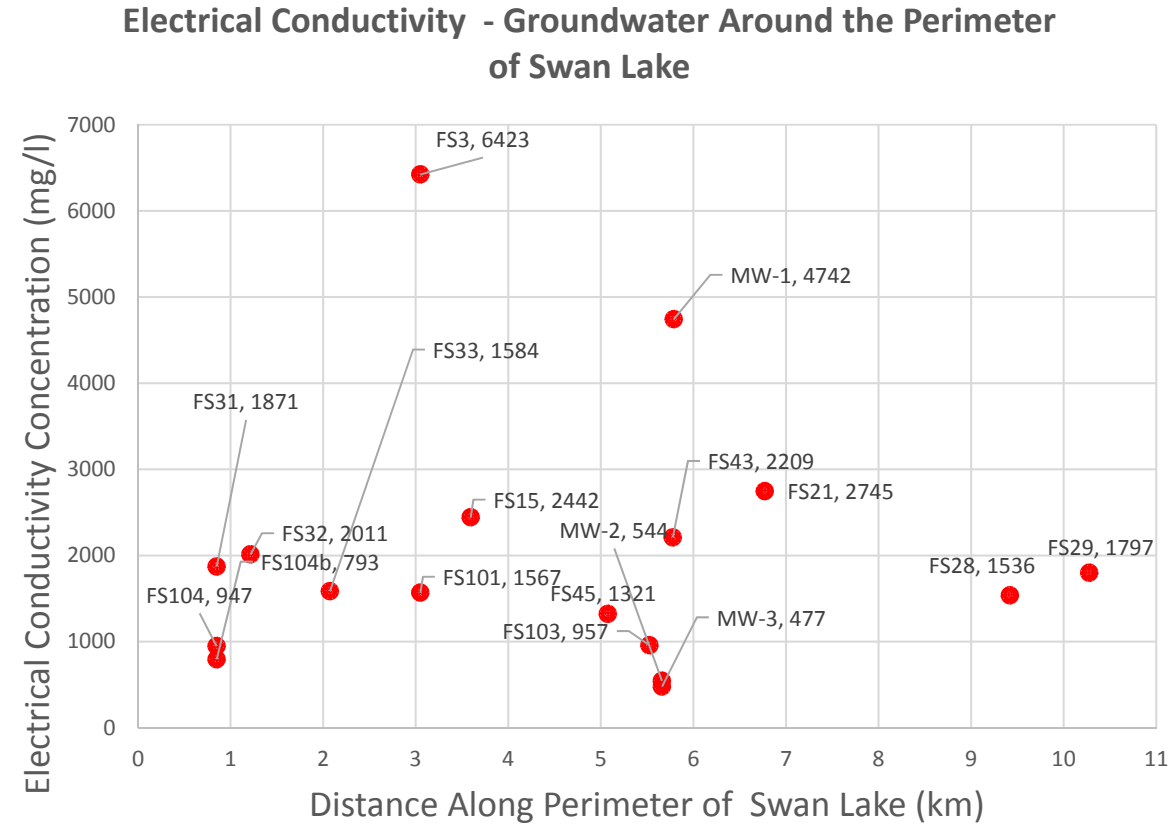
DRAWN	MJ	DATE	June 2017	PROJECT NO.	14-076-01
CHECKED	BM	SCALE		DWG. NO.	na
REVIEWED		FILE NO.		FIGURE NO.	1

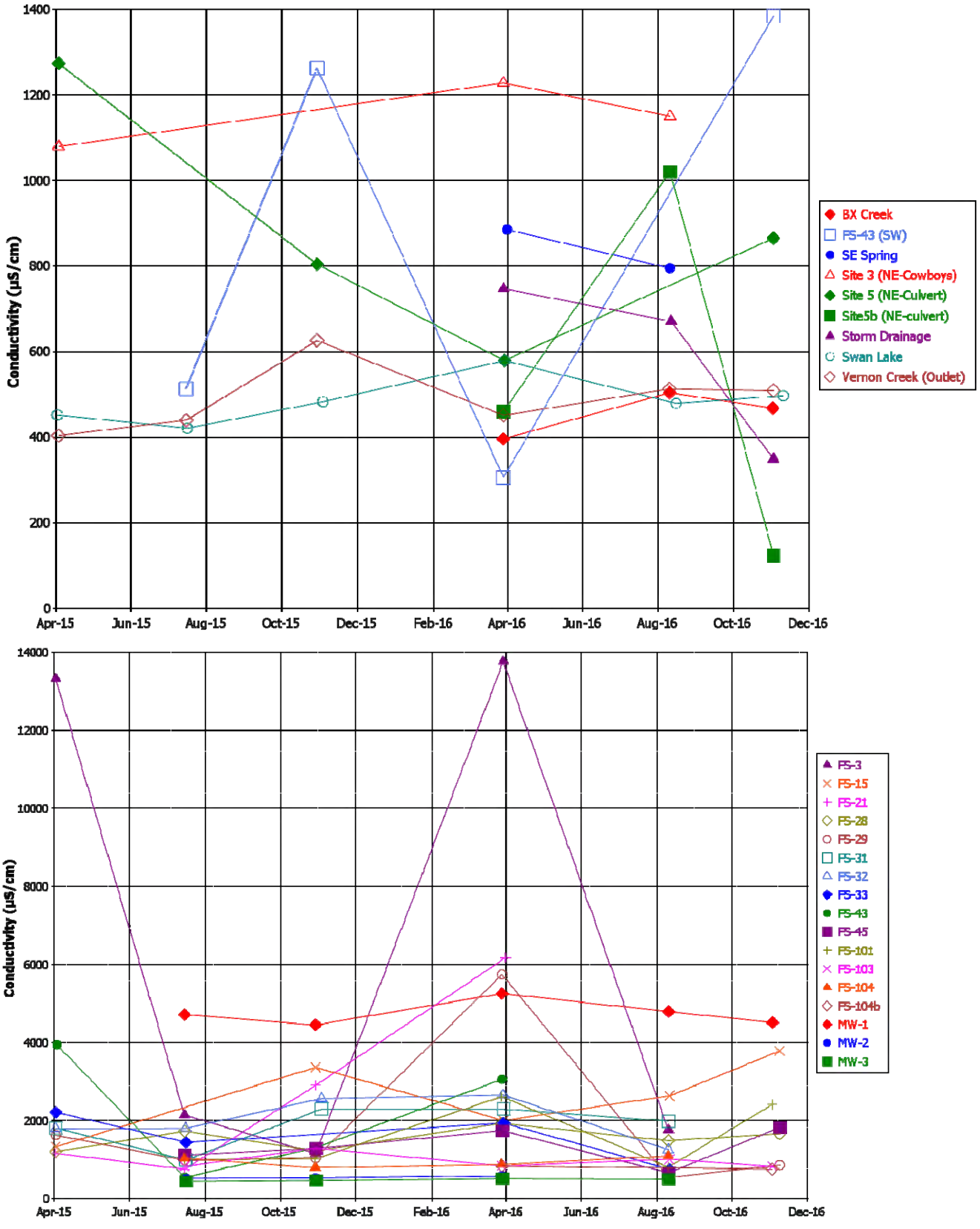




Regional District of North Okanagan	TITLE **Figure 4:** Average Electrical Conductivity Around the Perimeter of Swan Lake.

western water ASSOCIATES LTD

DRAWN		DATE	June 2017	PROJECT NO.	14-076-02
CHECKED	BRM	SCALE	n/a	DWG. NO.	n/a
REVIEWED	DG	FILE NO.		FIGURE NO.	1



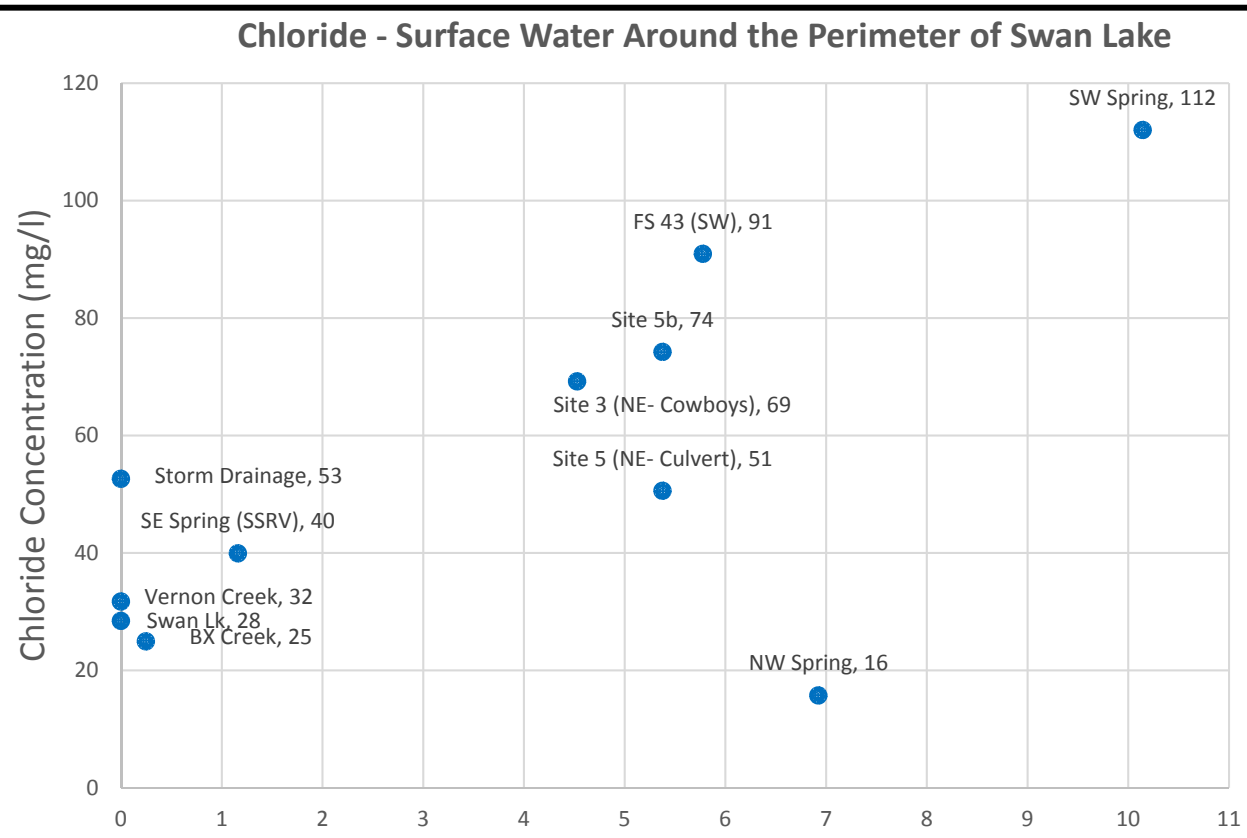
Regional District of North Okanagan

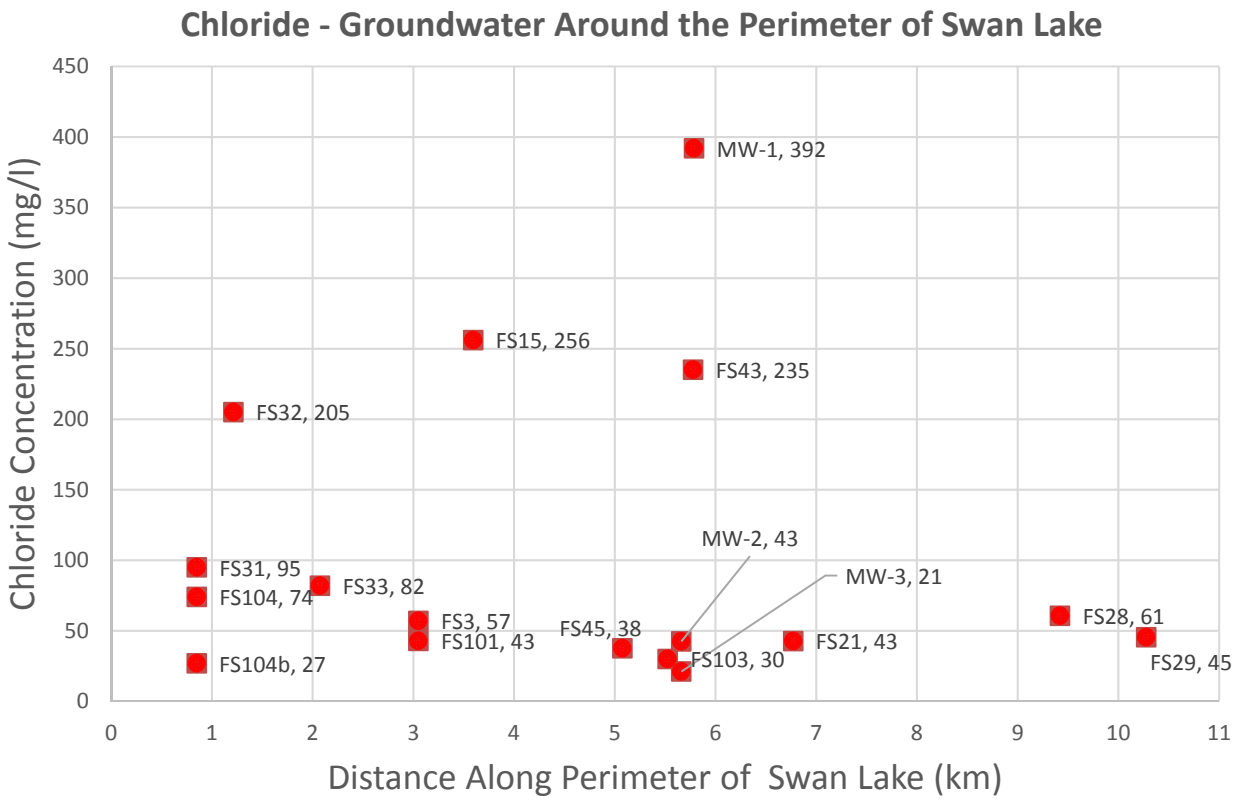
TITLE

Figure 5: Time-Series Plot for Electrical Conductivity at Swan Lake between 2015 and 2016. Upper plot shows surface waters and lower plot shows groundwaters.

western water ASSOCIATES LTD

DRAWN		DATE	June 2017	PROJECT NO.	14-076-02
CHECKED	BRM	SCALE	n/a	DWG. NO.	n/a
REVIEWED	DG	FILE NO.		FIGURE NO.	1

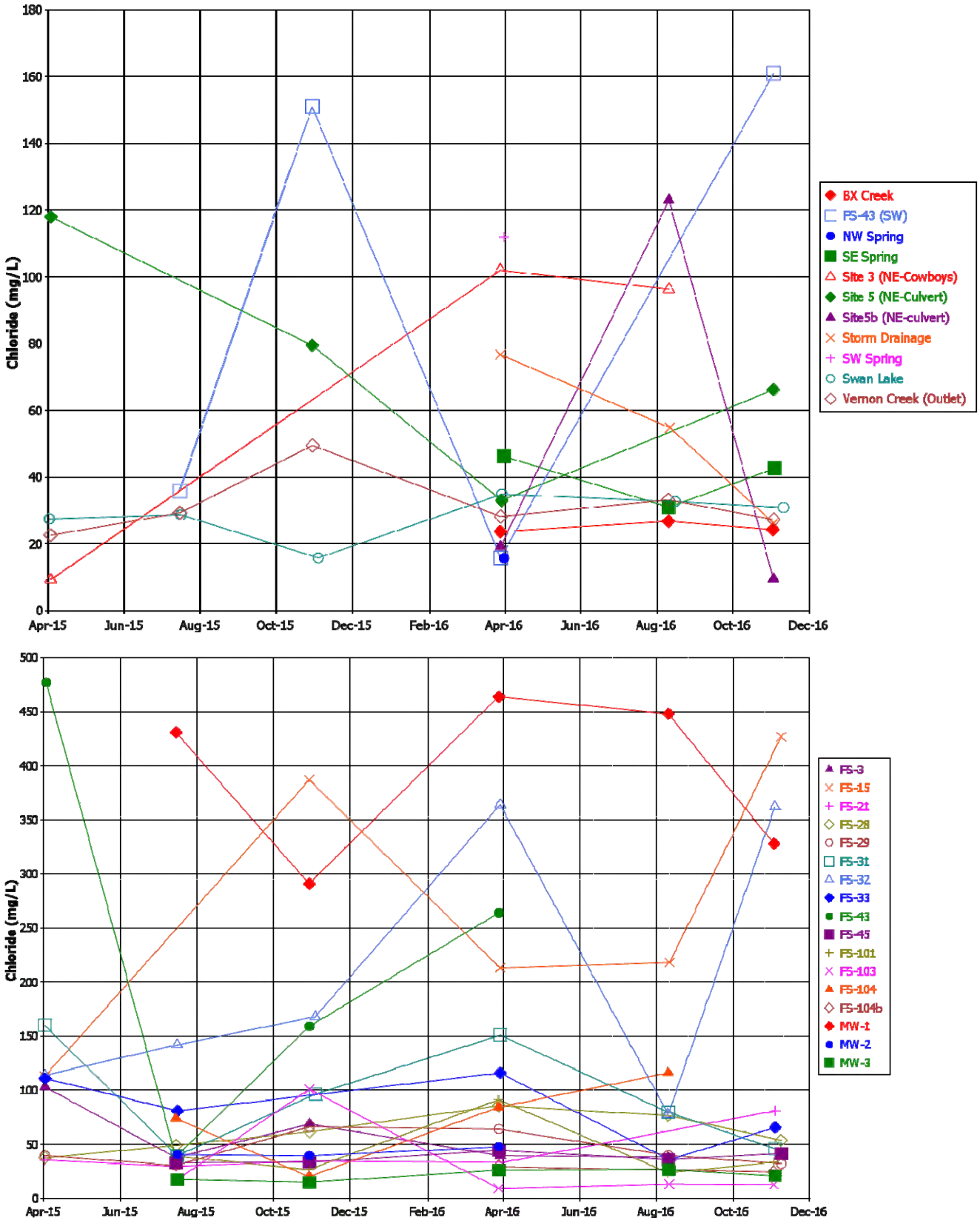




Regional District of North Okanagan	TITLE **Figure 6:** Average Chloride Concentrations Around the Perimeter of Swan Lake.

western water ASSOCIATES LTD

DRAWN		DATE	June 2017	PROJECT NO.	14-076-02
CHECKED	BRM	SCALE	n/a	DWG. NO.	n/a
REVIEWED	DG	FILE NO.		FIGURE NO.	1



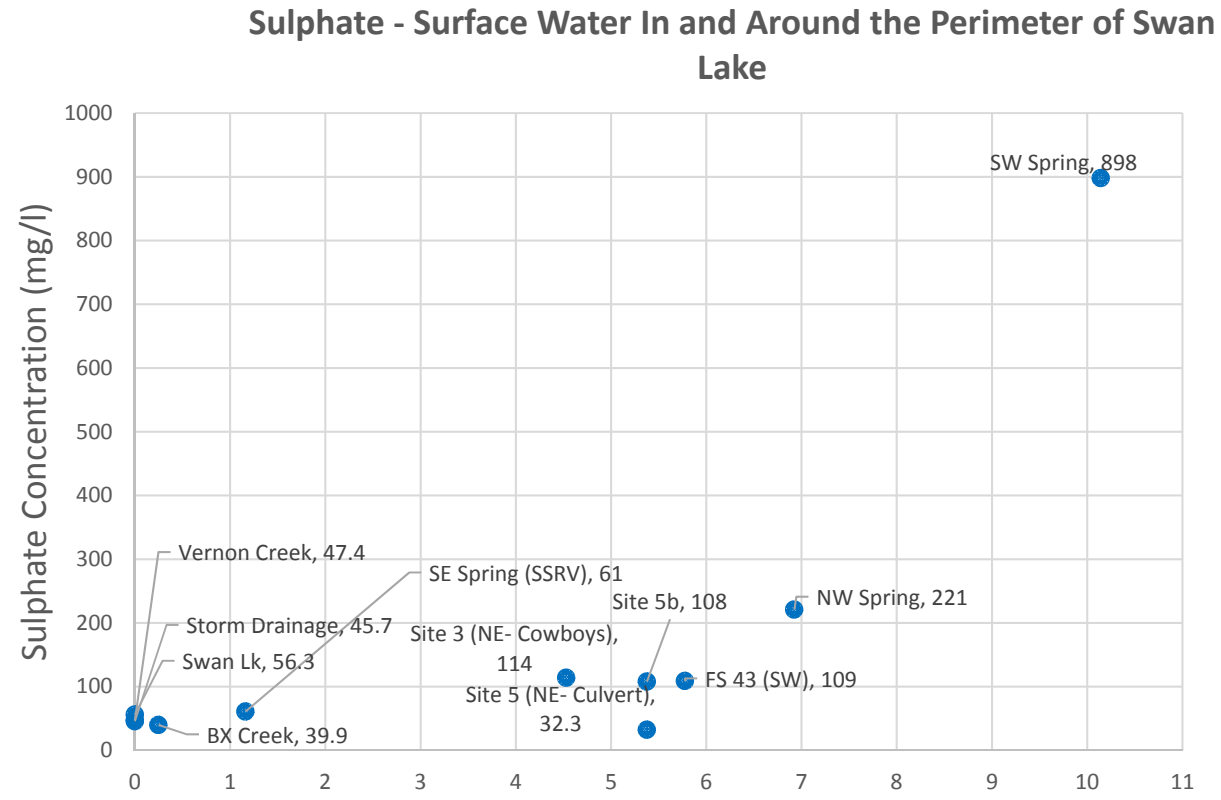
Regional District of North Okanagan

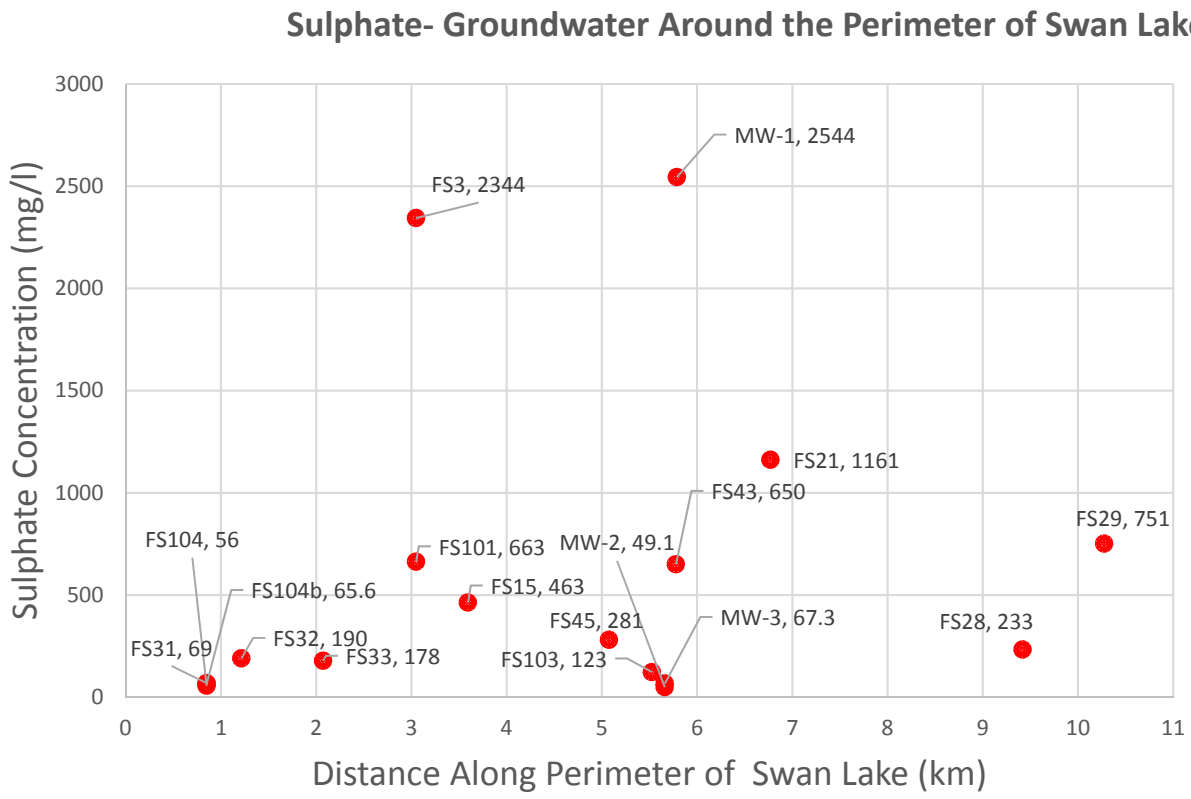
TITLE

Figure 7: Time-Series Plot for Chloride at Swan Lake between 2015 and 2016. Upper plot shows surface waters and lower plot shows groundwaters.

western water ASSOCIATES LTD

DRAWN		DATE	June 2017	PROJECT NO.	14-076-02
CHECKED	BRM	SCALE	n/a	DWG. NO.	n/a
REVIEWED	DG	FILE NO.		FIGURE NO.	1

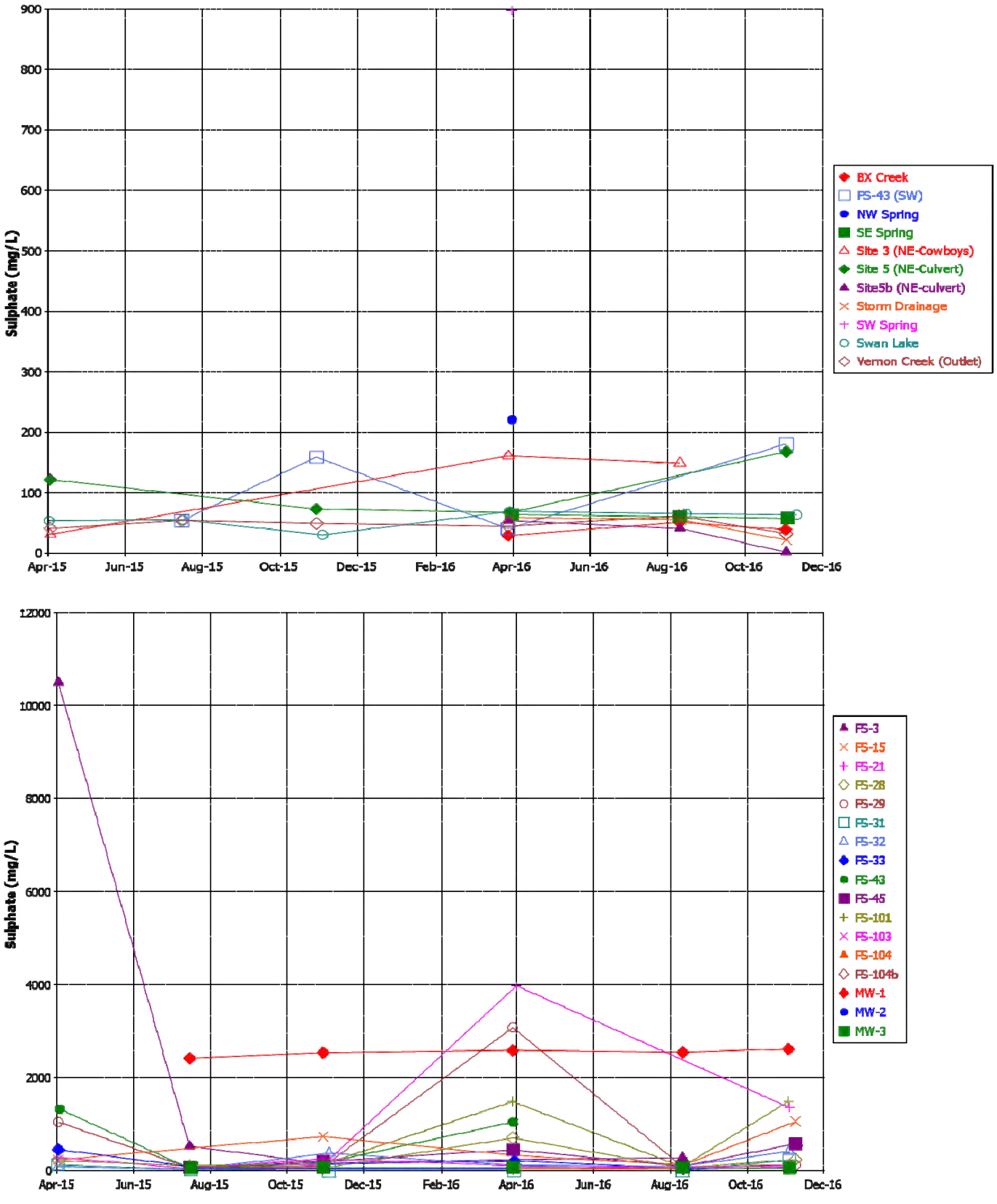




Regional District of North Okanagan	TITLE **Figure 8:** Average Sulphate Concentrations Around the Perimeter of Swan Lake.

western water ASSOCIATES LTD

DRAWN		DATE	June 2017	PROJECT NO.	14-076-02
CHECKED	BRM	SCALE	n/a	DWG. NO.	n/a
REVIEWED	DG	FILE NO.		FIGURE NO.	1



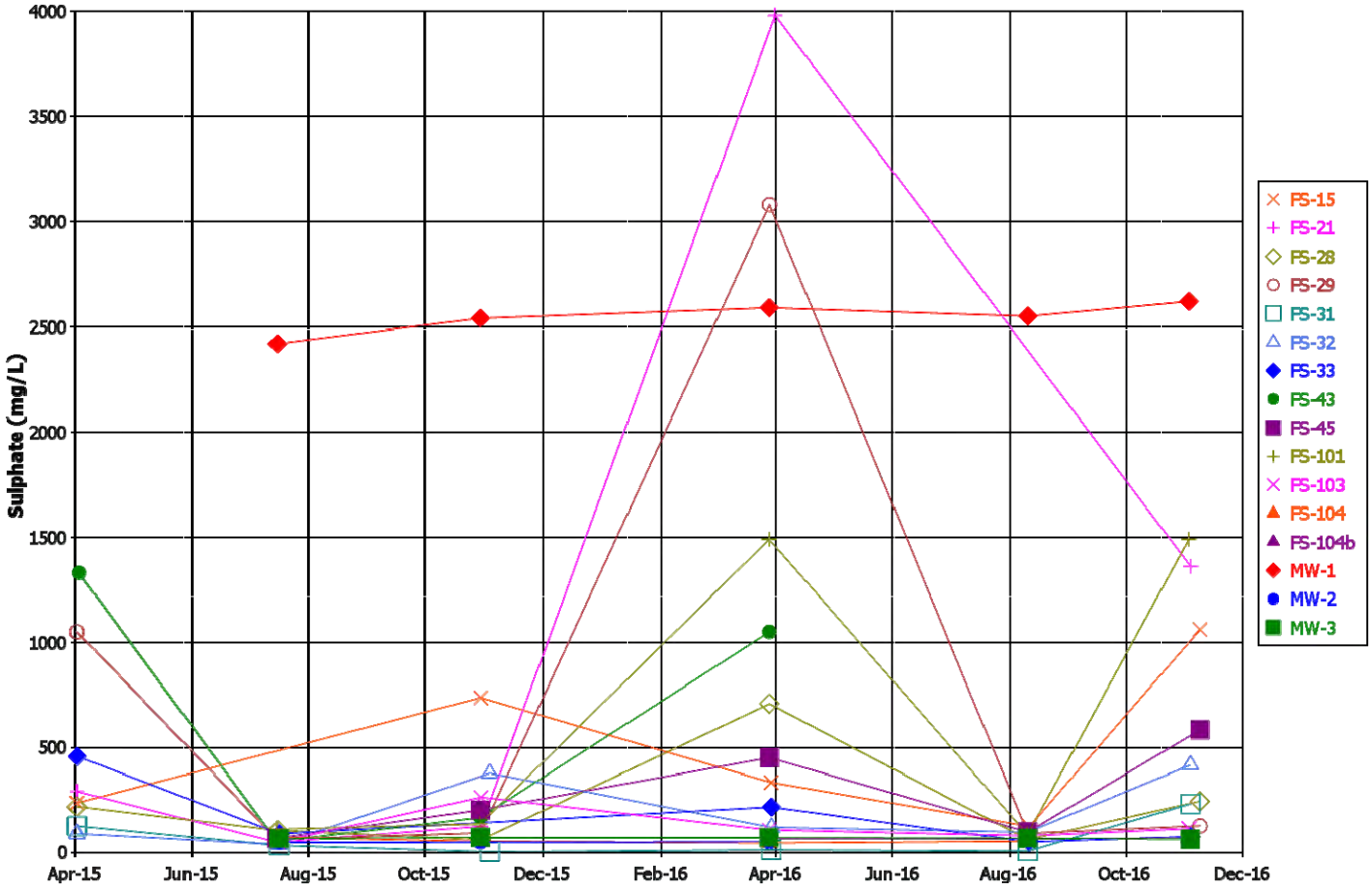
Regional District of North Okanagan

TITLE

Figure 9a: Time-Series Plot for Sulphate at Swan Lake between 2015 and 2016. Upper plot shows surface waters and lower plot shows groundwaters.

western water ASSOCIATES LTD

DRAWN		DATE	June 2017	PROJECT NO.	14-076-02
CHECKED	BRM	SCALE	n/a	DWG. NO.	n/a
REVIEWED	DG	FILE NO.		FIGURE NO.	1



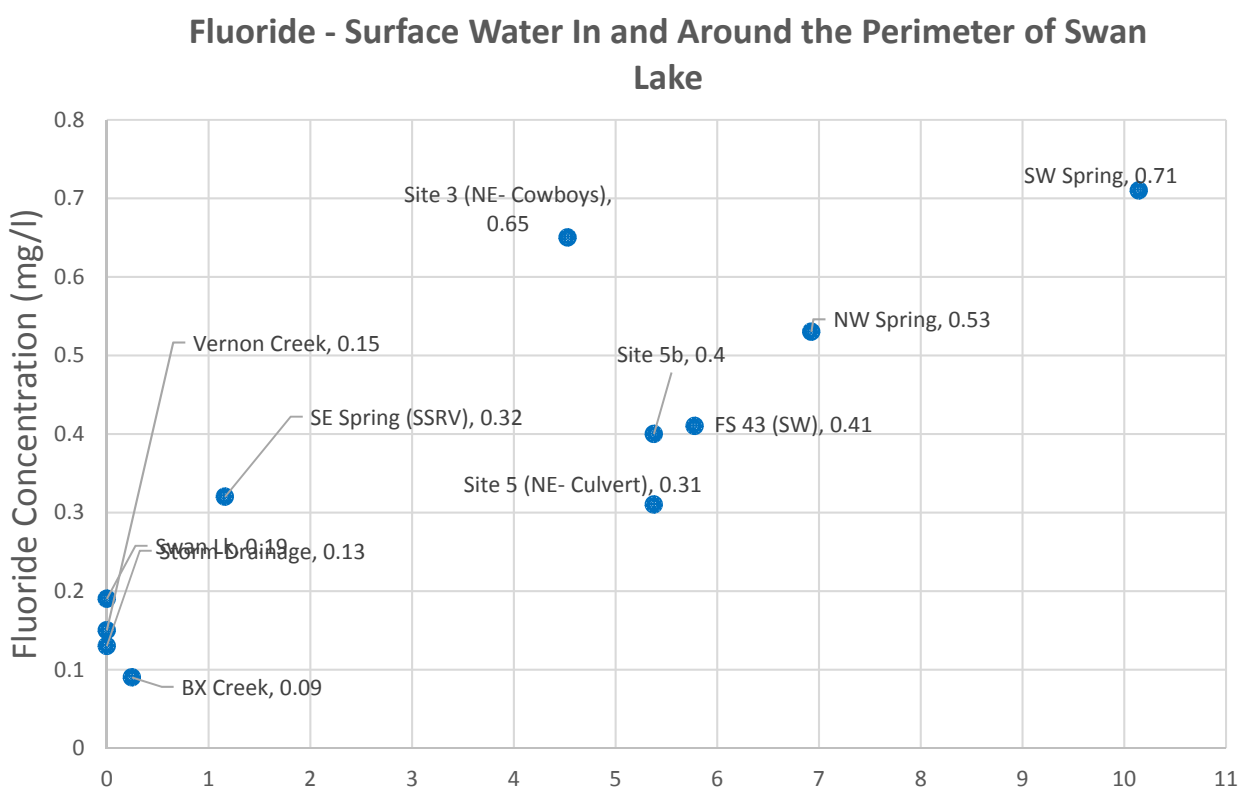
Regional District of North Okanagan

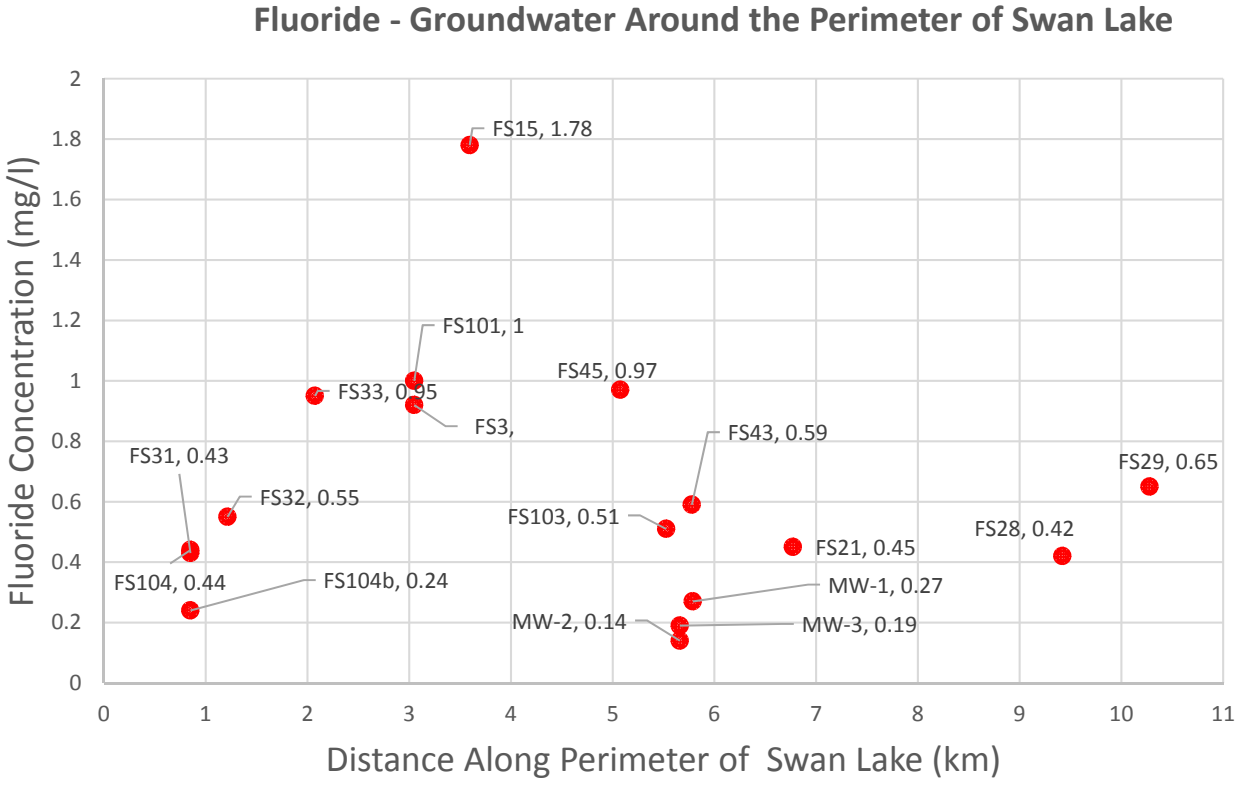
TITLE

Figure 9b: Modified Time-Series Plot for Sulphate at Swan Lake between 2015 and 2016 (groundwaters), with FS-3 removed.

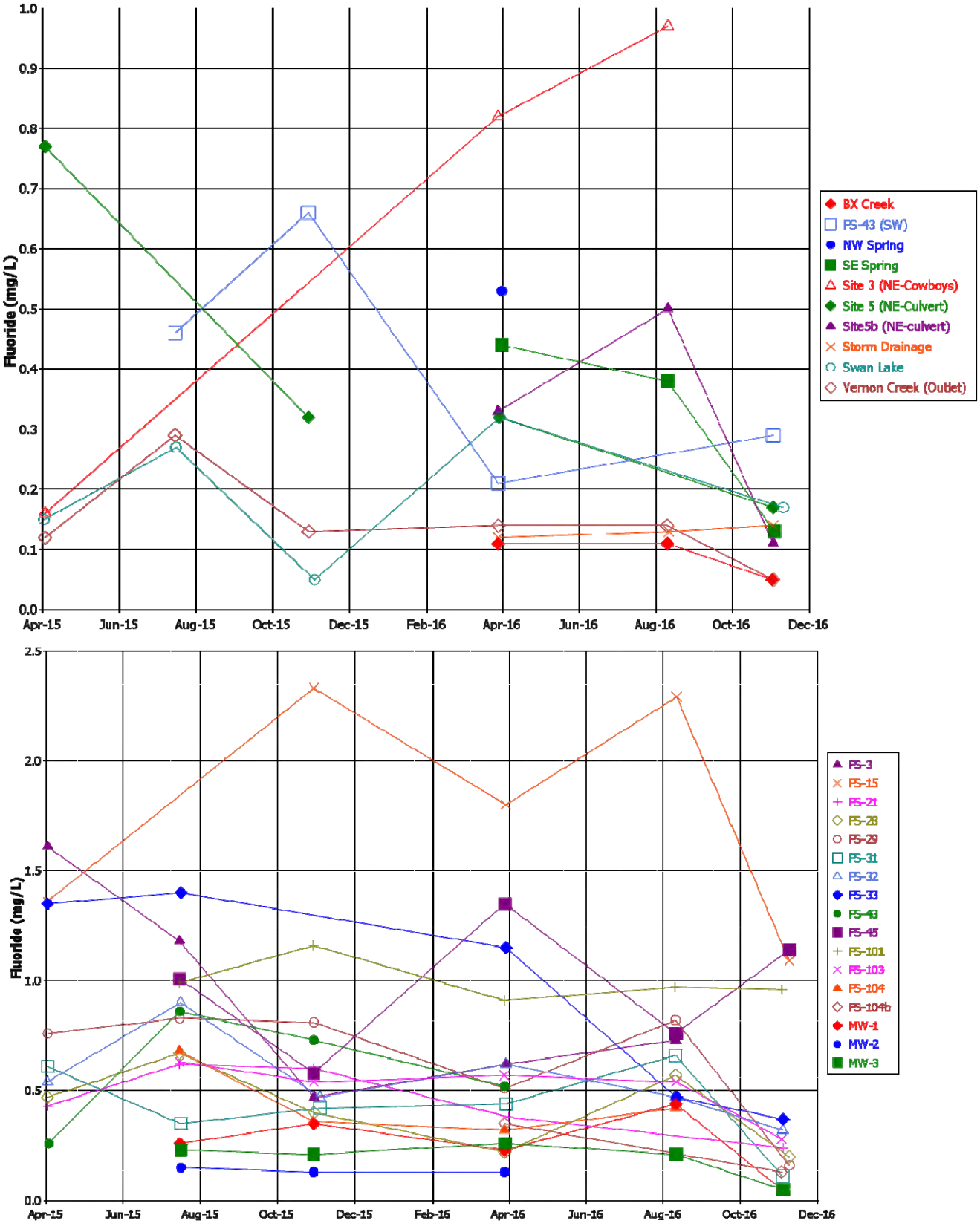
western water ASSOCIATES LTD

DRAWN		DATE	June 2017	PROJECT NO.	14-076-02
CHECKED	BRM	SCALE	n/a	DWG. NO.	n/a
REVIEWED	DG	FILE NO.		FIGURE NO.	1





Regional District of North Okanagan	TITLE **Figure 10:** Average Fluoride Concentrations Around the Perimeter of Swan Lake.			
western water ASSOCIATES LTD	DRAWN	DATE June 2017	PROJECT NO. 14-076-02	
	CHECKED BRM	SCALE n/a	DWG. NO. n/a	
	REVIEWED DG	FILE NO.	FIGURE NO. 1	



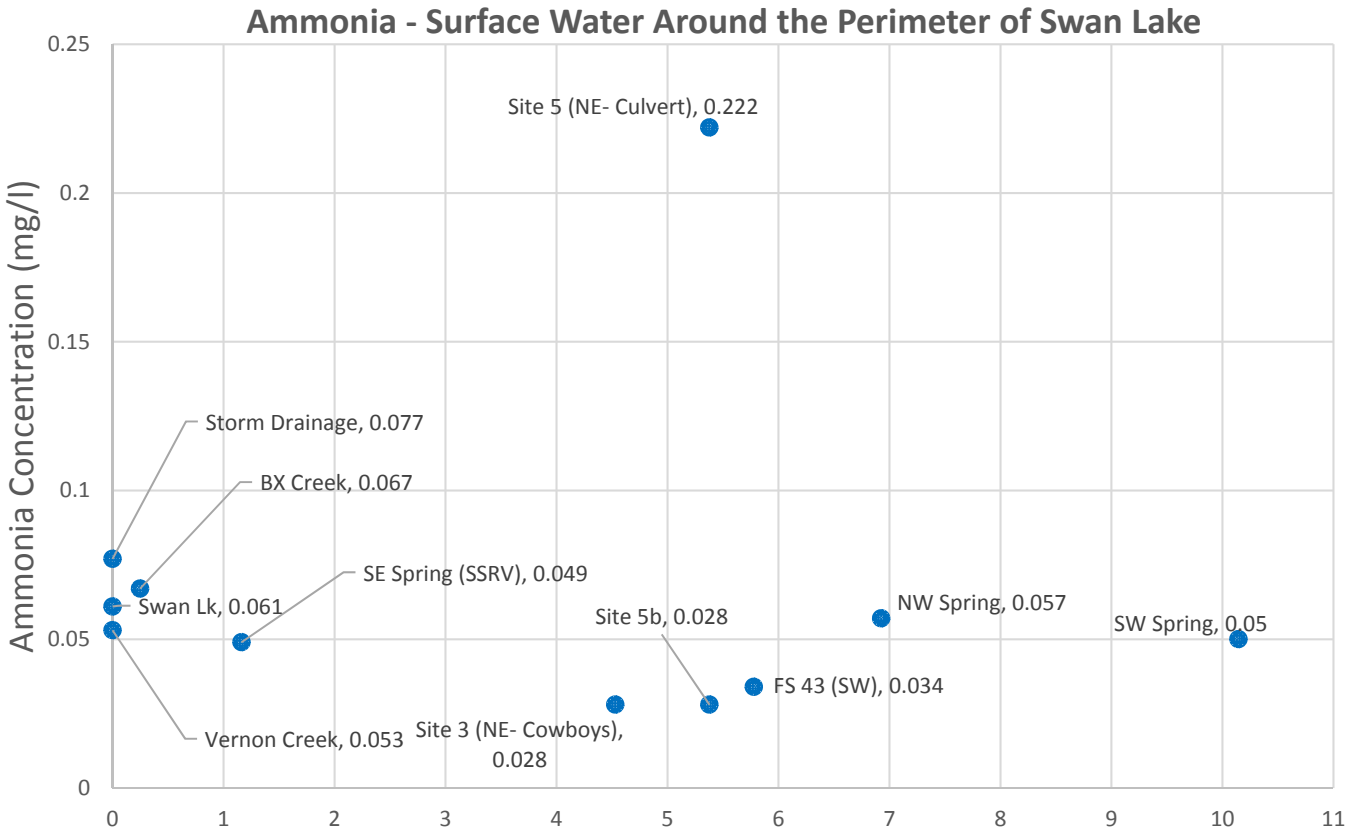
Regional District of North Okanagan

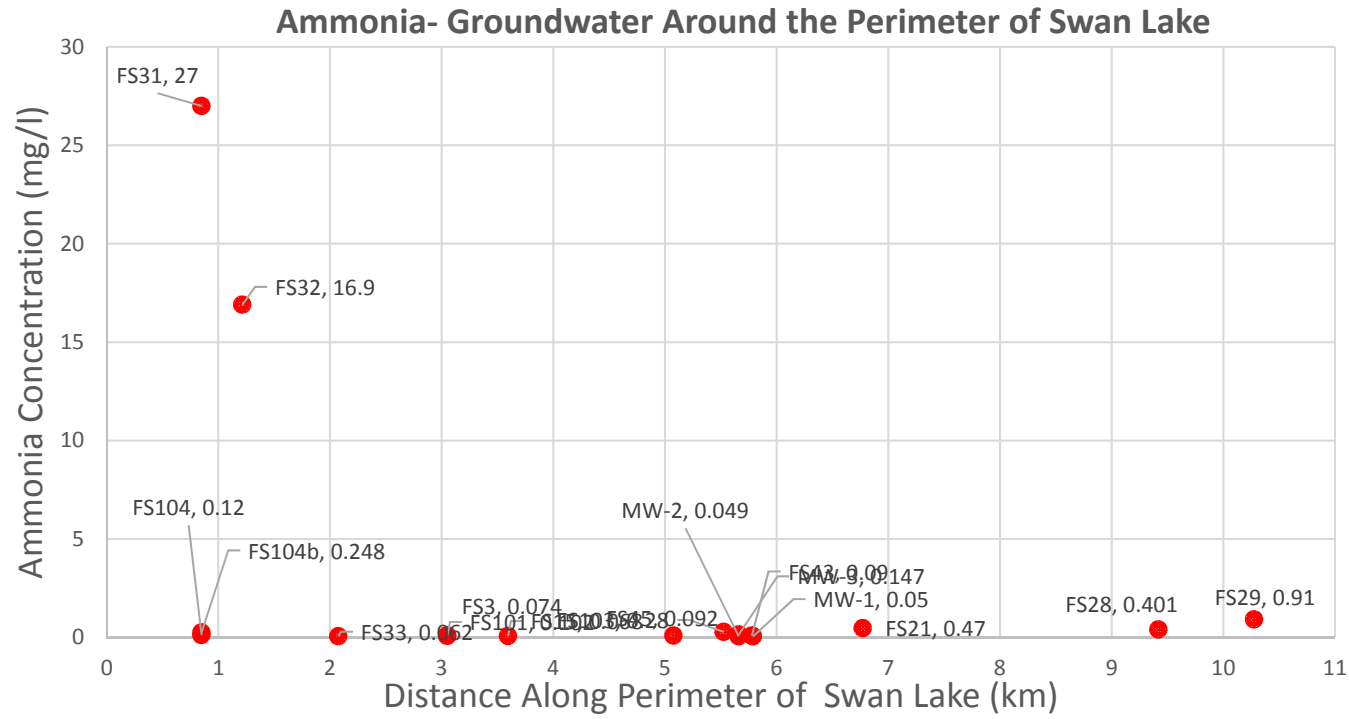
TITLE

Figure 11: Time-Series Plot for Fluoride at Swan Lake between 2015 and 2016. Upper plot shows surface waters and lower plot shows groundwaters.

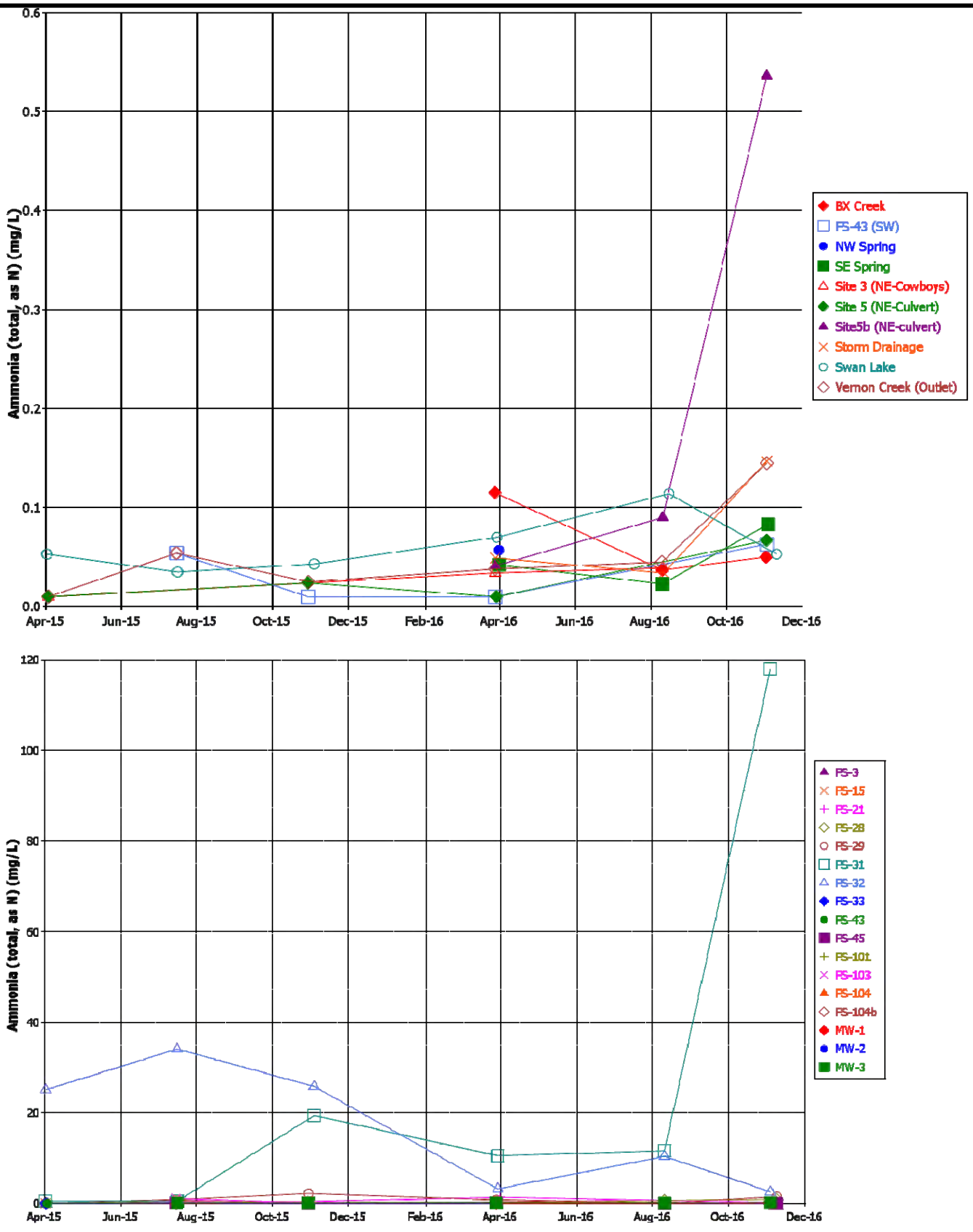
western water ASSOCIATES LTD

DRAWN		DATE	June 2017	PROJECT NO.	14-076-02
CHECKED	BRM	SCALE	n/a	DWG. NO.	n/a
REVIEWED	DG	FILE NO.		FIGURE NO.	1





Regional District of North Okanagan	TITLE **Figure 12:** Average Ammonia Around the Perimeter of Swan Lake.			
western water ASSOCIATES LTD	DRAWN	DATE June 2017	PROJECT NO. 14-076-02	
	CHECKED BRM	SCALE n/a	DWG. NO. n/a	
	REVIEWED DG	FILE NO.	FIGURE NO. 1	



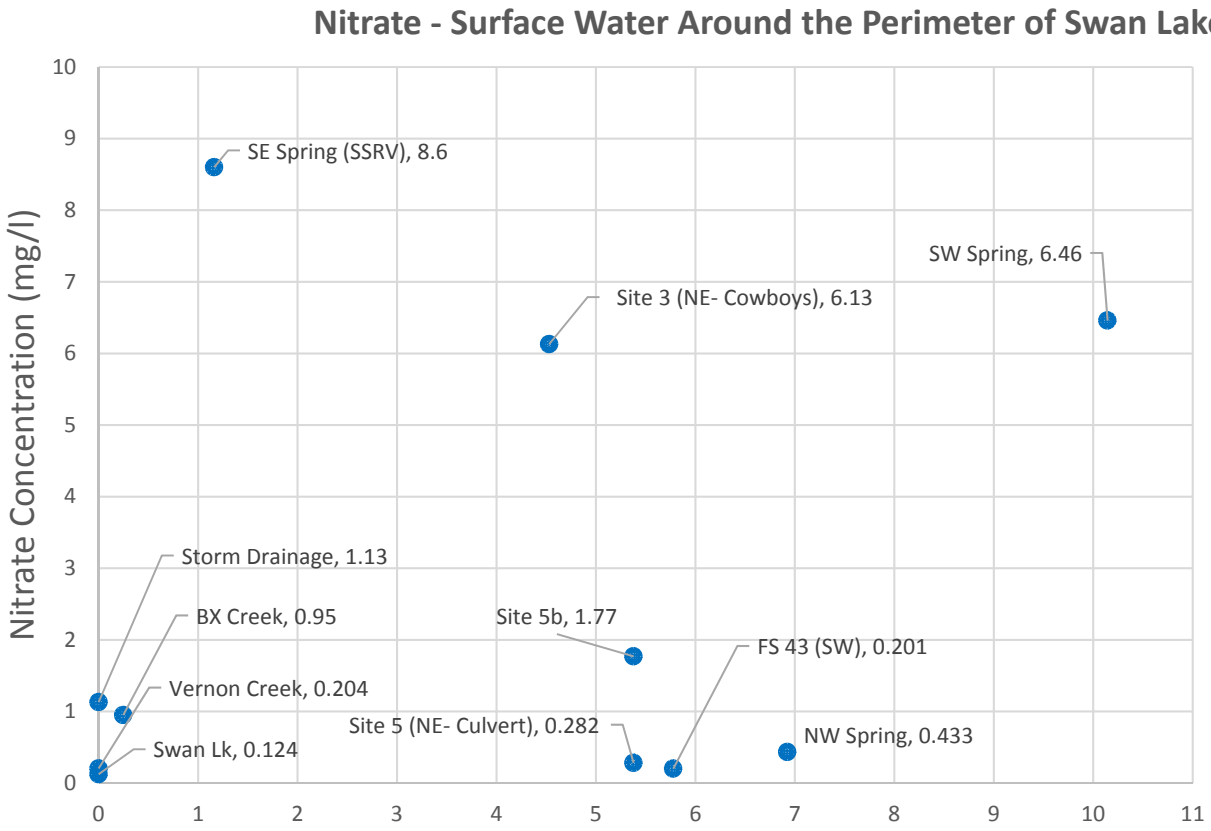
Regional District of North Okanagan

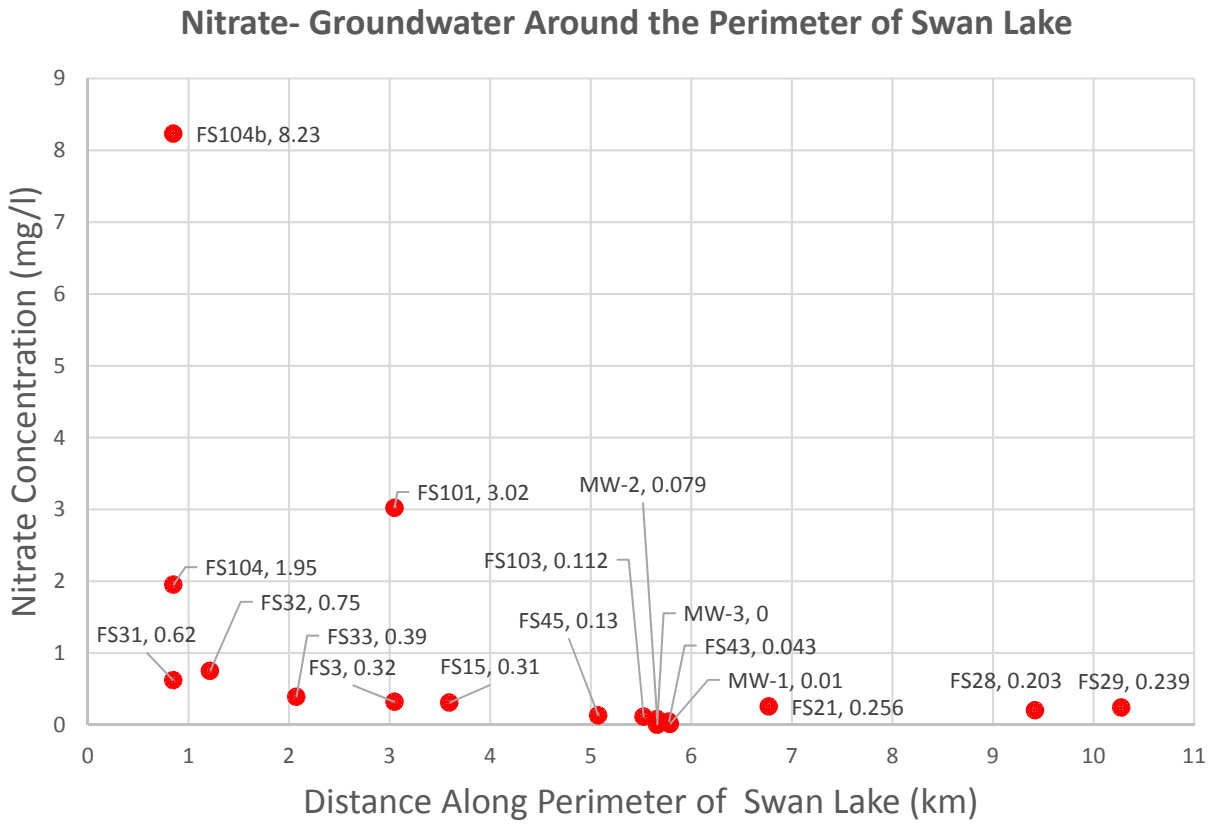
TITLE

Figure 13: Time-Series Plot for Ammonia at Swan Lake between 2015 and 2016. Upper plot shows surface waters and lower plot shows groundwaters.

western water ASSOCIATES LTD

DRAWN		DATE	June 2017	PROJECT NO.	14-076-02
CHECKED	BRM	SCALE	n/a	DWG. NO.	n/a
REVIEWED	DG	FILE NO.		FIGURE NO.	1

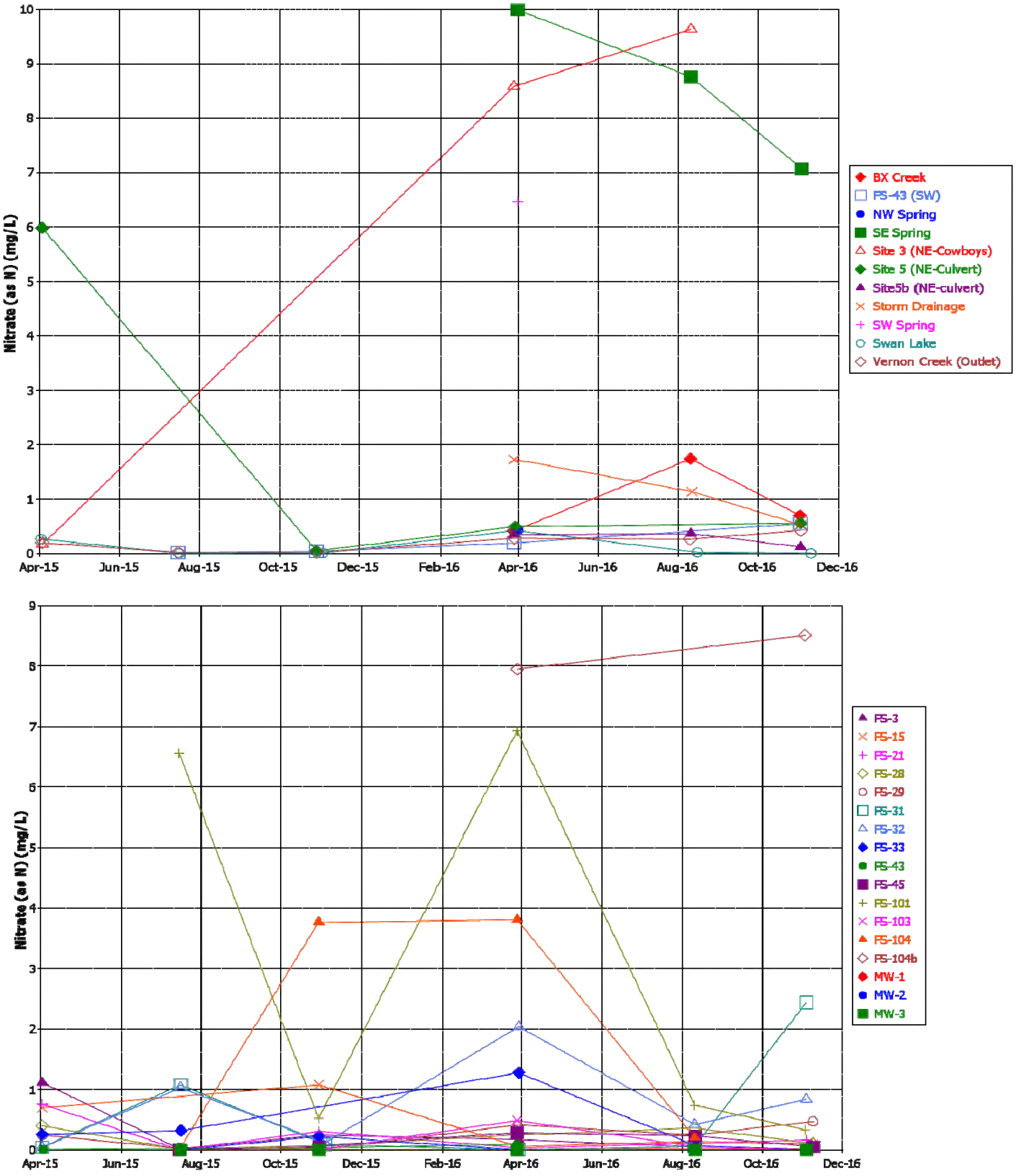




Regional District of North Okanagan	TITLE **Figure 14:** Average Nitrate Concentrations Around the Perimeter of Swan Lake.

western water ASSOCIATES LTD

DRAWN		DATE	June 2017	PROJECT NO.	14-076-02
CHECKED	BRM	SCALE	n/a	DWG. NO.	n/a
REVIEWED	DG	FILE NO.		FIGURE NO.	1



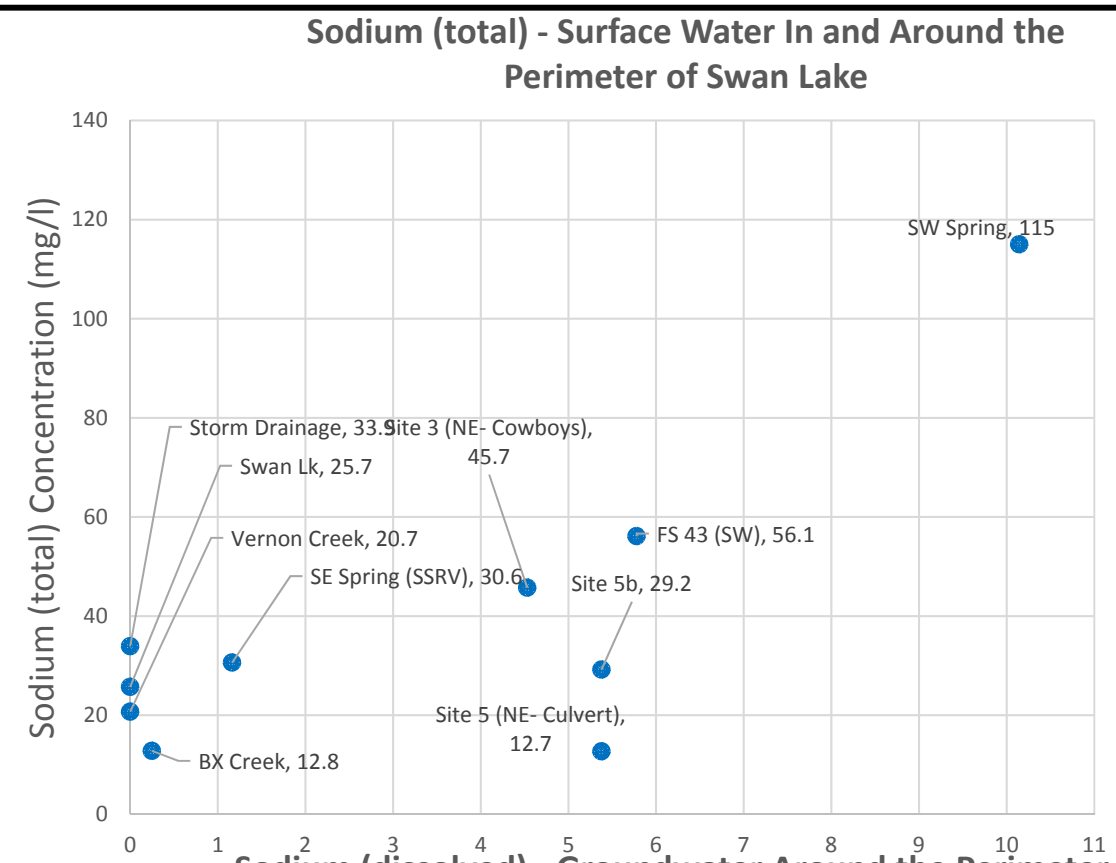
Regional District of North Okanagan

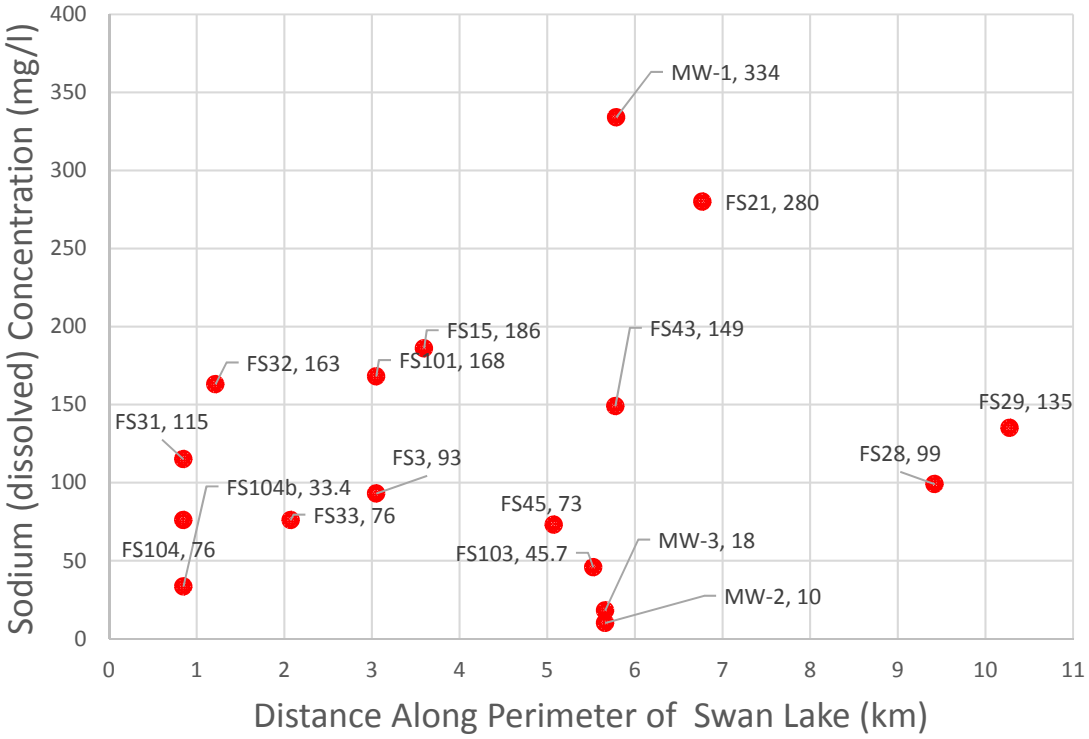
TITLE

Figure 15: Time-Series Plot for Nitrate at Swan Lake between 2015 and 2016. Upper plot shows surface waters and lower plot shows groundwaters.

western water ASSOCIATES LTD

DRAWN		DATE	June 2017	PROJECT NO.	14-076-02
CHECKED	BRM	SCALE	n/a	DWG. NO.	n/a
REVIEWED	DG	FILE NO.		FIGURE NO.	1

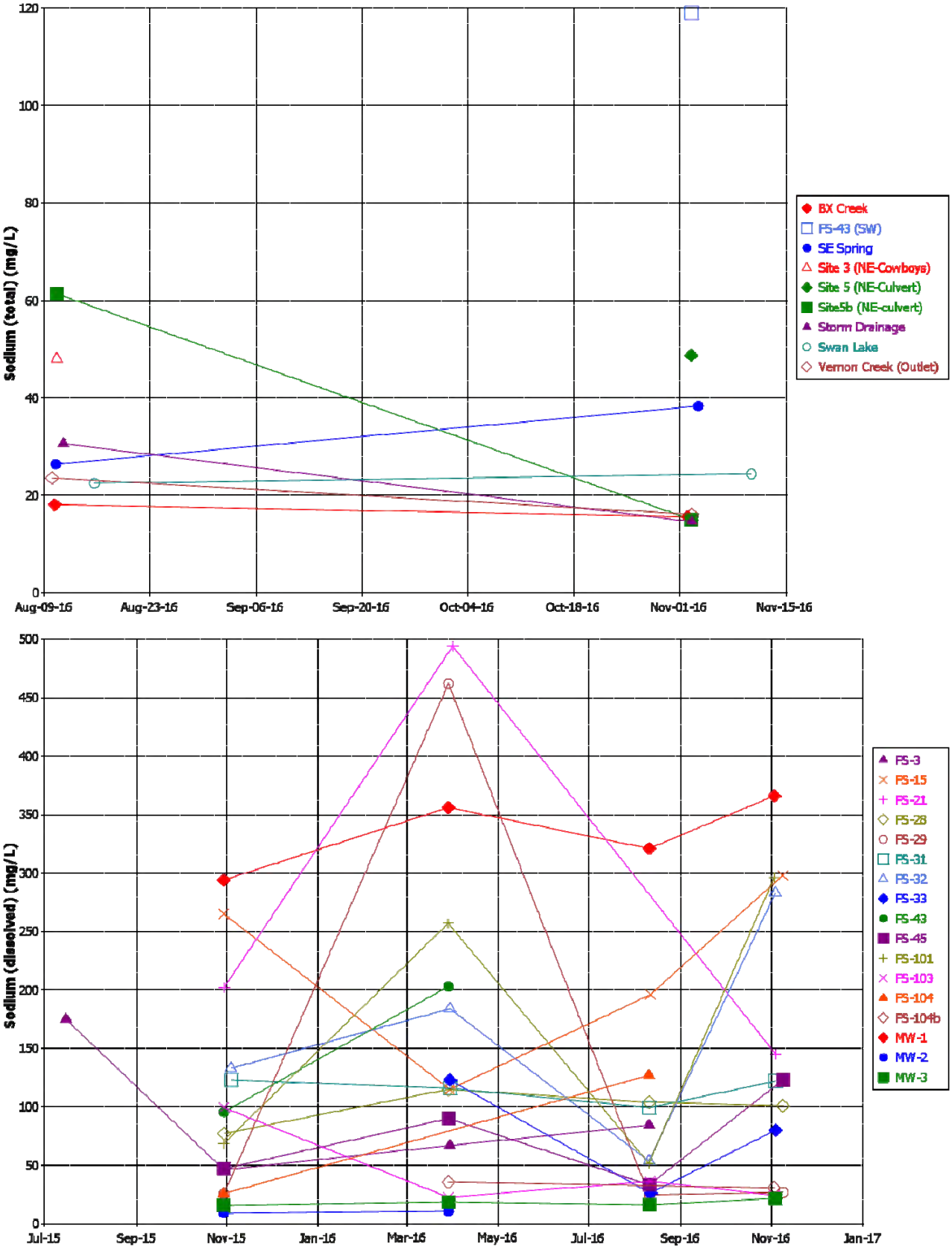




Regional District of North Okanagan	TITLE **Figure 16:** Average Sodium Concentrations Around the Perimeter of Swan Lake.

western water ASSOCIATES LTD

DRAWN		DATE	June 2017	PROJECT NO.	14-076-02
CHECKED	BRM	SCALE	n/a	DWG. NO.	n/a
REVIEWED	DG	FILE NO.		FIGURE NO.	1



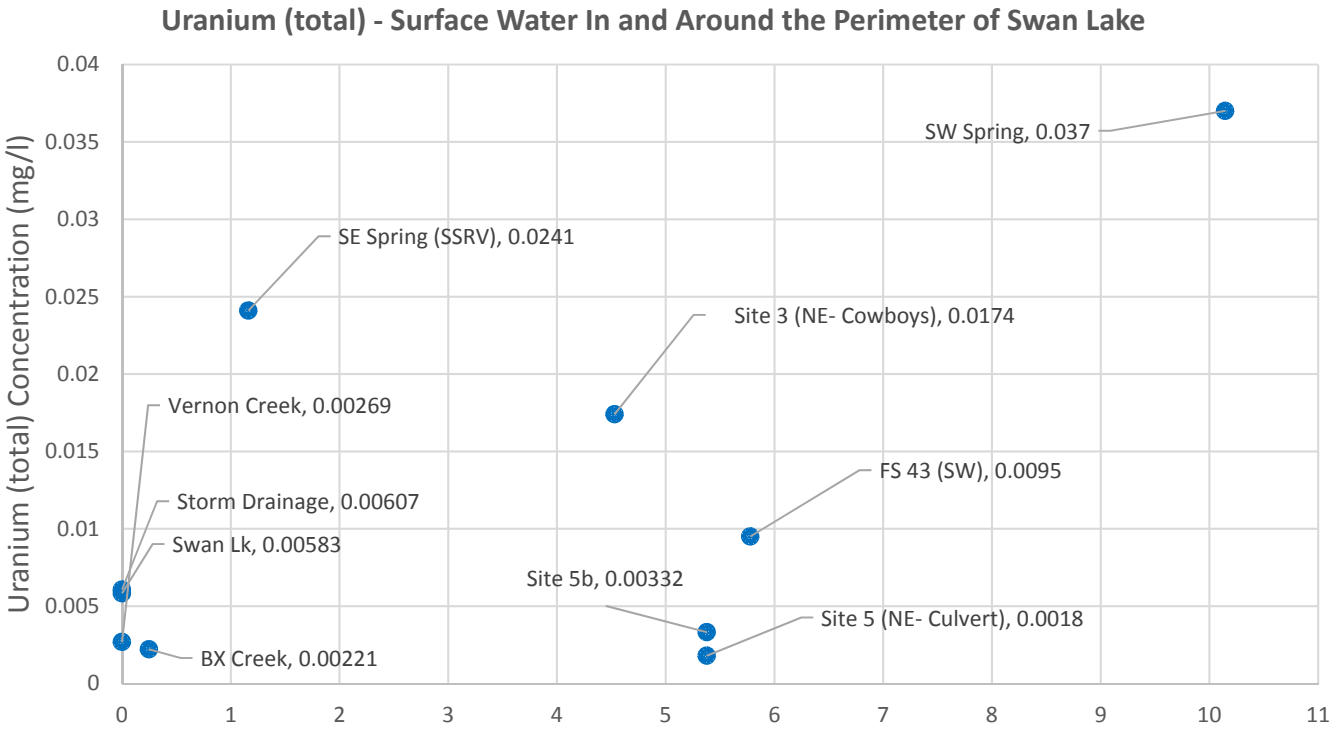
Regional District of North Okanagan

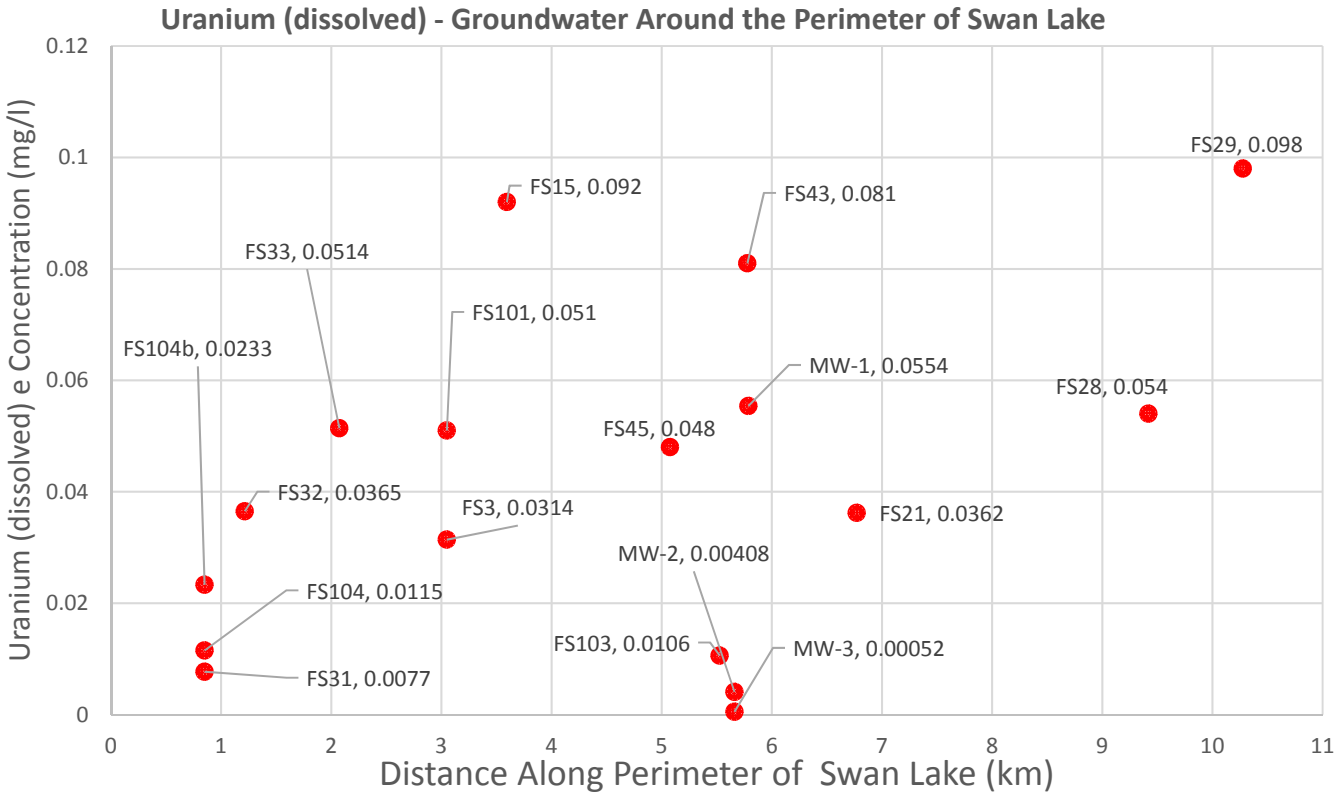
TITLE

Figure 17: Time-Series Plot for Sodium at Swan Lake between 2015 and 2016. Upper plot shows surface waters and lower plot shows groundwaters.

western water ASSOCIATES LTD

DRAWN		DATE	June 2017	PROJECT NO.	14-076-02
CHECKED	BRM	SCALE	n/a	DWG. NO.	n/a
REVIEWED	DG	FILE NO.		FIGURE NO.	1

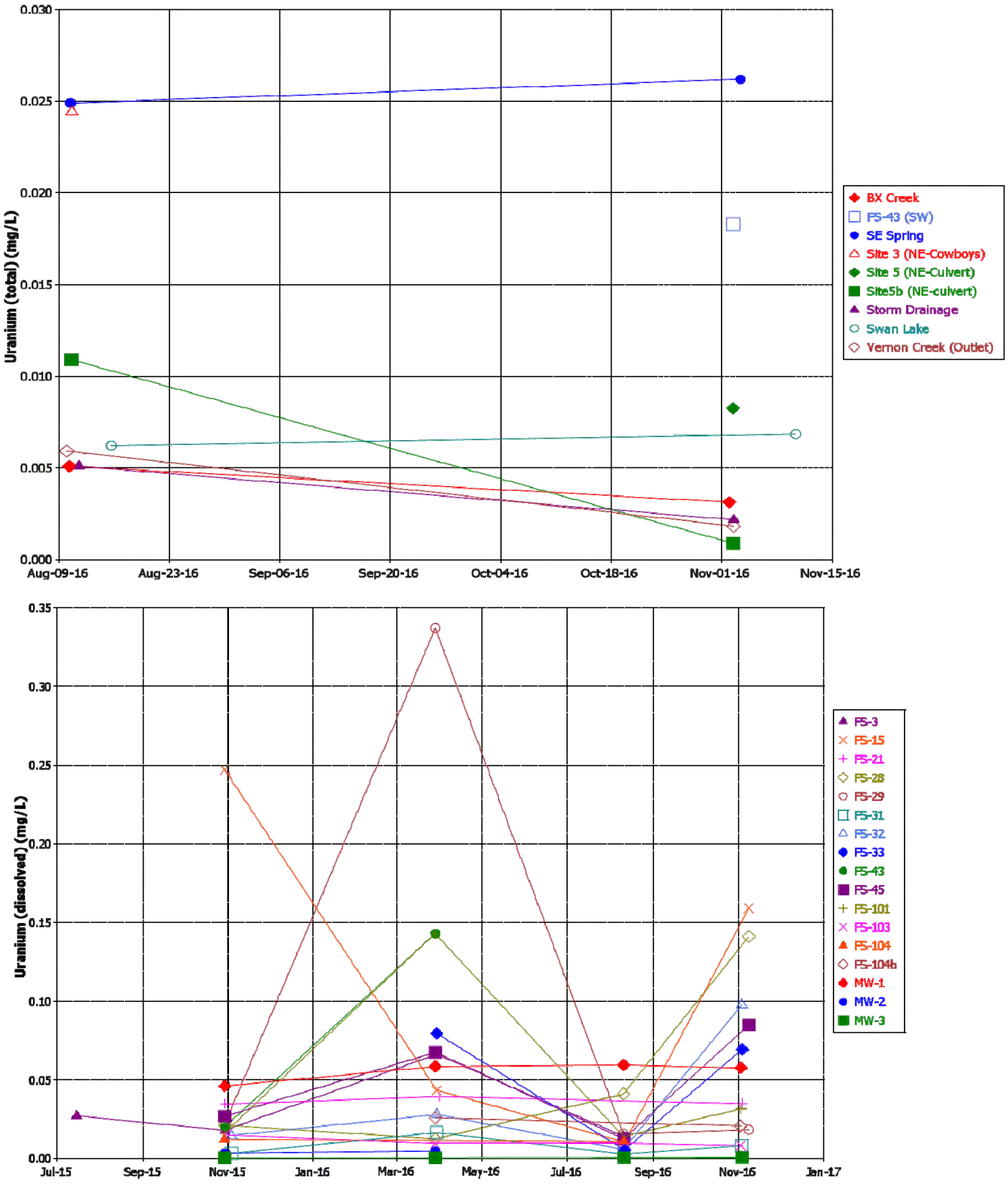




Regional District of North Okanagan	TITLE **Figure 18:** Average Uranium Concentrations Around the Perimeter of Swan Lake.

western water ASSOCIATES LTD

DRAWN		DATE	June 2017	PROJECT NO.	14-076-02
CHECKED	BRM	SCALE	n/a	DWG. NO.	n/a
REVIEWED	DG	FILE NO.		FIGURE NO.	1



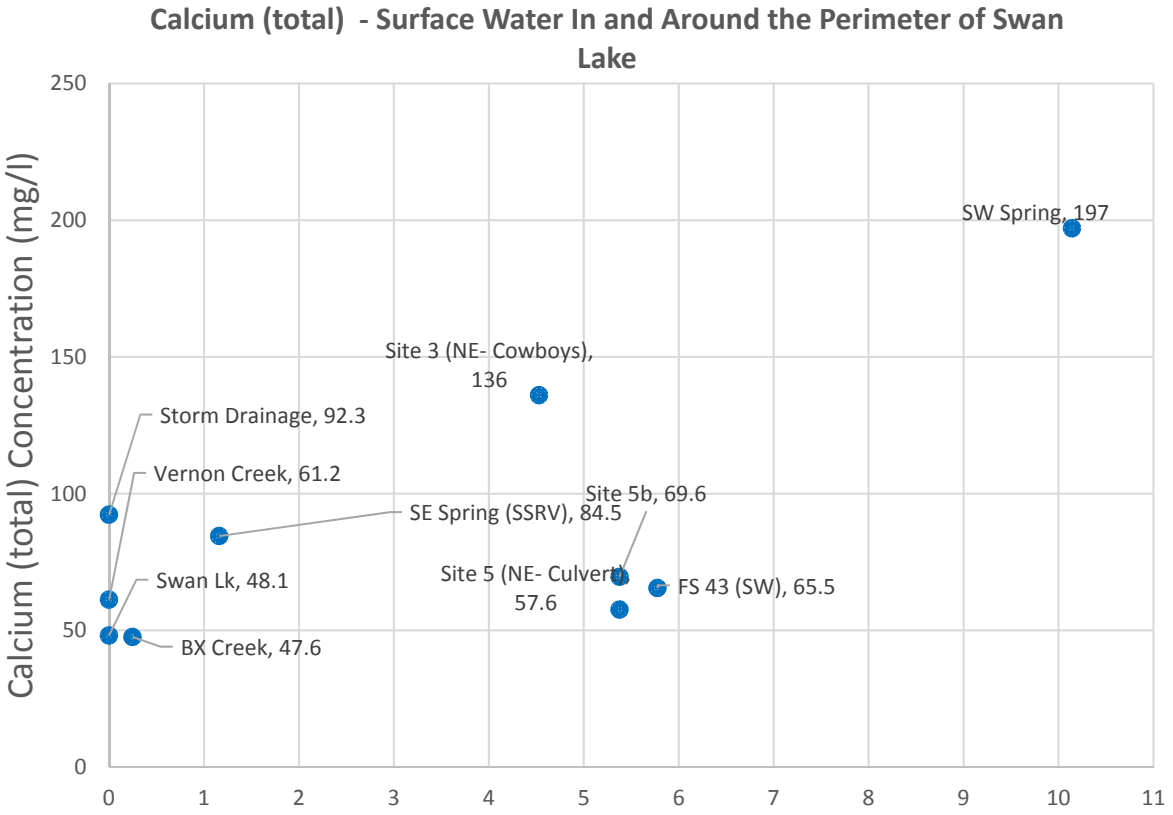
Regional District of North Okanagan

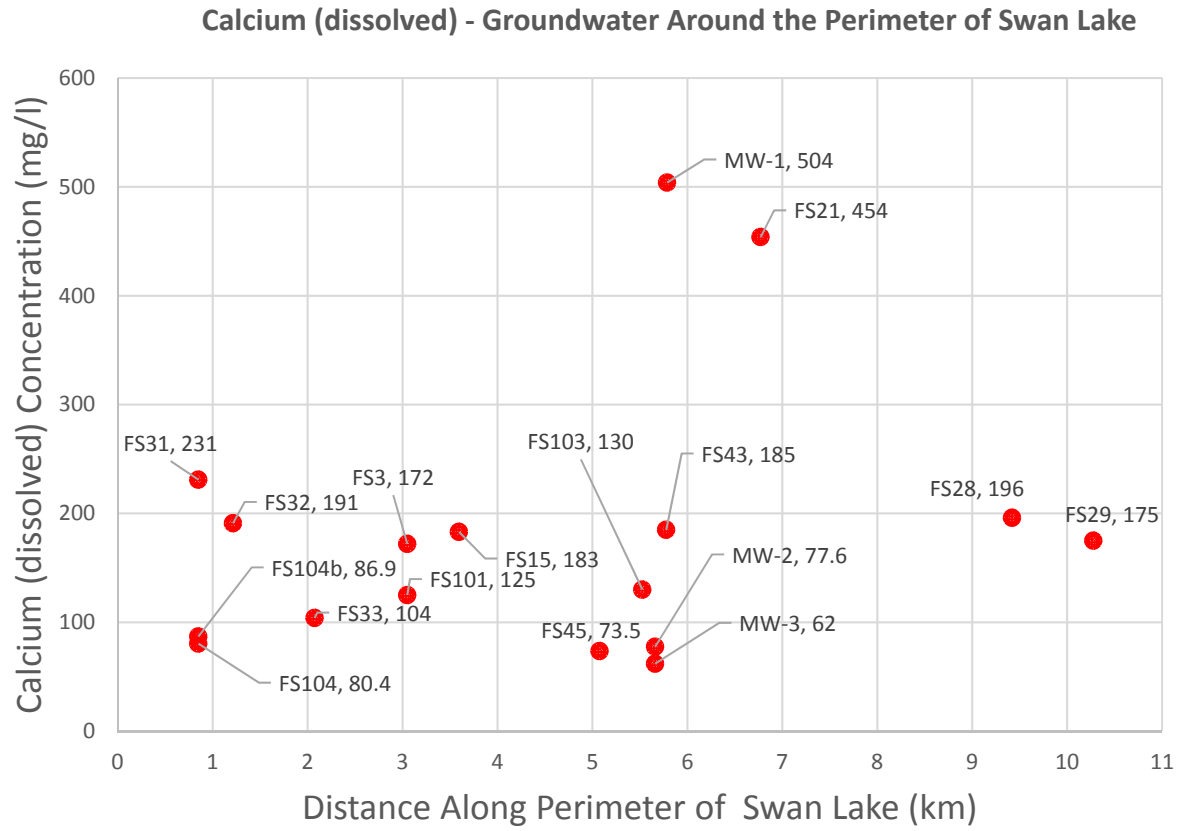
TITLE

Figure 19: Time-Series Plot for Uranium at Swan Lake between 2015 and 2016. Upper plot shows surface waters and lower plot shows groundwaters.

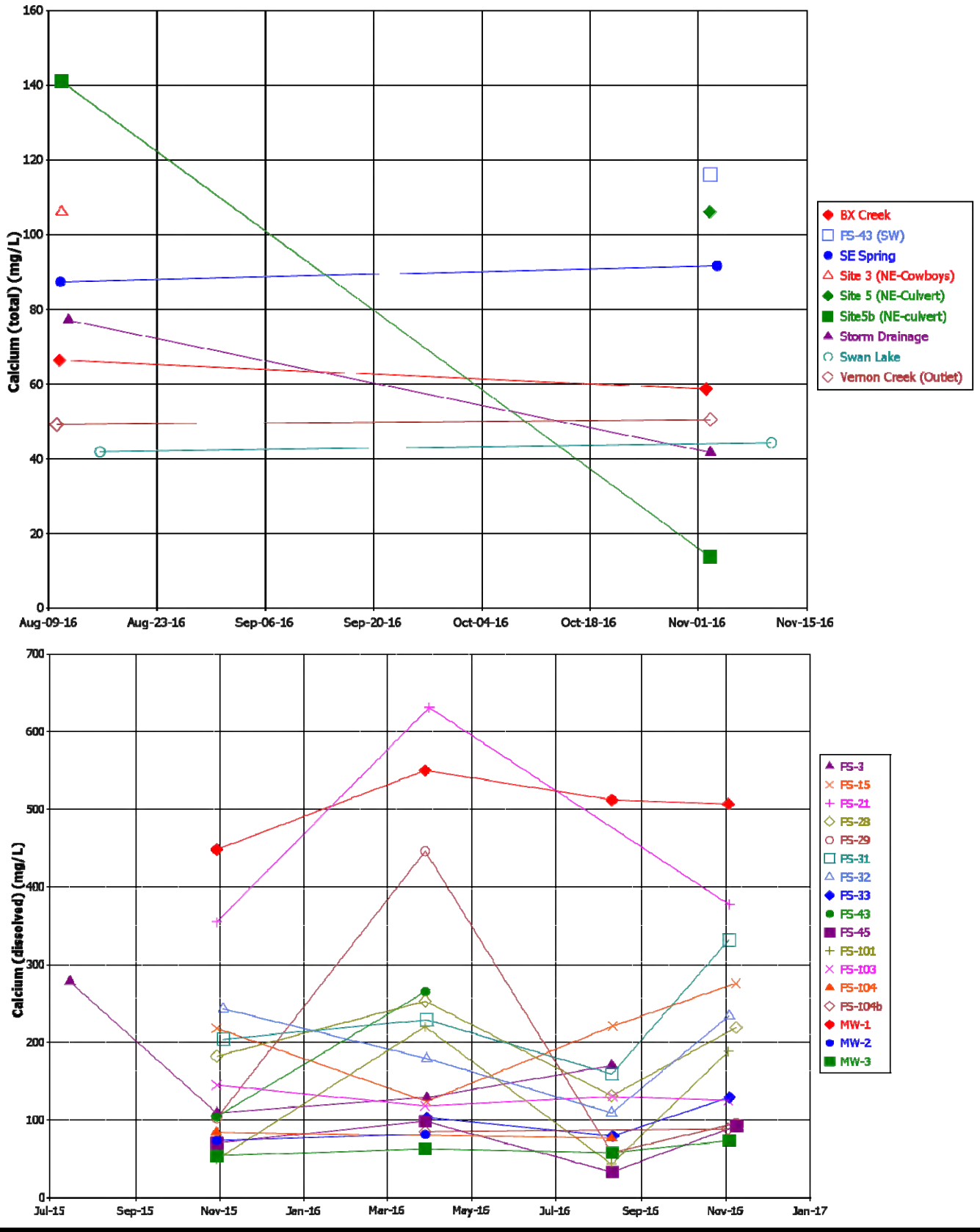
western water ASSOCIATES LTD

DRAWN		DATE	June 2017	PROJECT NO.	14-076-02
CHECKED	BRM	SCALE	n/a	DWG. NO.	n/a
REVIEWED	DG	FILE NO.		FIGURE NO.	1





Regional District of North Okanagan	TITLE **Figure 20:** Average Calcium Around the Perimeter of Swan Lake.			
western water ASSOCIATES LTD	DRAWN	DATE June 2017	PROJECT NO. 14-076-02	
	CHECKED BRM	SCALE n/a	DWG. NO. n/a	
	REVIEWED DG	FILE NO.	FIGURE NO. 1	



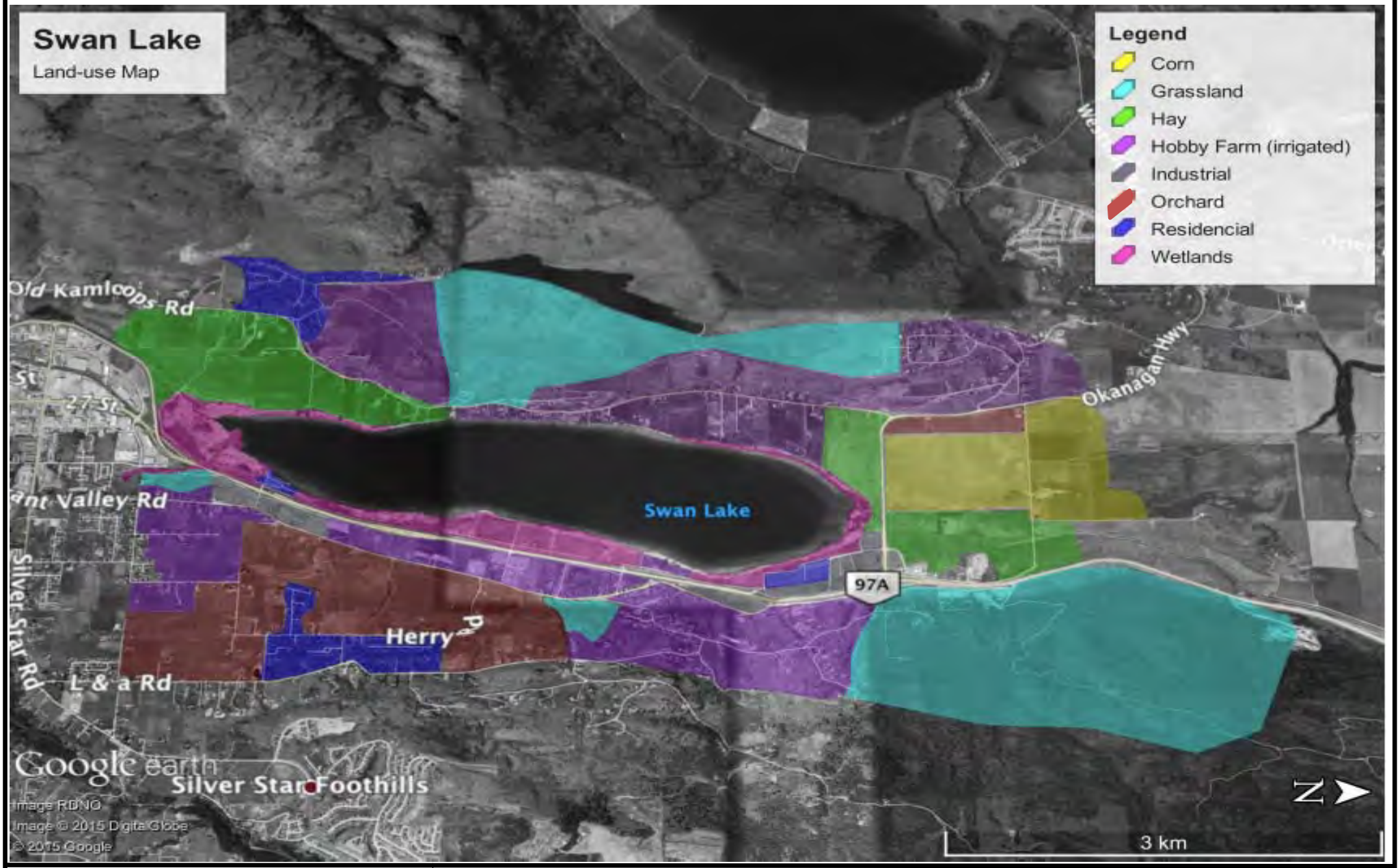
Regional District of North Okanagan

TITLE

Figure 21: Time-Series Plot for Calcium at Swan Lake between 2015 and 2016. Upper plot shows surface waters and lower plot shows groundwaters.

western water ASSOCIATES LTD

DRAWN		DATE	June 2017	PROJECT NO.	14-076-02
CHECKED	BRM	SCALE	n/a	DWG. NO.	n/a
REVIEWED	DG	FILE NO.		FIGURE NO.	1



Regional District of North Okanagan	TITLE	**Figure 20:** Swan Lake with Surrounding Land Use Polygons.		
western water ASSOCIATES LTD	DRAWN		DATE July 2017	PROJECT NO. 14-076-01
	CHECKED BRM		SCALE See figure	DWG. NO. n/a
	REVIEWED DG			FIGURE VERSION NO.

Appendix A

Water Quality Database

All results compared to the following guidelines:

- Guidelines for Canadian Drinking Water Quality - Aesthetic Objectives (GCDWQ AO);
- Guidelines for Canadian Drinking Water Quality - Maximum Acceptable Concentrations (GCDWQ MAC);
- BC Approved Water Quality Guidelines for drinking water (BCAWQG DW);
- BC Approved Water Quality Guidelines for irrigation (BCAWQG I);
- Working Water Quality Guidelines for British Columbia for irrigation (BCWWQG I);
- BC Approved Water Quality Guidelines for livestock (BCAWQG L); and
- Working Water Quality Guidelines for British Columbia for livestock (BCWWQG L).

Legend for Reports for RDNO Swan Lake Water Quality Assessment Water Quality Results

<	Less than reported detection limit
>	Greater than reported upper detection limit
A	Absent
BCAWQG DW	BC Approved Water Quality Guidelines for drinking water
BCAWQG I	BC Approved Water Quality Guidelines for irrigation
BCAWQG L	BC Approved Water Quality Guidelines for livestock
BCWWQG I	Working Water Quality Guidelines for British Columbia for irrigation
BCWWQG L	Working Water Quality Guidelines for British Columbia for livestock
Calc	Calculated guideline or standard. The guideline or standard is dependent on the value of one or more other analytes, and is calculated from a formula or table.
GCDWQ AO	Guidelines for Canadian Drinking Water Quality - Aesthetic Objectives
GCDWQ MAC	Guidelines for Canadian Drinking Water Quality - Maximum Acceptable Concentrations
L	Laboratory reading type (Lab result)
m asl	metres above sea level
N	Narrative type of guideline or standard, or Result Note.
ND	Non-detect. Result is less than lower detection limit.
NG	No Guideline
NR	No Result
NS	No Standard
NT	Not Tested
OG	Overgrown
P	Present
PR	Presumptive
TK	Test kit reading type (Field result)
TNTC	Too numerous to count
	Highlighted value has a lower detection limit that is greater than the guideline/standard maximum and/or the guideline/standard minimum, or has an upper detection limit that is less than the guideline/standard maximum and/or the guideline/standard minimum.
BCAWQG DW	Highlighted value exceeds BCAWQG DW
BCAWQG I	Highlighted value exceeds BCAWQG I
BCAWQG L	Highlighted value exceeds BCAWQG L
BCWWQG I	Highlighted value exceeds BCWWQG I
BCWWQG L	Highlighted value exceeds BCWWQG L
GCDWQ AO	Highlighted value exceeds GCDWQ AO
GCDWQ MAC	Highlighted value exceeds GCDWQ MAC
SL Criteria Override	Highlighted value exceeds sampling location criteria override

Swan Lake
Water Quality Results

Analyte	Unit	Guideline							Sampling Location	BX Creek	BX Creek	BX Creek	FS-3	FS-3	FS-3	FS-3	FS-3	FS-15	FS-15	FS-15
									Date Sampled	28-Mar-16	10-Aug-16	02-Nov-16	02-Apr-15	15-Jul-15	29-Oct-15	29-Mar-16	10-Aug-16	02-Apr-15	29-Oct-15	29-Mar-16
									Lab Sample ID	6031831-02	6080868-13	6110254-03	5040345-02	5071046-08	5102146-13	6031988-03	6080868-04	5040345-21	5102146-15	6031988-08
									Sample Type	Normal	Normal		Normal	Normal	Normal	Normal	Normal	Normal	Normal	Duplicate
		GCDWQ MAC	GCDWQ AO	*BCAWQG L*	*BCWWQG L*	BCAWQG I	BCWWQG I	BCAWQG DW												
Field Results																				
Conductivity	µS/cm	NG	NG	NG	NG	NG	700 [6.1]	NG		396	504	468	13320	2140	1151	13750	1756	1326	3360	2000
Dissolved oxygen	mg/L	NG	NG	NG	NG	NG	NG	NG		12.3		10.76			0.61	3.37			1.61	1.11
Dissolved oxygen (percent)	%	NG	NG	NG	NG	NG	NG	NG		95.1		90.3			5.6	28.5			14.3	9.0
Oxidation reduction potential	mV	NG	NG	NG	NG	NG	NG	NG		216	116	20	197		-21	111	-108	163	79	153
pH		NG	7.0 - 10.5 [2.1]	5.0 - 9.5 [3.1]	NG	5.0 - 9.0 [5.1]	NG	6.5 - 8.5 [7.1]		8.4	8.3		7.8	6.9	6.8	9		6.6	9.5	
Temperature	°C	NG	15	N [3.2]	NG	N [5.2]	NG	15		4.0	15.8	7.8	6.7	20.5	10.9	6.0	21.1	7.9	9.9	5.9
Lab Results																				
Dissolved Metals																				
Aluminum (dissolved)	mg/L	NG	N [2.2]	5 [3.3]	NG	5 [5.3]	NG	0.2		0.118				<0.005	<0.005	<0.005	0.005		<0.005	<0.005
Antimony (dissolved)	mg/L	0.006	NG	NG	NG	NG	NG	NG		0.0001				0.0003	0.0002	0.0004	0.0002		0.0012	0.0002
Arsenic (dissolved)	mg/L	0.010 [1.1]	NG	0.025 [3.4]	NG	0.100 [5.4]	NG	0.010		<0.0005				0.0021	0.0029	0.0007	0.0040		0.0015	0.0018
Barium (dissolved)	mg/L	1.0	NG	NG	NG	NG	NG	NG		0.033				0.068	0.135	0.083	0.093		0.142	0.085
Beryllium (dissolved)	mg/L	NG	NG	NG	0.100	NG	0.100	NG		<0.0001				<0.0001	<0.0001	<0.0001	<0.0001		<0.0001	<0.0001
Bismuth (dissolved)	mg/L	NG	NG	NG	NG	NG	NG	NG		<0.0001				<0.0001	<0.0001	<0.0001	<0.0001		<0.0001	<0.0001
Boron (dissolved)	mg/L	5	NG	5 [3.5]	NG	0.5 [5.5]	NG	5.0		0.006				0.013	0.007	0.012	0.021		0.021	0.029
Cadmium (dissolved)	mg/L	0.005	NG	NG	0.080 [4.1]	NG	0.0051 [6.2]	NG		0.00002				0.00009	<0.00001	0.00002	0.00001		0.00009	0.00002
Calcium (dissolved)	mg/L	NG	NG	NG	1000	NG	NG	NG		47.6				278	109	129	170		218	123
Chromium (dissolved)	mg/L	0.05	NG	NG	0.050 [4.2]	NG	0.0049 [6.3]	NG		<0.0005				0.0010	<0.0005	<0.0005	<0.0005		<0.0005	<0.0005
Cobalt (dissolved)	mg/L	NG	NG	NG	1	NG	0.050 [6.4]	NG		0.00009				0.00468	0.00122	0.00048	0.00100		0.00104	0.00011
Copper (dissolved)	mg/L	NG	1.0	0.300 [3.6]	NG	0.200 [5.6]	NG	0.5		0.0030				0.0043	<0.0002	0.0031	0.0007		0.0273	0.0042
Iron (dissolved)	mg/L	NG	0.3	NG	NG	NG	NG	NG		0.135				0.288	0.011	<0.010	0.015		0.019	<0.010
Lead (dissolved)	mg/L	0.010	NG	0.100 [3.7]	NG	0.200 [5.7]	NG	0.01		0.0001				0.0002	<0.0001	<0.0001	<0.0001		<0.0001	<0.0001
Lithium (dissolved)	mg/L	NG	NG	NG	NG	NG	0.75 [6.5]	NG		0.0031				0.0309	0.0085	0.0211	0.0189		0.0357	0.0289
Magnesium (dissolved)	mg/L	NG	NG	NG	NG	NG	NG	NG		10.1				150	42.7	51.2	81.7		241	106
Manganese (dissolved)	mg/L	NG	0.05	NG	NG	NG	0.200	NG		0.0054				1.24	1.14	0.0787	1.38		0.0202	0.0005
Mercury (dissolved)	mg/L	0.001	NG	0.0030 [3.8]	NG	0.0020 [5.8]	NG	0.0010		<0.00002					<0.00002	<0.00002	<0.00002		<0.00002	<0.00002
Molybdenum (dissolved)	mg/L	NG	NG	0.05 [3.9]	NG	0.05 [5.9]	NG	0.25		0.0022				0.0030	0.0102	0.0140	0.0062		*0.114*	0.0239
Nickel (dissolved)	mg/L	NG	NG	NG	1	NG	0.200	NG		0.0011				0.0134	0.0031	0.0021	0.0023		0.0097	0.0029
Selenium (dissolved)	mg/L	0.05	NG	0.0300 [3.10]	NG	0.010 [5.10]	NG	0.01		0.0022				0.0008	<0.0005	<0.0005	<0.0005		*0.0558*	0.0015
Silicon (dissolved, as Si)	mg/L	NG	NG	NG	NG	NG	NG	NG		8.5				23.0	7.2	6.5	17.8		7.4	8.9
Silver (dissolved)	mg/L	NG	NG	NG	NG	NG	NG	NG		<0.00005				<0.00005	<0.00005	<0.00005	0.00027		<0.00005	<0.00005
Sodium (dissolved)	mg/L	NG	200	NG	NG	NG	NG	NG		12.8				175	46.2	67.0	84.3		265	116
Strontium (dissolved)	mg/L	NG	NG	NG	NG	NG	NG	NG		0.331				3.42	1.04	1.41	1.91		4.20	1.66
Sulphur (dissolved)	mg/L	NG	NG	NG	NG	NG	NG	NG		5				226	54	77	92		244	113
Tellurium (dissolved)	mg/L	NG	NG	NG	NG	NG	NG	NG		<0.0002				<0.0002	<0.0002	<0.0002	<0.0002		<0.0002	<0.0002
Thallium (dissolved)	mg/L	NG	NG	NG	NG	NG	NG	NG		<0.00002				<0.00002	<0.00002	<0.00002	<0.00002		<0.00002	<0.00002
Thorium (dissolved)	mg/L	NG	NG	NG	NG	NG	NG	NG		<0.0001				<0.0001	<0.0001	<0.0001	<0.0001		<0.0001	<0.0001
Tin (dissolved)	mg/L	NG	NG	NG	NG	NG	NG	NG		<0.0002				<0.0002	<0.0002	<0.0002	<0.0002		<0.0002	<0.0002
Titanium (dissolved)	mg/L	NG	NG	NG	NG	NG	NG	NG		<0.005				<0.005	<0.005	<0.005	<0.005		<0.005	<0.005
Uranium (dissolved)	mg/L	0.02	NG	NG	0.200	NG	0.010	NG		0.00221				0.0271	0.0179	0.0663	0.0142		*0.247*	0.0427
Vanadium (dissolved)	mg/L	NG	NG	NG	0.100	NG	0.100	NG		<0.001				0.002	<0.001	0.002	0.001		0.007	0.013
Zinc (dissolved)	mg/L	NG	5.0	2.000 [3.11]	NG	1.000 [5.11]	NG	5.0		<0.004				<0.004	<0.004	<0.004	0.006		<0.004	0.020
Zirconium (dissolved)	mg/L	NG	NG	NG	NG	NG	NG	NG		0.0004				0.0011	0.0001	0.0002	0.0003		0.0042	0.0004
General																				
Alkalinity (bicarbonate, as CaCO3)	mg/L	NG	NG	NG	NG	NG	NG	NG		124	170	155	764	831	359	435	656	420	979	381
Alkalinity (carbonate, as CaCO3)	mg/L	NG	NG	NG	NG	NG	NG	NG		<1	<1	<1	<1	<1	<1	<1	<2	<1	<1	<1
Alkalinity (hydroxide, as CaCO3)	mg/L	NG	NG	NG	NG	NG	NG	NG		<1	<1	<1	<1	<1	<1	<1	<2	<1	<1	<1
Alkalinity (phenolphthalein, as CaCO3)	mg/L	NG	NG	NG	NG	NG	NG	NG		<1	<1	<1	<1	<1	<1	<1	<2	<1	<1	<1
Alkalinity (total, as CaCO3)	mg/L	NG	NG	NG	NG	NG	NG	NG		124	170	155	764	831	359	435	656	420	979	381
Bicarbonate Alkalinity (as HCO3)	mg/L	NG	NG	NG	NG	NG	NG	NG		151	207	190				531	800			465
Carbonate Alkalinity (as CO3)	mg/L	NG	NG	NG	NG	NG	NG	NG		<1	<0.6	<0.6				<1	<1			<1
Hydroxide Alkalinity (as OH)	mg/L	NG	NG	NG	NG	NG	NG	NG		<1	<0.3	<0.3				<1	<0.7			<1
Bromide	mg/L	NG	NG	NG	NG	NG	NG	NG		<0.10	<0.10	<0.10	<1.00	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Chloride	mg/L	NG	250	600 [3.12]	NG	100	NG	250		23.7	26.8	24.3	103	37.8	68.8	39.4	38.2	113	387	211
Chlorophyll a	mg/L	NG	NG	NG	NG	NG	NG	NG												
Conductivity	µS/cm	NG	NG	NG	NG	NG	700 [6.6]	NG		369	512	453				1250	1560			1870
Fluoride	mg/L	1.5	NG	1.5 [3.13]	NG	2.0 [5.12]	NG	1.5		0.11	0.11	<0.10	*1.61*	1.18	0.47	0.62	0.73	1.36	*2.33*	*1.80*
Hardness, total (dissolved as CaCO3)	mg/L	NG	NG	NG	NG	NG	NG	NG		160	231	198		1310	447	532	761		1540	743
pH		NG	7.0 - 10.5 [2.3]	5.0 - 9.5 [3.14]	NG	5.0 - 9.0 [5.13]	NG	6.5 - 8.5 [7.2]		8.08	8.16	8.07	7.65			7.62	7.65	7.83		7.89
Sulphate	mg/L	NG	500 [2.4]	1000	1000 [4.3]	NG	NG	500		29.2	51.4	39.2	*10500*	532	158	246	284	237	737	351
Sulphide (total, as S)	mg/L	NG	0.047 [2.5]	NG	NG	NG	NG	NG		<0.05				<0.05		<0.05				<0.05
Total suspended solids	mg/L	NG	NG	N [3.15]	NG	N [5.14]	NG	NG												
Turbidity	NTU	N [1.2]	NG	N [3.16]	NG	N [5.15]	NG	N [7.3]												
Microbiological																				

Swan Lake
Water Quality Results

Analyte	Unit	Guideline							Sampling Location	BX Creek	BX Creek	BX Creek	FS-3	FS-3	FS-3	FS-3	FS-3	FS-15	FS-15	FS-15
									Date Sampled	28-Mar-16	10-Aug-16	02-Nov-16	02-Apr-15	15-Jul-15	29-Oct-15	29-Mar-16	10-Aug-16	02-Apr-15	29-Oct-15	29-Mar-16
									Lab Sample ID	6031831-02	6080868-13	6110254-03	5040345-02	5071046-08	5102146-13	6031988-03	6080868-04	5040345-21	5102146-15	6031988-08
									Sample Type	Normal	Normal		Normal	Normal	Normal	Normal	Normal	Normal	Normal	Duplicate
		GCDWQ MAC	GCDWQ AO	*BCAWQG L*	*BCWWQG L*	BCAWQG I	BCWWQG I	BCAWQG DW												
Background Bacteria	CFU/100 mL	NG	NG	NG	NG	NG	NG	NG												
E. coli (counts)	CFU/100 mL	0 [1.3]	NG	200 [3.17]	NG	385 [5.16]	NG	0 [7.4]												
E. coli (MPN)	MPN/100 mL	0 [1.4]	NG	200 [3.18]	NG	385 [5.17]	NG	0 [7.5]							*430*					
Enterococcus (MPN)	MPN/100 mL	NG	NG	50 [3.19]	NG	100 [5.18]	NG	0 [7.6]											36	
Fecal coliforms (counts)	CFU/100 mL	0 [1.5]	NG	200 [3.20]	NG	1000 [5.19]	NG	0 [7.7]												
Fecal coliforms (MPN)	MPN/100 mL	0 [1.6]	NG	200 [3.21]	NG	1000 [5.20]	NG	0 [7.8]							*430*				36	
Total coliforms (counts)	CFU/100 mL	0 [1.7]	NG	NG	NG	NG	NG	NG												
Total coliforms (MPN)	MPN/100 mL	0 [1.8]	NG	NG	NG	NG	NG	NG							930				150	
Nutrients																				
Ammonia (total, as N)	mg/L	NG	NG	NG	NG	NG	NG	NG		0.115	0.037	0.050	0.028	0.070	0.067	0.172	0.032	<0.020	0.094	0.070
Nitrate (as N)	mg/L	10	NG	100 [3.22]	NG	NG	NG	10		0.419	1.74	0.702	1.12	0.022	0.248	0.176	0.055	0.701	1.08	0.041
Nitrate + Nitrite (as N) (calculated)	mg/L	10 [1.9]	NG	100 [3.23]	NG	NG	NG	NG		0.419	1.74	0.702	1.12	0.022	0.248	0.176	0.055	0.701	1.08	0.041
Nitrite (as N)	mg/L	1	NG	10 [3.24]	NG	NG	NG	1.0		<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Orthophosphate (dissolved, as P)	mg/L	NG	NG	NG	NG	NG	NG	NG		<0.01	<0.01	<0.01	<0.10	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Phosphorus (dissolved, by ICPMS/ICPOES)	mg/L	NG	NG	NG	NG	NG	NG	0.01 [7.9]		<0.02				<0.02	<0.02	<0.02	<0.02		<0.02	0.03
Phosphorus (total, by ICPMS/ICPOES)	mg/L	NG	NG	NG	NG	NG	NG	0.01 [7.10]			<0.2	<0.02								
Phosphorus (total, APHA 4500-P)	mg/L	NG	NG	NG	NG	NG	NG	0.01 [7.11]			0.192	0.050					0.378			
Phosphorus (dissolved, APHA 4500-P)	mg/L	NG	NG	NG	NG	NG	NG	0.01 [7.12]			0.116	0.014					0.005			
Potassium (dissolved)	mg/L	NG	NG	NG	NG	NG	NG	NG		2.38				9.42	3.90	6.65	3.52		13.2	13.7
Potassium (total)	mg/L	NG	NG	NG	NG	NG	NG	NG			4.3	3.70								
Total Metals																				
Aluminum (total)	mg/L	NG	N [2.6]	5 [3.25]	NG	5 [5.21]	NG	NG			0.07	0.150								
Antimony (total)	mg/L	0.006	NG	NG	NG	NG	NG	NG			<0.001	<0.0001								
Arsenic (total)	mg/L	0.010 [1.10]	NG	0.025 [3.26]	NG	0.100 [5.22]	NG	0.010			<0.005	<0.0005								
Barium (total)	mg/L	1.0	NG	NG	NG	NG	NG	NG			0.06	0.046								
Beryllium (total)	mg/L	NG	NG	NG	0.100	NG	0.100	NG			<0.001	<0.0001								
Bismuth (total)	mg/L	NG	NG	NG	NG	NG	NG	NG			<0.001	<0.0001								
Boron (total)	mg/L	5	NG	5	NG	0.5 [5.23]	NG	5.0			0.06	<0.004								
Cadmium (total)	mg/L	0.005	NG	NG	0.080 [4.4]	NG	0.0051 [6.7]	NG			<0.0001	0.00003								
Calcium (total)	mg/L	NG	NG	NG	NG	NG	NG	NG			66.3	58.6								
Chromium (total)	mg/L	0.05	NG	NG	0.050 [4.5]	NG	0.0049 [6.8]	NG			<0.005	0.0009								
Cobalt (total)	mg/L	NG	NG	NG	1	NG	0.050 [6.9]	NG			<0.0005	0.00013								
Copper (total)	mg/L	NG	1.0	0.300	NG	0.200 [5.24]	NG	0.5			0.002	0.0014								
Iron (total)	mg/L	NG	0.3	NG	NG	NG	NG	NG			0.12	0.25								
Lead (total)	mg/L	0.010	NG	0.100	NG	0.200 [5.25]	NG	0.01			<0.001	0.0002								
Lithium (total)	mg/L	NG	NG	NG	NG	NG	0.75 [6.10]	NG			0.006	0.0037								
Magnesium (total)	mg/L	NG	NG	NG	NG	NG	NG	NG			16.0	12.5								
Manganese (total)	mg/L	NG	0.05	NG	NG	NG	0.200	NG			0.013	0.0187								
Mercury (total)	mg/L	0.001	NG	0.0030	NG	0.0020	NG	0.0010			<0.00002	<0.00002								
Molybdenum (total)	mg/L	NG	NG	0.05 [3.27]	NG	0.05 [5.26]	NG	0.25			0.004	0.0024								
Nickel (total)	mg/L	NG	NG	NG	1	NG	0.200	NG			<0.002	0.0008								
Selenium (total)	mg/L	0.05	NG	0.0300 [3.28]	NG	0.010 [5.27]	NG	0.01			<0.005	0.0022								
Silicon (total, as Si)	mg/L	NG	NG	NG	NG	NG	NG	NG			9	7.1								
Silver (total)	mg/L	NG	NG	NG	NG	NG	NG	NG			<0.0005	<0.00005								
Sodium (total)	mg/L	NG	200	NG	NG	NG	NG	NG			18.1	15.6								
Strontium (total)	mg/L	NG	NG	NG	NG	NG	NG	NG			0.55	0.439								
Sulphur (total)	mg/L	NG	NG	NG	NG	NG	NG	NG			19	13								
Tellurium (total)	mg/L	NG	NG	NG	NG	NG	NG	NG			<0.002	<0.0002								
Thallium (total)	mg/L	NG	NG	NG	NG	NG	NG	NG			<0.0002	<0.00002								
Thorium (total)	mg/L	NG	NG	NG	NG	NG	NG	NG			<0.001	<0.0001								
Tin (total)	mg/L	NG	NG	NG	NG	NG	NG	NG			<0.002	<0.0002								
Titanium (total)	mg/L	NG	NG	NG	NG	NG	NG	NG			<0.05	0.007								
Uranium (total)	mg/L	0.02	NG	NG	0.200	NG	0.010	NG			0.0051	0.00314								
Vanadium (total)	mg/L	NG	NG	NG	0.100	NG	0.100	NG			<0.01	<0.001								
Zinc (total)	mg/L	NG	5.0	2.000	NG	1.000 [5.28]	NG	5.0			<0.04	0.006								
Zirconium (total)	mg/L	NG	NG	NG	NG	NG	NG	NG			<0.001	0.0001								

Swan Lake
Water Quality Results

Analyte	Unit	FS-15 29-Mar-16 6031988-09 Duplicate	FS-15 29-Mar-16 6031988-01 Normal	FS-15 11-Aug-16 6080942-03 Normal	FS-15 08-Nov-16 6110797-01 Normal	FS-21 02-Apr-15 5040345-03 Normal	FS-21 15-Jul-15 5071046-09 Normal	FS-21 29-Oct-15 5102146-16 Normal	FS-21 31-Mar-16 6040072-01 Normal	FS-21 03-Nov-16 6110391-01	FS-28 02-Apr-15 5040345-13 Normal	FS-28 15-Jul-15 5071046-10 Normal	FS-28 29-Oct-15 5102146-17 Normal	FS-28 28-Mar-16 6031831-13 Normal	FS-28 10-Aug-16 6080868-03	FS-28 08-Nov-16 6110797-04 Normal	FS-29 02-Apr-15 5040345-19 Normal	FS-29 15-Jul-15 5071046-11 Normal	FS-29 29-Oct-15 5102146-18 Normal	FS-29 28-Mar-16 6031831-14 Normal
Field Results																				
Conductivity	µS/cm	2000	2000	2630	3780	1160	749	2900	6170		1200	1724	1223	1927	1480	1660	1623	977	1040	5740
Dissolved oxygen	mg/L	1.11	1.11					0.82	0.62				0.97	1.3						3.47
Dissolved oxygen (percent)	%	9.0	9.0					7.2	5.2				8.3	10.7						30.6
Oxidation reduction potential	mV	153	153	-69	239	103		-1	14				-12	73	-130	-65			-14	58
pH				7	7.1	8.3	6.6	9.4	7.0			6.9	6.6	7.8	7.1	7.1		7.1	*10*	8.0
Temperature	°C	5.9	5.9	15.5	9.2	22.8	18.2	9.2	7.2		8.2	21	10.6	6.6	19.9	8.9		25.7	10.5	8.9
Lab Results																				
Dissolved Metals																				
Aluminum (dissolved)	mg/L	<0.005	<0.005	0.012	0.707			<0.005	<0.005	0.018			<0.005	<0.005	0.018	0.010			<0.005	0.006
Antimony (dissolved)	mg/L	0.0003	0.0003	0.0005	0.0006			0.0004	0.0003	0.0002			0.0004	0.0003	0.0005	0.0010			0.0003	0.0008
Arsenic (dissolved)	mg/L	0.0019	0.0018	0.0023	0.0012			0.0011	0.0009	0.0008			0.0010	0.0017	0.0141	0.0029			0.0011	0.0060
Barium (dissolved)	mg/L	0.093	0.082	0.095	0.123			0.065	0.130	0.122			0.152	0.319	0.101	0.265			0.140	0.102
Beryllium (dissolved)	mg/L	<0.0001	<0.0001	<0.0001	<0.0001			<0.0001	<0.0001	<0.0001			<0.0001	<0.0001	<0.0001	<0.0001			<0.0001	<0.0001
Bismuth (dissolved)	mg/L	<0.0001	<0.0001	<0.0001	<0.0001			<0.0001	<0.0001	<0.0001			<0.0001	<0.0001	<0.0001	<0.0001			<0.0001	<0.0001
Boron (dissolved)	mg/L	0.028	0.024	0.023	0.020			0.011	0.021	0.019			0.012	0.015	0.053	0.027			0.025	0.018
Cadmium (dissolved)	mg/L	0.00004	0.00003	0.00001	0.00012			0.00002	<0.00001	<0.00001			0.00001	0.00004	0.00003	0.00001			0.00004	0.00003
Calcium (dissolved)	mg/L	136	124	221	276			355	631	377			182	253	131	219			102	446
Chromium (dissolved)	mg/L	<0.0005	<0.0005	<0.0005	0.0029			<0.0005	<0.0005	<0.0005			<0.0005	<0.0005	0.0005	<0.0005			<0.0005	0.0006
Cobalt (dissolved)	mg/L	0.00012	0.00010	0.00290	0.00169			0.00120	0.00222	0.00111			0.00084	0.0118	0.00179	0.00117			0.00054	0.00842
Copper (dissolved)	mg/L	0.0051	0.0051	0.0013	0.0100			0.0013	0.0029	0.0005			0.0012	0.0012	0.0023	0.0016			0.0015	0.0040
Iron (dissolved)	mg/L	<0.010	<0.010	1.44	0.802			0.085	0.088	0.133			0.079	0.544	0.057	0.026			0.013	0.146
Lead (dissolved)	mg/L	0.0003	<0.0001	0.0004	0.0009			<0.0001	<0.0001	0.0001			<0.0001	<0.0001	0.0002	0.0003			<0.0001	0.0001
Lithium (dissolved)	mg/L	0.0324	0.0290	0.0468	0.0580			0.0191	0.0264	0.0280			0.0083	0.0098	0.0081	0.0130			0.0054	0.0319
Magnesium (dissolved)	mg/L	115	106	155	256			188	422	206			65.1	105	56.8	94.4			36.4	507
Manganese (dissolved)	mg/L	0.0006	0.0006	0.225	0.0451			0.404	1.40	0.234			0.385	3.53	0.679	0.419			3.03	4.63
Mercury (dissolved)	mg/L	<0.00002	<0.00002	<0.00002	<0.00002			<0.00002		<0.00002			<0.00002	<0.00002	<0.00002	<0.00002			<0.00002	<0.00002
Molybdenum (dissolved)	mg/L	0.0264	0.0247	0.0020	*0.0731*			0.0089	0.0045	0.0162			0.0058	0.0036	0.0132	0.0244			0.0100	*0.0762*
Nickel (dissolved)	mg/L	0.0030	0.0028	0.0085	0.0099			0.0041	0.0047	0.0024			0.0038	0.0139	0.0108	0.0048			0.0015	0.0120
Selenium (dissolved)	mg/L	0.0016	0.0015	0.0017	0.0030			0.0019	0.0009	0.0007			0.0018	0.0005	0.0017	0.0033			0.0006	0.0016
Silicon (dissolved, as Si)	mg/L	9.8	8.9	35.8	11.5			25.7	21.2	23.9			20.8	19.5	30.9	25.1			10.3	11.9
Silver (dissolved)	mg/L	<0.00005	<0.00005	<0.00005	<0.00005			<0.00005	<0.00005	<0.00005			<0.00005	<0.00005	0.00030	0.00006			<0.00005	<0.00005
Sodium (dissolved)	mg/L	127	115	196	298			202	494	145			77.2	115	104	101			25.7	462
Strontium (dissolved)	mg/L	1.84	1.67	3.30	4.54			3.79	7.60	5.67			2.78	4.39	2.72	4.10			1.45	8.00
Sulphur (dissolved)	mg/L	126	113	48	393			417	1140	495			16	233	22	104			37	1040
Tellurium (dissolved)	mg/L	<0.0002	<0.0002	<0.0002	<0.0002			<0.0002	<0.0002	<0.0002			<0.0002	<0.0002	<0.0002	<0.0002			<0.0002	<0.0002
Thallium (dissolved)	mg/L	<0.00002	<0.00002	<0.00002	0.00002			<0.00002	<0.00002	<0.00002			<0.00002	<0.00002	<0.00002	<0.00002			<0.00002	<0.00002
Thorium (dissolved)	mg/L	<0.0001	<0.0001	<0.0001	0.0001			<0.0001	<0.0001	<0.0001			<0.0001	<0.0001	<0.0001	<0.0001			<0.0001	<0.0001
Tin (dissolved)	mg/L	<0.0002	<0.0002	<0.0002	<0.0002			<0.0002	<0.0002	<0.0002			<0.0002	<0.0002	<0.0002	<0.0002			<0.0002	<0.0002
Titanium (dissolved)	mg/L	<0.005	<0.005	<0.005	0.036			<0.005	<0.005	<0.005			<0.005	<0.005	<0.005	<0.005			<0.005	<0.005
Uranium (dissolved)	mg/L	0.0472	0.0434	0.0104	0.159			0.0346	0.0392	0.0349			0.0211	0.0125	0.0410	0.141			0.0222	*0.337*
Vanadium (dissolved)	mg/L	0.015	0.012	0.002	0.004			0.002	0.001	0.002			0.002	0.007	0.011	0.008			0.002	0.015
Zinc (dissolved)	mg/L	0.017	<0.004	<0.004	0.015			<0.004	0.007	0.016			<0.004	0.102	0.030	0.025			<0.004	0.022
Zirconium (dissolved)	mg/L	0.0004	0.0004	0.0021	0.0023			0.0014	0.0008	0.0001			0.0007	0.0008	0.0011	0.0006			0.0004	0.0044
General																				
Alkalinity (bicarbonate, as CaCO3)	mg/L	377	378	1230	535	479	584	798		431	455	1010	853	447	676	3720	368	233	2110	822
Alkalinity (carbonate, as CaCO3)	mg/L	<1	<1	<2	<1	<1	<1	<1		<1	<1	<1	<1	<1	<2	<1	<1	<1	<1	<1
Alkalinity (hydroxide, as CaCO3)	mg/L	<1	<1	<2	<1	<1	<1	<1		<1	<1	<1	<1	<1	<2	<1	<1	<1	<1	<1
Alkalinity (phenolphthalein, as CaCO3)	mg/L	<1	<1	<2	<1	<1	<1	<1		<1	<1	<1	<1	<1	<2	<1	<1	<1	<1	<1
Alkalinity (total, as CaCO3)	mg/L	377	378	1230	535	479	584	798		431	455	1010	853	447	676	3720	368	233	2110	822
Bicarbonate Alkalinity (as HCO3)	mg/L	459	461	1500	653					526				545	825	4540				
Carbonate Alkalinity (as CO3)	mg/L	<1	<1	<1	<0.6					<0.6				<1	<1	<0.6				
Hydroxide Alkalinity (as OH)	mg/L	<1	<1	<0.7	<0.3					<0.3				<1	<0.7	<0.3				
Bromide	mg/L	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.10	<0.10	<0.10	<0.10	<0.10	0.14	0.18	<0.10	<0.10	<0.10	<0.10	0.23
Chloride	mg/L	220	213	218	427	35.2	29.7	34.3	33.2	81.1	37.4	49.0	61.6	85.7	76.7	53.7	39.6	30.4	66.3	64.1
Chlorophyll a	mg/L																			
Conductivity	µS/cm	1870	1870	2620	3410				6410	2600				2050	1340	1580				5260
Fluoride	mg/L	*1.78*	*1.80*	*2.29*	1.09	0.43	0.62	0.60	0.38	0.24	0.47	0.67	0.40	0.22	0.57	0.20	0.76	0.83	0.81	0.51
Hardness, total (dissolved as CaCO3)	mg/L	814	745	1190	1740			1660	3310	1790			724	1060	562	935			404	3200
pH		7.91	7.91	7.37	7.37	7.78			7.61	7.00	7.77			7.15	7.64	6.77	7.96			7.42
Sulphate	mg/L	394	334	125	*1060*	291	48.7	125	*3980*	*1360*	219	106	60.4	708	61.9	245	*1050*	62.0	93.2	*3080*
Sulphide (total, as S)	mg/L	<0.05	<0.05				<0.05					<0.05		<0.05				<0.05		<0.05
Total suspended solids	mg/L																			
Turbidity	NTU																			
Microbiological																				

Swan Lake
Water Quality Results

Analyte	Unit	FS-15 29-Mar-16 6031988-09 Duplicate	FS-15 29-Mar-16 6031988-01 Normal	FS-15 11-Aug-16 6080942-03 Normal	FS-15 08-Nov-16 6110797-01 Normal	FS-21 02-Apr-15 5040345-03 Normal	FS-21 15-Jul-15 5071046-09 Normal	FS-21 29-Oct-15 5102146-16 Normal	FS-21 31-Mar-16 6040072-01 Normal	FS-21 03-Nov-16 6110391-01	FS-28 02-Apr-15 5040345-13 Normal	FS-28 15-Jul-15 5071046-10 Normal	FS-28 29-Oct-15 5102146-17 Normal	FS-28 28-Mar-16 6031831-13 Normal	FS-28 10-Aug-16 6080868-03	FS-28 08-Nov-16 6110797-04 Normal	FS-29 02-Apr-15 5040345-19 Normal	FS-29 15-Jul-15 5071046-11 Normal	FS-29 29-Oct-15 5102146-18 Normal	FS-29 28-Mar-16 6031831-14 Normal
Background Bacteria	CFU/100 mL																			
E. coli (counts)	CFU/100 mL																			
E. coli (MPN)	MPN/100 mL							*230*					*930*						*>110000*	
Enterococcus (MPN)	MPN/100 mL																			
Fecal coliforms (counts)	CFU/100 mL																			
Fecal coliforms (MPN)	MPN/100 mL							*230*					*930*						*>110000*	
Total coliforms (counts)	CFU/100 mL																			
Total coliforms (MPN)	MPN/100 mL							24000					3900						>110000	
Nutrients																				
Ammonia (total, as N)	mg/L	0.080	0.072	0.053	0.100	<0.020	0.350	0.416	1.38	0.187	<0.020	0.537	0.240	0.102	0.646	0.868	<0.020	0.837	2.20	0.812
Nitrate (as N)	mg/L	0.028	0.059	0.147	0.099	0.761	<0.010	0.312	0.034	0.168	0.400	0.018	0.075	0.252	0.366	0.108	0.248	0.032	0.014	0.416
Nitrate + Nitrite (as N) (calculated)	mg/L	0.028	<0.10	0.147	0.099	0.761	<0.014	0.312	0.034	0.168	0.400	0.018	0.075	0.252	0.366	0.108	0.258	0.032	0.034	0.449
Nitrite (as N)	mg/L	<0.010	<0.100	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.010	<0.010	0.020	0.033
Orthophosphate (dissolved, as P)	mg/L	<0.01	<0.01	<0.01		1.47	<0.01	<0.01	<0.01	<0.01	<0.01	0.10	<0.01	<0.01	1.66	0.02	0.19	<0.01	<0.01	<0.01
Phosphorus (dissolved, by ICPMS/ICPOES)	mg/L	0.03	<0.02	0.29	0.09			<0.02	<0.02	0.03			<0.02	0.03	3.10	0.04			<0.02	0.34
Phosphorus (total, by ICPMS/ICPOES)	mg/L																			
Phosphorus (total, APHA 4500-P)	mg/L			1.92	0.759					0.499					7.01	15.1				
Phosphorus (dissolved, APHA 4500-P)	mg/L			0.234	0.058					0.012					3.00	0.048				
Potassium (dissolved)	mg/L	15.1	13.5	7.32	11.3			7.68	12.4	8.51			3.53	6.54	5.80	5.72			8.78	20.3
Potassium (total)	mg/L																			
Total Metals																				
Aluminum (total)	mg/L																			
Antimony (total)	mg/L																			
Arsenic (total)	mg/L																			
Barium (total)	mg/L																			
Beryllium (total)	mg/L																			
Bismuth (total)	mg/L																			
Boron (total)	mg/L																			
Cadmium (total)	mg/L																			
Calcium (total)	mg/L																			
Chromium (total)	mg/L																			
Cobalt (total)	mg/L																			
Copper (total)	mg/L																			
Iron (total)	mg/L																			
Lead (total)	mg/L																			
Lithium (total)	mg/L																			
Magnesium (total)	mg/L																			
Manganese (total)	mg/L																			
Mercury (total)	mg/L																			
Molybdenum (total)	mg/L																			
Nickel (total)	mg/L																			
Selenium (total)	mg/L																			
Silicon (total, as Si)	mg/L																			
Silver (total)	mg/L																			
Sodium (total)	mg/L																			
Strontium (total)	mg/L																			
Sulphur (total)	mg/L																			
Tellurium (total)	mg/L																			
Thallium (total)	mg/L																			
Thorium (total)	mg/L																			
Tin (total)	mg/L																			
Titanium (total)	mg/L																			
Uranium (total)	mg/L																			
Vanadium (total)	mg/L																			
Zinc (total)	mg/L																			
Zirconium (total)	mg/L																			

Swan Lake
Water Quality Results

Analyte	Unit	FS-29 10-Aug-16 6080868-10 Normal	FS-29 08-Nov-16 6110797-03 Normal	FS-31 02-Apr-15 5040345-15 Normal	FS-31 16-Jul-15 5071187-02 Normal	FS-31 03-Nov-15 5110157-02 Normal	FS-31 29-Mar-16 6031988-05 Normal	FS-31 10-Aug-16 6080868-07 Normal	FS-31 03-Nov-16 6110391-04	FS-32 02-Apr-15 5040345-16 Normal	FS-32 16-Jul-15 5071187-01 Normal	FS-32 03-Nov-15 5110157-01 Normal	FS-32 29-Mar-16 6031988-06 Normal	FS-32 10-Aug-16 6080868-12 Normal	FS-32 03-Nov-16 6110391-06	FS-33 02-Apr-15 5040345-20 Normal	FS-33 16-Jul-15 5071187-06 Normal	FS-33 29-Mar-16 6031988-04 Normal	FS-33 11-Aug-16 6080942-01 Normal	FS-33 03-Nov-16 6110391-02
Field Results																				
Conductivity	µS/cm	546	854	1801	990	2290	2290	1984		1795	1801	2560	2650	1250		2210	1439	1935	750	
Dissolved oxygen	mg/L					1.94	1.55					0.76	0.91							
Dissolved oxygen (percent)	%					17.0	13.1					6.7	7.8							
Oxidation reduction potential	mV	70	-66		-134	24	-20	-101		-147	-102	162	52	-182		46	5	132	-137	
pH		7.8	7.3		7.0	7.4	10	6.8			7.2	6.7	7.5	7.0			6.9	6.9	7.2	
Temperature	°C	22.6	8.8	8.8	17.8	7.8	7.1	19.2		8.8	17.9	8.7	7.5	18.3		7.5	21.5	8.0	19.6	
Lab Results																				
Dissolved Metals																				
Aluminum (dissolved)	mg/L	0.013	<0.005			<0.005	<0.005	0.006	<0.005			<0.005	0.016	0.010	<0.005			<0.005	<0.005	<0.005
Antimony (dissolved)	mg/L	0.0008	0.0004			0.0002	0.0002	0.0002	0.0002			0.0004	0.0004	0.0002	0.0006			0.0003	0.0003	0.0006
Arsenic (dissolved)	mg/L	0.0022	0.0011			0.0031	0.0011	0.0024	0.0141			0.0039	0.0067	0.0041	0.0017			0.0008	0.0017	0.0006
Barium (dissolved)	mg/L	0.047	0.148			0.165	0.110	0.158	0.251			0.160	0.203	0.132	0.194			0.192	0.133	0.101
Beryllium (dissolved)	mg/L	0.0004	<0.0001			<0.0001	<0.0001	<0.0001	<0.0001			<0.0001	<0.0001	<0.0001	<0.0001			<0.0001	<0.0001	<0.0001
Bismuth (dissolved)	mg/L	<0.0001	<0.0001			<0.0001	<0.0001	<0.0001	<0.0001			<0.0001	<0.0001	<0.0001	<0.0001			<0.0001	<0.0001	<0.0001
Boron (dissolved)	mg/L	0.162	0.030			0.057	0.057	0.040	0.088			0.140	0.333	0.299	0.259			0.042	0.031	0.016
Cadmium (dissolved)	mg/L	0.00020	0.00007			0.00001	0.00003	0.00002	<0.00001			0.00002	0.00003	<0.00001	0.00001			0.00002	<0.00001	0.00001
Calcium (dissolved)	mg/L	57.9	95.9			204	229	159	332			243	179	109	234			103	79.5	129
Chromium (dissolved)	mg/L	<0.0005	<0.0005			<0.0005	<0.0005	0.0005	<0.0005			<0.0005	<0.0005	<0.0005	<0.0005			<0.0005	<0.0005	<0.0005
Cobalt (dissolved)	mg/L	0.00019	0.00128			0.00412	0.00355	0.00189	0.00131			0.00094	0.00104	0.00045	0.00211			<0.00005	0.00036	0.00092
Copper (dissolved)	mg/L	0.0017	0.0022			<0.0002	0.0024	0.0007	0.0004			<0.0002	0.0024	0.0002	0.0031			0.0038	<0.0002	0.0007
Iron (dissolved)	mg/L	<0.010	<0.010			3.42	0.111	2.13	0.086			0.220	0.186	0.503	0.014			<0.010	<0.010	<0.010
Lead (dissolved)	mg/L	0.0004	<0.0001			0.0001	0.0001	0.0002	0.0001			0.0001	0.0003	0.0006	<0.0001			<0.0001	<0.0001	<0.0001
Lithium (dissolved)	mg/L	0.0086	0.0077			0.0162	0.0120	0.0167	0.0184			0.0242	0.0206	0.0154	0.0495			0.0345	0.0112	0.0466
Magnesium (dissolved)	mg/L	19.6	40.5			148	98.7	102	146			178	145	73.0	240			122	28.6	151
Manganese (dissolved)	mg/L	0.0132	3.02			0.982	2.23	0.391	0.403			0.470	0.188	0.255	0.436			0.0005	0.145	0.251
Mercury (dissolved)	mg/L	0.00003	<0.00002			0.00002	<0.00002	<0.00002	<0.00002			0.00002	<0.00002	<0.00002	<0.00002			<0.00002	<0.00002	<0.00002
Molybdenum (dissolved)	mg/L	0.0130	0.0072			0.0013	0.0034	0.0013	0.0042			0.0108	0.0160	0.0034	0.0560			0.0423	0.0052	0.0199
Nickel (dissolved)	mg/L	0.0018	0.0015			0.0058	0.0085	0.0048	0.0036			0.0106	0.0092	0.0030	0.0206			0.0025	0.0030	0.0025
Selenium (dissolved)	mg/L	0.0011	0.0006			0.0035	0.0018	0.0032	0.0037			0.0020	0.0023	0.0012	0.0011			<0.0005	<0.0005	<0.0005
Silicon (dissolved, as Si)	mg/L	6.8	11.0			36.8	26.3	40.9	31.7			24.9	22.9	27.3	11.3			5.4	6.6	9.5
Silver (dissolved)	mg/L	0.00695	0.00008			<0.00005	<0.00005	<0.00005	<0.00005			<0.00005	<0.00005	<0.00005	<0.00005			<0.00005	<0.00005	<0.00005
Sodium (dissolved)	mg/L	24.9	27.0			123	116	99.4	122			133	184	53.6	283			123	26.2	80.1
Strontium (dissolved)	mg/L	1.08	1.60			2.61	2.25	2.56	3.40			4.64	3.93	2.26	5.21			2.85	0.937	3.18
Sulphur (dissolved)	mg/L	32	42			5	2	4	129			170	52	33	175			70	17	31
Tellurium (dissolved)	mg/L	<0.0002	<0.0002			<0.0002	<0.0002	<0.0002	<0.0002			<0.0002	<0.0002	<0.0002	<0.0002			<0.0002	<0.0002	<0.0002
Thallium (dissolved)	mg/L	0.00008	<0.00002			<0.00002	0.00003	<0.00002	<0.00002			<0.00002	<0.00002	<0.00002	<0.00002			<0.00002	<0.00002	<0.00002
Thorium (dissolved)	mg/L	<0.0001	<0.0001			<0.0001	<0.0001	<0.0001	<0.0001			<0.0001	<0.0001	<0.0001	<0.0001			<0.0001	<0.0001	<0.0001
Tin (dissolved)	mg/L	<0.0002	<0.0002			<0.0002	<0.0002	<0.0002	<0.0002			<0.0002	<0.0002	<0.0002	<0.0002			<0.0002	<0.0002	<0.0002
Titanium (dissolved)	mg/L	<0.005	<0.005			<0.005	<0.005	<0.005	<0.005			<0.005	<0.005	<0.005	<0.005			<0.005	<0.005	<0.005
Uranium (dissolved)	mg/L	0.0157	0.0182			0.00325	0.0165	0.00280	0.00820			0.0146	0.0279	0.00575	0.0976			0.0795	0.00551	0.0693
Vanadium (dissolved)	mg/L	0.006	<0.001			<0.001	<0.001	0.001	0.002			0.004	0.004	0.002	0.004			0.003	0.001	<0.001
Zinc (dissolved)	mg/L	0.026	0.006			<0.004	0.860	<0.004	<0.004			<0.004	0.012	<0.004	0.175			0.015	<0.004	<0.004
Zirconium (dissolved)	mg/L	<0.0001	0.0003			0.0007	0.0011	0.0006	0.0003			0.0007	0.0008	0.0004	0.0010			0.0007	0.0001	0.0003
General																				
Alkalinity (bicarbonate, as CaCO3)	mg/L	700	283	944	431	1390	1090	15600	1940	750	1600	1030	929	860	900	864	22500	2160	575	830
Alkalinity (carbonate, as CaCO3)	mg/L	<2	<1	<1	<1	<1	<1	<2	<1	<1	<1	<1	<1	<2	<1	<1	<1	<1	<2	<1
Alkalinity (hydroxide, as CaCO3)	mg/L	<2	<1	<1	<1	<1	<1	<2	<1	<1	<1	<1	<1	<2	<1	<1	<1	<1	<2	<1
Alkalinity (phenolphthalein, as CaCO3)	mg/L	<2	<1	<1	<1	<1	<1	<2	<1	<1	<1	<1	<1	<2	<1	<1	<1	<1	<2	<1
Alkalinity (total, as CaCO3)	mg/L	700	283	944	431	1390	1090	15600	1940	750	1600	1030	929	860	900	864	22500	2160	575	830
Bicarbonate Alkalinity (as HCO3)	mg/L	854	345				1340	19100	2370				1130	1050	1100			2630	702	1010
Carbonate Alkalinity (as CO3)	mg/L	<1	<0.6				<1	<1	<0.6				<1	<1	<0.6			<1	<1	<0.6
Hydroxide Alkalinity (as OH)	mg/L	<0.7	<0.3				<1	<0.7	<0.3				<1	<0.7	<0.3			<1	<0.7	<0.3
Bromide	mg/L	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<1.00	0.14	<0.10	<0.10	<0.10	0.11	<0.10	<0.10
Chloride	mg/L	39.8	32.0	160	39.5	96.3	151	79.7	45.9	114	142	168	364	78.0	362	111	81.0	116	35.8	65.6
Chlorophyll a	mg/L																			
Conductivity	µS/cm	568	808				2210	1830	2930				2820	1330	2970			1940	735	1700
Fluoride	mg/L	0.82	0.16	0.61	0.35	0.42	0.44	0.66	0.11	0.54	0.90	0.47	0.62	0.47	0.32	1.35	1.40	1.15	0.47	0.37
Hardness, total (dissolved as CaCO3)	mg/L	225	406			1120	978	819	1430			1340	1040	574	1570			761	316	943
pH		7.41	7.72	7.93			7.46	7.07	7.61	7.66			7.64	6.91	7.39	8.05		7.76	7.38	7.68
Sulphate	mg/L	91.8	127	126	33.9	3.3	12.0	6.2	232	89.4	38.7	378	120	97.3	417	458	89.8	217	50.8	75.5
Sulphide (total, as S)	mg/L				<0.05		<0.05				<0.05		<0.05				<0.05	<0.05		
Total suspended solids	mg/L																			
Turbidity	NTU																			
Microbiological																				

Swan Lake
Water Quality Results

Analyte	Unit	FS-29 10-Aug-16 6080868-10 Normal	FS-29 08-Nov-16 6110797-03 Normal	FS-31 02-Apr-15 5040345-15 Normal	FS-31 16-Jul-15 5071187-02 Normal	FS-31 03-Nov-15 5110157-02 Normal	FS-31 29-Mar-16 6031988-05 Normal	FS-31 10-Aug-16 6080868-07 Normal	FS-31 03-Nov-16 6110391-04	FS-32 02-Apr-15 5040345-16 Normal	FS-32 16-Jul-15 5071187-01 Normal	FS-32 03-Nov-15 5110157-01 Normal	FS-32 29-Mar-16 6031988-06 Normal	FS-32 10-Aug-16 6080868-12 Normal	FS-32 03-Nov-16 6110391-06	FS-33 02-Apr-15 5040345-20 Normal	FS-33 16-Jul-15 5071187-06 Normal	FS-33 29-Mar-16 6031988-04 Normal	FS-33 11-Aug-16 6080942-01 Normal	FS-33 03-Nov-16 6110391-02
Background Bacteria	CFU/100 mL																			
E. coli (counts)	CFU/100 mL																			
E. coli (MPN)	MPN/100 mL					*230*						*430*								
Enterococcus (MPN)	MPN/100 mL																			
Fecal coliforms (counts)	CFU/100 mL																			
Fecal coliforms (MPN)	MPN/100 mL					*230*						*430*								
Total coliforms (counts)	CFU/100 mL																			
Total coliforms (MPN)	MPN/100 mL					1200						>110000								
Nutrients																				
Ammonia (total, as N)	mg/L	0.081	1.51	0.538	0.485	19.4	10.5	11.6	118	25.1	34.1	25.8	3.22	10.4	2.56	<0.020	0.090	0.126	0.042	0.042
Nitrate (as N)	mg/L	0.253	0.474	<0.100	1.08	0.092	<0.010	0.059	2.44	<0.100	1.03	0.125	2.04	0.424	0.842	0.263	0.324	1.28	0.072	0.010
Nitrate + Nitrite (as N) (calculated)	mg/L	0.253	0.492	<0.10	1.10	0.092	<0.014	0.059	2.57	<0.10	1.03	0.125	2.04	0.456	0.863	0.263	0.324	1.28	0.072	<0.014
Nitrite (as N)	mg/L	<0.010	0.018	<0.010	0.024	<0.010	<0.010	<0.010	0.125	<0.010	<0.010	<0.010	<0.100	0.032	0.021	<0.010	<0.010	<0.010	<0.010	<0.010
Orthophosphate (dissolved, as P)	mg/L	<0.01	0.01	0.24	<0.01	<0.01	<0.01	<0.01	0.58	1.80	0.39	<0.01	0.55	0.19	<0.01	0.20	<0.01	<0.01	<0.01	<0.01
Phosphorus (dissolved, by ICPMS/ICPOES)	mg/L	<0.02	<0.02			0.21	<0.02	0.17	6.20			0.64	1.00	1.60	0.09			<0.02	<0.02	<0.02
Phosphorus (total, by ICPMS/ICPOES)	mg/L																			
Phosphorus (total, APHA 4500-P)	mg/L	1.11	2.88					2.80	9.72					0.445	1.25				0.492	
Phosphorus (dissolved, APHA 4500-P)	mg/L	0.007	0.053					0.077	4.35					0.203	0.077				0.008	
Potassium (dissolved)	mg/L	5.80	9.85			25.3	17.3	19.9	39.5			28.5	49.4	16.1	36.2			16.0	6.10	20.1
Potassium (total)	mg/L																			
Total Metals																				
Aluminum (total)	mg/L																			
Antimony (total)	mg/L																			
Arsenic (total)	mg/L																			
Barium (total)	mg/L																			
Beryllium (total)	mg/L																			
Bismuth (total)	mg/L																			
Boron (total)	mg/L																			
Cadmium (total)	mg/L																			
Calcium (total)	mg/L																			
Chromium (total)	mg/L																			
Cobalt (total)	mg/L																			
Copper (total)	mg/L																			
Iron (total)	mg/L																			
Lead (total)	mg/L																			
Lithium (total)	mg/L																			
Magnesium (total)	mg/L																			
Manganese (total)	mg/L																			
Mercury (total)	mg/L																			
Molybdenum (total)	mg/L																			
Nickel (total)	mg/L																			
Selenium (total)	mg/L																			
Silicon (total, as Si)	mg/L																			
Silver (total)	mg/L																			
Sodium (total)	mg/L																			
Strontium (total)	mg/L																			
Sulphur (total)	mg/L																			
Tellurium (total)	mg/L																			
Thallium (total)	mg/L																			
Thorium (total)	mg/L																			
Tin (total)	mg/L																			
Titanium (total)	mg/L																			
Uranium (total)	mg/L																			
Vanadium (total)	mg/L																			
Zinc (total)	mg/L																			
Zirconium (total)	mg/L																			

Swan Lake
Water Quality Results

Analyte	Unit	FS-43 03-Apr-15 5040345-26 Normal	FS-43 15-Jul-15 5071046-05 Normal	FS-43 29-Oct-15 5102146-04 Normal	FS-43 28-Mar-16 6031831-10 Normal	FS-43 (SW) 15-Jul-15 5071046-06 Normal	FS-43 (SW) 29-Oct-15 5102146-03 Normal	FS-43 (SW) 28-Mar-16 6031831-09 Normal	FS-43 (SW) 02-Nov-16 6110254-06	FS-45 15-Jul-15 5071046-03 Normal	FS-45 29-Oct-15 5102146-06 Normal	FS-45 28-Mar-16 6031831-12 Normal	FS-45 10-Aug-16 6080868-08 Normal	FS-45 08-Nov-16 6110797-02 Normal	FS-101 15-Jul-15 5071046-02 Normal	FS-101 29-Oct-15 5102146-09 Normal	FS-101 28-Mar-16 6031831-03 Normal	FS-101 10-Aug-16 6080868-05 Normal	FS-101 02-Nov-16 6110254-08	FS-103 15-Jul-15 5071046-13 Normal
Field Results																				
Conductivity	µS/cm	3940	545	1302	3050	513	1262	306	1384	1114	1281	1738	658	1816	995	1018	2610	804	2410	825
Dissolved oxygen	mg/L			10.31	1.85		10.09	11.64	9.68		1.58	3.86				3.14	2.34			
Dissolved oxygen (percent)	%			88	15.2		86.1	95.4	86		14.1	33.6				27.7	18.5			
Oxidation reduction potential	mV	176		60	43		45	4	150		42	63	135	97	-20	215	192	181	142	
pH		6.69	7.4	9.0	8.0	7.6	8.8	8.2	7.9		7.0	8.0	7.9	8.0	7.9	6.9	8.2	7.4	7.6	7.2
Temperature	°C	7.4	17.5	8.2	6.4	17.1	8.2	6.7	8.3	21.7	10.0	8.6	24.1	9.6	17.5	9.7	6.8	17.8	10.0	19
Lab Results																				
Dissolved Metals																				
Aluminum (dissolved)	mg/L			<0.005	<0.005		0.026	0.419			<0.005	<0.005	<0.005	<0.005		<0.005	<0.005	0.005	<0.005	
Antimony (dissolved)	mg/L			0.0004	0.0002		0.0005	0.0001			0.0006	0.0002	0.0005	0.0002		0.0007	0.0008	0.0019	0.0001	
Arsenic (dissolved)	mg/L			0.0011	0.0017		0.0012	<0.0005			0.0019	0.0011	0.0016	<0.0005		0.0012	0.0015	0.0011	0.0009	
Barium (dissolved)	mg/L			0.072	0.068		0.055	0.025			0.163	0.055	0.037	0.029		0.032	0.158	0.074	0.041	
Beryllium (dissolved)	mg/L			<0.0001	<0.0001		<0.0001	<0.0001			<0.0001	<0.0001	<0.0001	<0.0001		<0.0001	<0.0001	<0.0001	<0.0001	
Bismuth (dissolved)	mg/L			<0.0001	<0.0001		<0.0001	<0.0001			<0.0001	<0.0001	<0.0001	<0.0001		<0.0001	<0.0001	<0.0001	<0.0001	
Boron (dissolved)	mg/L			0.021	<0.004		0.025	<0.004			0.009	0.006	0.016	0.010		0.064	0.049	0.119	0.108	
Cadmium (dissolved)	mg/L			0.00002	0.00006		0.00003	<0.00001			<0.00001	0.00001	<0.00001	0.00002		0.00004	0.00008	0.00012	0.00004	
Calcium (dissolved)	mg/L			104	265		101	30.0			70.4	98.4	32.9	92.4		48.8	220	43.1	188	
Chromium (dissolved)	mg/L			<0.0005	<0.0005		0.0007	0.0007			<0.0005	<0.0005	<0.0005	0.0006		<0.0005	<0.0005	<0.0005	<0.0005	
Cobalt (dissolved)	mg/L			0.00009	0.00031		0.00014	0.00023			0.00097	0.00172	0.00022	0.00017		0.00008	0.00023	0.00014	0.00016	
Copper (dissolved)	mg/L			0.0025	0.0055		0.0025	0.0035			<0.0002	0.0014	0.0006	0.0062		0.0041	0.0059	0.0081	0.0019	
Iron (dissolved)	mg/L			<0.010	<0.010		0.038	0.438			<0.010	<0.010	<0.010	<0.010		<0.010	0.013	<0.010	<0.010	
Lead (dissolved)	mg/L			<0.0001	<0.0001		<0.0001	0.0003			<0.0001	<0.0001	<0.0001	<0.0001		0.0001	<0.0001	0.0002	<0.0001	
Lithium (dissolved)	mg/L			0.0171	0.0150		0.0181	0.0058			0.0096	0.0199	0.0091	0.0194		0.0150	0.0333	0.0226	0.0193	
Magnesium (dissolved)	mg/L			40.6	198		42.8	10.5			77.2	138	32.2	185		43.5	252	45.0	249	
Manganese (dissolved)	mg/L			0.0003	0.0045		0.0099	0.0087			0.387	0.316	0.0069	0.0126		0.0005	0.0170	0.0020	0.0024	
Mercury (dissolved)	mg/L			<0.00002	<0.00002		<0.000005	<0.00002			<0.00002	<0.00002	<0.00002	<0.00002		<0.00002	<0.00002	<0.00002	<0.00002	
Molybdenum (dissolved)	mg/L			0.0065	0.0076		0.0064	0.0011			0.0289	0.0398	0.0200	*0.0985*		0.0162	0.0249	0.0137	0.0274	
Nickel (dissolved)	mg/L			0.0024	0.0064		0.0029	0.0024			0.0029	0.0032	0.0017	0.0021		0.0020	0.0035	0.0030	0.0019	
Selenium (dissolved)	mg/L			0.0006	<0.0005		<0.0005	<0.0005			0.0023	0.0008	0.0011	0.0089		0.0008	0.0052	0.0021	0.0007	
Silicon (dissolved, as Si)	mg/L			8.9	12.3		9.7	11.6			6.7	5.8	5.9	7.5		10.5	9.3	14.7	15.7	
Silver (dissolved)	mg/L			0.00005	<0.00005		0.00007	<0.00005			0.00006	<0.00005	0.00014	<0.00005		0.00005	<0.00005	0.00034	<0.00005	
Sodium (dissolved)	mg/L			95.5	203		98.5	13.7			47.2	90.0	33.3	123		68.5	257	51.8	296	
Strontium (dissolved)	mg/L			1.04	2.39		1.18	0.211			2.13	3.89	0.951	4.50		0.587	2.82	0.687	2.93	
Sulphur (dissolved)	mg/L			56	359		56	9			66	144	35	230		52	509	29	525	
Tellurium (dissolved)	mg/L			<0.0002	<0.0002		<0.0002	<0.0002			<0.0002	<0.0002	<0.0002	<0.0002		<0.0002	<0.0002	<0.0002	<0.0002	
Thallium (dissolved)	mg/L			<0.00002	<0.00002		<0.00002	<0.00002			<0.00002	<0.00002	<0.00002	<0.00002		<0.00002	<0.00002	<0.00002	<0.00002	
Thorium (dissolved)	mg/L			<0.0001	<0.0001		<0.0001	<0.0001			<0.0001	<0.0001	<0.0001	<0.0001		<0.0001	<0.0001	<0.0001	<0.0001	
Tin (dissolved)	mg/L			<0.0002	<0.0002		<0.0002	<0.0002			<0.0002	<0.0002	<0.0002	<0.0002		<0.0002	<0.0002	<0.0002	<0.0002	
Titanium (dissolved)	mg/L			<0.005	<0.005		<0.005	0.019			<0.005	<0.005	<0.005	<0.005		<0.005	<0.005	<0.005	<0.005	
Uranium (dissolved)	mg/L			0.0200	0.143		0.0165	0.00248			0.0269	0.0675	0.0126	0.0848		0.0161	0.143	0.0140	0.0316	
Vanadium (dissolved)	mg/L			0.002	0.009		0.002	0.002			0.002	0.002	0.004	0.002		0.005	0.004	0.007	0.005	
Zinc (dissolved)	mg/L			<0.004	<0.004		0.019	0.009			<0.004	<0.004	<0.004	<0.004		<0.004	<0.004	<0.004	<0.004	
Zirconium (dissolved)	mg/L			0.0002	0.0004		0.0002	0.0008			0.0003	0.0002	<0.0001	0.0001		0.0003	0.0004	0.0003	0.0003	
General																				
Alkalinity (bicarbonate, as CaCO3)	mg/L	153	210	305	374	187	303	80	326	333	421	482	700	639	419	295	372	316	448	15000
Alkalinity (carbonate, as CaCO3)	mg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<2	<1	<1	<1	<1	<2	<2	<1
Alkalinity (hydroxide, as CaCO3)	mg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<2	<1	<1	<1	<1	<2	<2	<1
Alkalinity (phenolphthalein, as CaCO3)	mg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<2	<1	<1	<1	<1	<2	<2	<1
Alkalinity (total, as CaCO3)	mg/L	153	210	305	374	187	303	80	326	333	421	482	700	639	419	295	372	316	448	15000
Bicarbonate Alkalinity (as HCO3)	mg/L				456			97	398			588	854	780			454	386	546	
Carbonate Alkalinity (as CO3)	mg/L				<1			<1	<0.6			<1	<1	<0.6			<1	<1	<1	
Hydroxide Alkalinity (as OH)	mg/L				<1			<1	<0.3			<1	<0.7	<0.3			<1	<0.7	<0.7	
Bromide	mg/L	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.12	<0.10	<0.10	0.13	<0.10	<0.10	<0.10	<0.10	0.19	<0.10	0.17	<0.10
Chloride	mg/L	477	38.4	159	264	35.8	151	15.8	161	32.9	33.4	44.3	36.0	41.5	39.0	26.7	91.2	23.8	33.4	16.7
Chlorophyll a	mg/L																			
Conductivity	µS/cm				2940			288	1420			1610	608	1780			3130	794	3010	
Fluoride	mg/L	0.26	0.86	0.73	0.52	0.46	0.66	0.21	0.29	1.01	0.58	1.35	0.76	1.14	0.99	1.16	0.91	0.97	0.96	0.63
Hardness, total (dissolved as CaCO3)	mg/L			427	1480		429	118	502		494	816	215	993		301	1590	293	1500	
pH		7.43			7.71			7.94	8.13			7.88	7.59	7.55			7.72	7.12	7.25	
Sulphate	mg/L	*1330*	53.2	167	*1050*	54.0	159	40.6	181	68.6	203	452	97.9	584	111	136	*1490*	85.9	*1490*	49.9
Sulphide (total, as S)	mg/L		<0.05		0.39	<0.05		<0.05		<0.05		<0.05			<0.05		<0.05			<0.10
Total suspended solids	mg/L																			
Turbidity	NTU																			
Microbiological																				

Swan Lake
Water Quality Results

Analyte	Unit	FS-43 03-Apr-15 5040345-26 Normal	FS-43 15-Jul-15 5071046-05 Normal	FS-43 29-Oct-15 5102146-04 Normal	FS-43 28-Mar-16 6031831-10 Normal	FS-43 (SW) 15-Jul-15 5071046-06 Normal	FS-43 (SW) 29-Oct-15 5102146-03 Normal	FS-43 (SW) 28-Mar-16 6031831-09 Normal	FS-43 (SW) 02-Nov-16 6110254-06	FS-45 15-Jul-15 5071046-03 Normal	FS-45 29-Oct-15 5102146-06 Normal	FS-45 28-Mar-16 6031831-12 Normal	FS-45 10-Aug-16 6080868-08 Normal	FS-45 08-Nov-16 6110797-02 Normal	FS-101 15-Jul-15 5071046-02 Normal	FS-101 29-Oct-15 5102146-09 Normal	FS-101 28-Mar-16 6031831-03 Normal	FS-101 10-Aug-16 6080868-05 Normal	FS-101 02-Nov-16 6110254-08	FS-103 15-Jul-15 5071046-13 Normal
Background Bacteria	CFU/100 mL																			
E. coli (counts)	CFU/100 mL																			
E. coli (MPN)	MPN/100 mL			91			9.1				9.1					<3.0				
Enterococcus (MPN)	MPN/100 mL																			
Fecal coliforms (counts)	CFU/100 mL																			
Fecal coliforms (MPN)	MPN/100 mL			91			23				9.1					36				
Total coliforms (counts)	CFU/100 mL																			
Total coliforms (MPN)	MPN/100 mL			46000			1200				2400					>110000				
Nutrients																				
Ammonia (total, as N)	mg/L	<0.020	0.204	0.061	0.084	0.054	<0.020	<0.020	0.063	0.141	0.074	0.126	0.045	0.076	0.033	0.104	0.191	0.113	0.069	1.10
Nitrate (as N)	mg/L	0.012	0.025	0.038	0.096	0.018	0.039	0.197	0.550	<0.010	0.062	0.291	0.236	0.055	6.56	0.524	6.93	0.744	0.333	<0.010
Nitrate + Nitrite (as N) (calculated)	mg/L	<0.014	0.025	0.038	0.096	0.018	0.039	0.197	0.550	<0.014	0.062	0.291	0.236	0.055	6.56	0.524	6.93	0.744	0.333	<0.014
Nitrite (as N)	mg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Orthophosphate (dissolved, as P)	mg/L	<0.01	<0.01	<0.01	0.08	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.16	<0.01	<0.01	<0.01
Phosphorus (dissolved, by ICPMS/ICPOES)	mg/L			0.04	0.15		0.04	0.03			<0.02	<0.02	<0.02	<0.02		0.24	0.26	0.15	0.12	
Phosphorus (total, by ICPMS/ICPOES)	mg/L								<0.02											
Phosphorus (total, APHA 4500-P)	mg/L								0.057				1.11	0.092				1.20	18.5	
Phosphorus (dissolved, APHA 4500-P)	mg/L								0.072				0.011	0.007				0.170	0.088	
Potassium (dissolved)	mg/L			6.90	8.83		9.00	3.00			6.09	9.02	4.66	7.12		8.59	16.4	8.24	18.2	
Potassium (total)	mg/L								9.60											
Total Metals																				
Aluminum (total)	mg/L								0.113											
Antimony (total)	mg/L								0.0003											
Arsenic (total)	mg/L								0.0012											
Barium (total)	mg/L								0.068											
Beryllium (total)	mg/L								<0.0001											
Bismuth (total)	mg/L								<0.0001											
Boron (total)	mg/L								0.013											
Cadmium (total)	mg/L								0.00002											
Calcium (total)	mg/L								116											
Chromium (total)	mg/L								0.0008											
Cobalt (total)	mg/L								0.00017											
Copper (total)	mg/L								0.0031											
Iron (total)	mg/L								0.15											
Lead (total)	mg/L								0.0001											
Lithium (total)	mg/L								0.0187											
Magnesium (total)	mg/L								51.4											
Manganese (total)	mg/L								0.0136											
Mercury (total)	mg/L								<0.00002											
Molybdenum (total)	mg/L								0.0069											
Nickel (total)	mg/L								0.0033											
Selenium (total)	mg/L								<0.0005											
Silicon (total, as Si)	mg/L								10.0											
Silver (total)	mg/L								<0.00005											
Sodium (total)	mg/L								119											
Strontium (total)	mg/L								1.47											
Sulphur (total)	mg/L								63											
Tellurium (total)	mg/L								<0.0002											
Thallium (total)	mg/L								<0.00002											
Thorium (total)	mg/L								<0.0001											
Tin (total)	mg/L								0.0003											
Titanium (total)	mg/L								<0.005											
Uranium (total)	mg/L								0.0183											
Vanadium (total)	mg/L								0.002											
Zinc (total)	mg/L								0.025											
Zirconium (total)	mg/L								0.0003											

Swan Lake
Water Quality Results

Analyte	Unit	FS-103 29-Oct-15 5102146-12 Normal	FS-103 28-Mar-16 6031831-05 Normal	FS-103 11-Aug-16 6080942-02 Normal	FS-103 02-Nov-16 6110254-09	FS-104 15-Jul-15 5071046-01 Normal	FS-104 29-Oct-15 5102146-11 Normal	FS-104 28-Mar-16 6031831-01 Normal	FS-104 10-Aug-16 6080868-14 Normal	FS-104b 28-Mar-16 6031831-17 Normal	FS-104b 02-Nov-16 6110254-07	MW-1 15-Jul-15 5071046-07 Normal	MW-1 29-Oct-15 5102146-10 Normal	MW-1 28-Mar-16 6031831-08 Normal	MW-1 10-Aug-16 6080868-06 Normal	MW-1 02-Nov-16 6110254-10	MW-2 16-Jul-15 5071187-04 Normal	MW-2 29-Oct-15 5102146-07 Normal	MW-2 28-Mar-16 6031831-07 Normal	MW-3 16-Jul-15 5071187-05 Normal
Field Results																				
Conductivity	µS/cm	1290	837	1008	823	1035	789	872	1090	835	751	4710	4450	5250	4790	4510	520	528	583	439
Dissolved oxygen	mg/L	7.07	5.54				1.90	2.67		8.60			2.56	2.09				5.28	3.8	
Dissolved oxygen (percent)	%	63.8	47				18.6	22.7		76.4			23.6	16.9				48.6	33.8	
Oxidation reduction potential	mV	-13	179	126	135	-35	222	226	176	40	156		38	27	137	132	-148	-47	-88	-14
pH		6.9	7.5	7.5	7.9	7.0	*12.4*	7.2	7.2	8.3	7.9	6.9	8.2	7.2	7.2	7.1	7.6	7.6	7.7	7.9
Temperature	°C	10.5	8.0	16.7	10.3	18.6	14.0	4.4	19.8	9.4	10.1	9.5	11	7.5	10.5	10.2	17.9	11.3	10.6	22.6
Lab Results																				
Dissolved Metals																				
Aluminum (dissolved)	mg/L	<0.005	<0.005	<0.005	<0.005		<0.005		<0.005	0.006	<0.005		0.041	0.128	0.025	1.05		0.005	0.007	
Antimony (dissolved)	mg/L	0.0002	0.0002	0.0003	0.0001		<0.0001		0.0006	0.0006	0.0004		<0.0001	0.0002	<0.0001	0.0002		<0.0001	<0.0001	
Arsenic (dissolved)	mg/L	<0.0005	<0.0005	0.0013	<0.0005		<0.0005		0.0005	0.0009	0.0010		0.0007	0.0006	0.0008	0.0023		0.0008	<0.0005	
Barium (dissolved)	mg/L	0.070	0.068	0.105	0.042		0.083		0.127	0.097	0.098		0.028	0.032	0.028	0.084		0.056	0.061	
Beryllium (dissolved)	mg/L	<0.0001	<0.0001	<0.0001	<0.0001		<0.0001		<0.0001	<0.0001	<0.0001		<0.0001	<0.0001	<0.0001	<0.0001		<0.0001	<0.0001	
Bismuth (dissolved)	mg/L	<0.0001	<0.0001	<0.0001	<0.0001		<0.0001		<0.0001	<0.0001	<0.0001		<0.0001	<0.0001	<0.0001	<0.0001		<0.0001	<0.0001	
Boron (dissolved)	mg/L	0.004	0.009	0.018	0.018		0.027		0.028	0.034	0.032		0.010	0.007	0.026	0.013		0.005	<0.004	
Cadmium (dissolved)	mg/L	0.00003	0.00002	0.00002	0.00003		0.00001		0.00004	0.00002	0.00003		0.00011	0.00013	0.00007	0.00035		0.00001	<0.00001	
Calcium (dissolved)	mg/L	145	118	130	125		84.1		76.6	85.2	88.5		448	550	512	507		73.6	81.6	
Chromium (dissolved)	mg/L	<0.0005	<0.0005	<0.0005	<0.0005		<0.0005		<0.0005	<0.0005	<0.0005		<0.0005	<0.0005	<0.0005	0.0023		<0.0005	<0.0005	
Cobalt (dissolved)	mg/L	0.00031	0.00015	0.00105	0.00031		0.00009		0.00038	0.00041	0.00011		0.00252	0.00114	0.00472	0.00350		0.00010	0.00008	
Copper (dissolved)	mg/L	0.0102	0.0049	0.0013	0.0038		0.0014		0.0036	0.0012	0.0021		0.0007	0.0031	0.0009	0.0080		<0.0002	0.0007	
Iron (dissolved)	mg/L	<0.010	<0.010	0.062	<0.010		<0.010		<0.010	0.012	<0.010		0.126	0.301	0.182	2.28		0.230	0.202	
Lead (dissolved)	mg/L	<0.0001	<0.0001	<0.0001	<0.0001		<0.0001		<0.0001	0.0002	0.0002		0.0001	0.0004	<0.0001	0.0018		<0.0001	0.0003	
Lithium (dissolved)	mg/L	0.0137	0.0162	0.0190	0.0191		0.0131		0.0076	0.0107	0.0104		0.0168	0.0226	0.0230	0.0187		0.0061	0.0073	
Magnesium (dissolved)	mg/L	41.7	34.2	37.0	35.0		30.3		19.7	40.0	40.8		333	410	381	423		14.1	17.1	
Manganese (dissolved)	mg/L	0.0071	0.0018	0.735	0.0089		0.0016		0.0766	0.191	0.0234		0.866	0.391	1.57	1.11		0.129	0.156	
Mercury (dissolved)	mg/L	<0.00002	<0.00002	<0.00002	<0.00002		<0.00002		<0.00002	<0.00002	<0.00002		<0.000005	<0.00002	<0.00002	<0.00002		<0.000005	<0.00002	
Molybdenum (dissolved)	mg/L	0.0055	0.0041	0.0055	0.0052		0.0120		0.0080	0.0130	0.0093		0.0033	0.0026	0.0039	0.0032		0.0010	0.0015	
Nickel (dissolved)	mg/L	0.0048	0.0024	0.0049	0.0029		0.0012		0.0026	0.0011	0.0016		0.0074	0.0067	0.0070	0.0104		0.0004	0.0006	
Selenium (dissolved)	mg/L	<0.0005	0.0014	<0.0005	0.0021		0.0298		0.0008	0.0188	0.0269		<0.0005	0.0020	<0.0005	<0.0005		<0.0005	<0.0005	
Silicon (dissolved, as Si)	mg/L	6.0	12.6	19.4	12.9		9.9		9.5	9.3	11.2		7.6	7.8	8.6	10.5		9.1	8.9	
Silver (dissolved)	mg/L	<0.00005	<0.00005	<0.00005	<0.00005		<0.00005		<0.00005	<0.00005	<0.00005		<0.00005	<0.00005	<0.00005	<0.00005		0.00007	<0.00005	
Sodium (dissolved)	mg/L	99.3	22.7	36.4	24.4		25.8		127	35.8	31.0		294	356	321	366		9.10	10.8	
Strontium (dissolved)	mg/L	0.870	0.654	0.925	0.685		0.919		0.800	0.920	0.973		4.62	5.74	5.70	5.24		0.449	0.514	
Sulphur (dissolved)	mg/L	91	32	28	48		16		18	18	24		767	877	812	888		15	13	
Tellurium (dissolved)	mg/L	<0.0002	<0.0002	<0.0002	<0.0002		<0.0002		<0.0002	<0.0002	<0.0002		<0.0002	<0.0002	<0.0002	<0.0002		<0.0002	<0.0002	
Thallium (dissolved)	mg/L	<0.00002	<0.00002	<0.00002	<0.00002		<0.00002		<0.00002	<0.00002	<0.00002		0.00003	0.00004	0.00004	0.00009		<0.00002	<0.00002	
Thorium (dissolved)	mg/L	<0.0001	<0.0001	<0.0001	<0.0001		<0.0001		<0.0001	<0.0001	<0.0001		<0.0001	<0.0001	<0.0001	0.0004		<0.0001	<0.0001	
Tin (dissolved)	mg/L	<0.0002	0.0002	<0.0002	<0.0002		<0.0002		<0.0002	<0.0002	<0.0002		<0.0002	0.0002	<0.0002	<0.0002		<0.0002	<0.0002	
Titanium (dissolved)	mg/L	<0.005	<0.005	<0.005	<0.005		<0.005		<0.005	<0.005	<0.005		<0.005	0.009	<0.005	0.047		<0.005	<0.005	
Uranium (dissolved)	mg/L	0.0150	0.00959	0.00966	0.00820		0.0121		0.0109	0.0259	0.0207		0.0461	0.0585	0.0594	0.0576		0.00340	0.00476	
Vanadium (dissolved)	mg/L	<0.001	0.002	0.003	0.001		0.002		0.003	0.004	0.005		<0.001	<0.001	<0.001	0.005		<0.001	<0.001	
Zinc (dissolved)	mg/L	<0.004	<0.004	0.004	<0.004		<0.004		<0.004	<0.004	0.026		0.008	0.020	0.008	0.018		0.008	0.150	
Zirconium (dissolved)	mg/L	0.0002	0.0001	0.0004	<0.0001		<0.0001		0.0002	0.0001	0.0001		0.0003	0.0004	0.0002	0.0014		<0.0001	<0.0001	
General																				
Alkalinity (bicarbonate, as CaCO3)	mg/L	411	390	494	1360	427	355	311	408	460	819	436	436	400	421	422	186	184	177	164
Alkalinity (carbonate, as CaCO3)	mg/L	<1	<1	<2	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Alkalinity (hydroxide, as CaCO3)	mg/L	<1	<1	<2	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Alkalinity (phenolphthalein, as CaCO3)	mg/L	<1	<1	<2	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Alkalinity (total, as CaCO3)	mg/L	411	390	494	1360	427	355	311	408	460	819	436	436	400	421	422	186	184	177	164
Bicarbonate Alkalinity (as HCO3)	mg/L		476	603	1660			379	498		999			488	514	515			216	
Carbonate Alkalinity (as CO3)	mg/L		<1	<1	<0.6			<1	<0.6		<0.6			<1	<0.6	<0.6			<1	
Hydroxide Alkalinity (as OH)	mg/L		<1	<0.7	<0.3			<1	<0.3		<0.3			<1	<0.3	<0.3			<1	
Bromide	mg/L	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.10	0.21	0.44	0.38	0.33	<0.10	<0.10	<0.10	<0.10
Chloride	mg/L	101	9.16	13.0	12.5	73.9	20.1	84.3	116	29.4	24.5	431	291	464	448	328	40.5	39.3	47.6	17.4
Chlorophyll a	mg/L																			
Conductivity	µS/cm		847	999	860				1100	801				5160	5150	4440			571	
Fluoride	mg/L	0.54	0.57	0.54	0.28	0.68	0.36	0.32	0.42	0.35	0.13	0.26	0.35	0.23	0.44	<0.10	0.15	0.13	0.13	0.23
Hardness, total (dissolved as CaCO3)	mg/L	534	436	477	456		335		272	378	389		2490	3060	2850	3010		242	274	
pH			7.84	7.47	6.84				7.89	7.19	7.30			7.60	7.61	7.07			7.99	
Sulphate	mg/L	264	108	80.0	114	71.2	53.3	45.7	53.7	64.3	66.8	*2420*	*2540*	*2590*	*2550*	*2620*	47.9	49.0	50.3	64.8
Sulphide (total, as S)	mg/L		<0.05			<0.05				<0.05		<0.05		<0.05			<0.05		<0.05	<0.05
Total suspended solids	mg/L																			
Turbidity	NTU																			
Microbiological																				

Swan Lake
Water Quality Results

Analyte	Unit	FS-103 29-Oct-15 5102146-12 Normal	FS-103 28-Mar-16 6031831-05 Normal	FS-103 11-Aug-16 6080942-02 Normal	FS-103 02-Nov-16 6110254-09	FS-104 15-Jul-15 5071046-01 Normal	FS-104 29-Oct-15 5102146-11 Normal	FS-104 28-Mar-16 6031831-01 Normal	FS-104 10-Aug-16 6080868-14 Normal	FS-104b 28-Mar-16 6031831-17 Normal	FS-104b 02-Nov-16 6110254-07	MW-1 15-Jul-15 5071046-07 Normal	MW-1 29-Oct-15 5102146-10 Normal	MW-1 28-Mar-16 6031831-08 Normal	MW-1 10-Aug-16 6080868-06 Normal	MW-1 02-Nov-16 6110254-10	MW-2 16-Jul-15 5071187-04 Normal	MW-2 29-Oct-15 5102146-07 Normal	MW-2 28-Mar-16 6031831-07 Normal	MW-3 16-Jul-15 5071187-05 Normal
Background Bacteria	CFU/100 mL																			
E. coli (counts)	CFU/100 mL																			
E. coli (MPN)	MPN/100 mL	3.6					3.6						<3.0					<3.0		
Enterococcus (MPN)	MPN/100 mL																			
Fecal coliforms (counts)	CFU/100 mL																			
Fecal coliforms (MPN)	MPN/100 mL	3.6					3.6						<3.0					<3.0		
Total coliforms (counts)	CFU/100 mL																			
Total coliforms (MPN)	MPN/100 mL	15					46000						3.6					<3.0		
Nutrients																				
Ammonia (total, as N)	mg/L	0.049	0.075	0.105	0.062	0.138	0.052		0.169	0.411	0.085	0.052	0.032	0.028	0.038	0.098	0.065	0.036	0.046	0.148
Nitrate (as N)	mg/L	<0.010	0.491	0.056	<0.010	<0.010	3.77	3.81	0.214	7.95	8.51	<0.010	<0.010	<0.010	0.022	0.011	<0.010	0.228	<0.010	<0.010
Nitrate + Nitrite (as N) (calculated)	mg/L	<0.014	0.491	0.056	<0.014	<0.014	3.77	3.81	0.214	7.99	8.51	<0.014	<0.014	<0.014	0.022	<0.014	<0.014	0.228	<0.014	<0.014
Nitrite (as N)	mg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.038	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Orthophosphate (dissolved, as P)	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Phosphorus (dissolved, by ICPMS/ICPOES)	mg/L	<0.02	<0.02	<0.02	<0.02		<0.02		0.02	0.04	0.12		0.04	0.06	0.03	0.17		<0.02	<0.02	
Phosphorus (total, by ICPMS/ICPOES)	mg/L																			
Phosphorus (total, APHA 4500-P)	mg/L			0.161	17.1				1.64		0.119				0.332	0.851				
Phosphorus (dissolved, APHA 4500-P)	mg/L			0.063	<0.002				0.023		0.100				0.046	0.174				
Potassium (dissolved)	mg/L	5.06	7.56	5.69	7.71		5.75		8.10	11.6	7.20		5.33	5.38	5.53	7.66		2.84	3.26	
Potassium (total)	mg/L																			
Total Metals																				
Aluminum (total)	mg/L																			
Antimony (total)	mg/L																			
Arsenic (total)	mg/L																			
Barium (total)	mg/L																			
Beryllium (total)	mg/L																			
Bismuth (total)	mg/L																			
Boron (total)	mg/L																			
Cadmium (total)	mg/L																			
Calcium (total)	mg/L																			
Chromium (total)	mg/L																			
Cobalt (total)	mg/L																			
Copper (total)	mg/L																			
Iron (total)	mg/L																			
Lead (total)	mg/L																			
Lithium (total)	mg/L																			
Magnesium (total)	mg/L																			
Manganese (total)	mg/L																			
Mercury (total)	mg/L																			
Molybdenum (total)	mg/L																			
Nickel (total)	mg/L																			
Selenium (total)	mg/L																			
Silicon (total, as Si)	mg/L																			
Silver (total)	mg/L																			
Sodium (total)	mg/L																			
Strontium (total)	mg/L																			
Sulphur (total)	mg/L																			
Tellurium (total)	mg/L																			
Thallium (total)	mg/L																			
Thorium (total)	mg/L																			
Tin (total)	mg/L																			
Titanium (total)	mg/L																			
Uranium (total)	mg/L																			
Vanadium (total)	mg/L																			
Zinc (total)	mg/L																			
Zirconium (total)	mg/L																			

Swan Lake
Water Quality Results

Analyte	Unit	MW-3 29-Oct-15 5102146-05 Normal	MW-3 28-Mar-16 6031831-06 Normal	MW-3 10-Aug-16 6080868-09 Normal	MW-3 03-Nov-16 6110391-05	NW Spring 31-Mar-16 6040072-03 Normal	SE Spring 31-Mar-16 6040072-04 Normal	SE Spring 10-Aug-16 6080868-11 Normal	SE Spring 03-Nov-16 6110391-03	Site 3 (NE-Cowboys) 03-Apr-15 5040345-06 Normal	Site 3 (NE-Cowboys) 28-Mar-16 6031831-04 Normal	Site 3 (NE-Cowboys) 10-Aug-16 6080868-02	Site 5 (NE-Culvert) 03-Apr-15 5040345-05 Normal	Site 5 (NE-Culvert) 29-Oct-15 5102146-08 Normal	Site 5 (NE-Culvert) 29-Mar-16 6031988-02 Normal	Site 5 (NE-Culvert) 02-Nov-16 6110254-04	Site5b (NE-culvert) 28-Mar-16 6031831-11 Normal	Site5b (NE-culvert) 10-Aug-16 6080868-01	Site5b (NE-culvert) 02-Nov-16 6110254-05	Storm Drainage 28-Mar-16 6031831-16 Normal
Field Results																				
Conductivity	µS/cm	461	508	498			885	795		1079	1228	1150	1273	804	579	865	460	1020	124	747
Dissolved oxygen	mg/L	0.80	2.45				11.04				11.15			9.29	11.19	8.2	11.3			10.48
Dissolved oxygen (percent)	%	8.0	25.3				102.4				93.5			80.4	95.4	74.6	93.8			94.4
Oxidation reduction potential	mV	-119	-84	-112			117	159		168	154	160		79	171	143	33	103	122	29
pH		7.7	7.7	7.9			8.0	8		8.23	8.5	8.2	9.1	8.8	7.8	8.0	8.3	7.6	8.4	8.3
Temperature	°C	15.3	17	21.3			11.1	14.8		7.9	7.6	20.5	7.87	8.8	5.6	10.5	7.0	19.1	8.2	10.2
Lab Results																				
Dissolved Metals																				
Aluminum (dissolved)	mg/L	0.005	0.019	0.033	<0.005		0.006				0.023			0.053	0.019		0.017			0.040
Antimony (dissolved)	mg/L	<0.0001	<0.0001	<0.0001	<0.0001		0.0002				0.0002			0.0002	0.0001		0.0001			0.0016
Arsenic (dissolved)	mg/L	0.0020	0.0015	0.0024	0.0032		0.0006				0.0009			<0.0005	<0.0005		<0.0005			0.0006
Barium (dissolved)	mg/L	0.040	0.048	0.053	0.056		0.058				0.055			0.038	0.028		0.022			0.069
Beryllium (dissolved)	mg/L	<0.0001	<0.0001	<0.0001	<0.0001		<0.0001				<0.0001			<0.0001	<0.0001		<0.0001			<0.0001
Bismuth (dissolved)	mg/L	<0.0001	<0.0001	<0.0001	<0.0001		<0.0001				<0.0001			<0.0001	<0.0001		<0.0001			<0.0001
Boron (dissolved)	mg/L	0.009	0.015	0.012	0.013		0.037				0.061			0.012	0.010		<0.004			0.015
Cadmium (dissolved)	mg/L	<0.00001	<0.00001	<0.00001	<0.00001		0.00002				<0.00001			0.00001	0.00001		<0.00001			0.00010
Calcium (dissolved)	mg/L	53.9	62.8	57.9	73.4		84.5				136			73.1	66.0		57.6			92.3
Chromium (dissolved)	mg/L	<0.0005	<0.0005	<0.0005	0.0008		0.0009				<0.0005			<0.0005	<0.0005		<0.0005			<0.0005
Cobalt (dissolved)	mg/L	<0.00005	<0.00005	<0.00005	<0.00005		0.00008				0.00018			0.00042	0.00011		0.00011			0.00020
Copper (dissolved)	mg/L	<0.0002	0.0006	0.0004	0.0002		0.0028				0.0035			0.0014	0.0030		0.0031			0.0017
Iron (dissolved)	mg/L	0.210	0.206	0.286	0.325		0.011				0.030			0.108	0.039		0.041			0.119
Lead (dissolved)	mg/L	<0.0001	<0.0001	0.0001	<0.0001		0.0001				<0.0001			0.0001	<0.0001		<0.0001			<0.0001
Lithium (dissolved)	mg/L	0.0042	0.0073	0.0051	0.0061		0.0112				0.0263			0.0120	0.0086		0.0081			0.0044
Magnesium (dissolved)	mg/L	13.4	16.6	15.5	19.3		35.1				54.5			25.0	18.2		14.5			17.8
Manganese (dissolved)	mg/L	0.0680	0.0724	0.0755	0.0938		0.0154				0.0017			0.0757	0.0088		0.0064			0.153
Mercury (dissolved)	mg/L	<0.000005	<0.00002	<0.00002	<0.00002						<0.00002			<0.000005	<0.00002		<0.00002			<0.00002
Molybdenum (dissolved)	mg/L	0.0027	0.0027	0.0026	0.0033		0.0084				0.0057			0.0016	0.0016		0.0015			0.0033
Nickel (dissolved)	mg/L	0.0003	0.0003	0.0003	<0.0002		0.0014				0.0016			0.0017	0.0013		0.0015			0.0013
Selenium (dissolved)	mg/L	<0.0005	<0.0005	<0.0005	<0.0005		0.0072				0.0014			<0.0005	0.0007		0.0008			0.0086
Silicon (dissolved, as Si)	mg/L	8.3	9.4	9.5	11.8		9.0				12.5			8.5	16.2		14.6			8.2
Silver (dissolved)	mg/L	0.00015	<0.00005	0.00011	<0.00005		<0.00005				<0.00005			<0.00005	<0.00005		<0.00005			<0.00005
Sodium (dissolved)	mg/L	15.7	18.6	16.2	21.6		30.6				45.7			38.1	20.3		12.7			33.9
Strontium (dissolved)	mg/L	0.502	0.604	0.608	0.709		1.04				1.10			0.547	0.429		0.352			0.590
Sulphur (dissolved)	mg/L	21	20	21	26		16				51			25	22		15			17
Tellurium (dissolved)	mg/L	<0.0002	<0.0002	<0.0002	<0.0002		<0.0002				<0.0002			<0.0002	<0.0002		<0.0002			<0.0002
Thallium (dissolved)	mg/L	<0.00002	<0.00002	<0.00002	<0.00002		<0.00002				<0.00002			<0.00002	<0.00002		<0.00002			<0.00002
Thorium (dissolved)	mg/L	<0.0001	<0.0001	<0.0001	<0.0001		<0.0001				<0.0001			<0.0001	<0.0001		<0.0001			<0.0001
Tin (dissolved)	mg/L	<0.0002	<0.0002	<0.0002	<0.0002		<0.0002				<0.0002			<0.0002	<0.0002		<0.0002			<0.0002
Titanium (dissolved)	mg/L	<0.005	<0.005	<0.005	<0.005		<0.005				<0.005			<0.005	<0.005		<0.005			<0.005
Uranium (dissolved)	mg/L	0.00040	0.00043	0.00056	0.00069		0.0241				0.0174			0.00393	0.00271		0.00180			0.00607
Vanadium (dissolved)	mg/L	<0.001	<0.001	<0.001	<0.001		0.002				0.002			<0.001	<0.001		<0.001			<0.001
Zinc (dissolved)	mg/L	0.005	0.006	0.007	0.005		0.021				0.005			0.018	0.013		0.006			0.015
Zirconium (dissolved)	mg/L	<0.0001	<0.0001	<0.0001	<0.0001		0.0001				0.0001			0.0001	0.0001		0.0001			<0.0001
General																				
Alkalinity (bicarbonate, as CaCO3)	mg/L	161	157	163	148			288	318	78	311	322	315	241	162	247	148	347	40	200
Alkalinity (carbonate, as CaCO3)	mg/L	<1	<1	<1	<1			<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<2	<1	<1
Alkalinity (hydroxide, as CaCO3)	mg/L	<1	<1	<1	<1			<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<2	<1	<1
Alkalinity (phenolphthalein, as CaCO3)	mg/L	<1	<1	<1	<1			<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<2	<1	<1
Alkalinity (total, as CaCO3)	mg/L	161	157	163	148			288	318	78	311	323	315	241	162	247	148	347	40	200
Bicarbonate Alkalinity (as HCO3)	mg/L		191		181			352	388		379	393			198	301	181	423	49	
Carbonate Alkalinity (as CO3)	mg/L		<1		<0.6			<0.6	<0.6		<1	<0.6			<1	<0.6	<1	<1	<0.6	
Hydroxide Alkalinity (as OH)	mg/L		<1		<0.3			<0.3	<0.3		<1	<0.3			<1	<0.3	<1	<0.7	<0.3	
Bromide	mg/L	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.15	0.29	<0.10	<0.10	<0.10	<0.10	<0.10	0.13	<0.10	0.23
Chloride	mg/L	14.9	26.2	26.6	20.9	15.7	46.2	31.0	42.6	9.29	102	96.3	118	79.5	33.0	66.2	19.2	123	9.43	76.7
Chlorophyll a	mg/L																			
Conductivity	µS/cm		503	508	502	913	847	778	889		1180	1170			531	989	442	1030	118	708
Fluoride	mg/L	0.21	0.26	0.21	<0.10	0.53	0.44	0.38	0.13	0.16	0.82	0.97	0.77	0.32	0.32	0.17	0.33	0.50	0.11	0.12
Hardness, total (dissolved as CaCO3)	mg/L	190	225	208	263		355	364	404		564	559		285	240	430	203	559	74.8	304
pH			8.07	8.05	7.76	8.09	8.14	8.11	8.02	7.95	8.23	8.30	8.10		8.08	8.04	8.11	7.45	6.41	7.83
Sulphate	mg/L	71.0	70.0	67.5	63.2	221	64.0	60.9	58.2	31.3	161	149	122	73.2	67.3	168	54.0	41.3	1.7	59.9
Sulphide (total, as S)	mg/L		<0.05								<0.05				<0.05		<0.05			<0.05
Total suspended solids	mg/L																			
Turbidity	NTU																			
Microbiological																				

Swan Lake

Water Quality Results

Analyte	Unit	MW-3 29-Oct-15 5102146-05 Normal	MW-3 28-Mar-16 6031831-06 Normal	MW-3 10-Aug-16 6080868-09 Normal	MW-3 03-Nov-16 6110391-05	NW Spring 31-Mar-16 6040072-03 Normal	SE Spring 31-Mar-16 6040072-04 Normal	SE Spring 10-Aug-16 6080868-11 Normal	SE Spring 03-Nov-16 6110391-03	Site 3 (NE-Cowboys) 03-Apr-15 5040345-06 Normal	Site 3 (NE-Cowboys) 28-Mar-16 6031831-04 Normal	Site 3 (NE-Cowboys) 10-Aug-16 6080868-02	Site 5 (NE-Culvert) 03-Apr-15 5040345-05 Normal	Site 5 (NE-Culvert) 29-Oct-15 5102146-08 Normal	Site 5 (NE-Culvert) 29-Mar-16 6031988-02 Normal	Site 5 (NE-Culvert) 02-Nov-16 6110254-04	Site5b (NE-culvert) 28-Mar-16 6031831-11 Normal	Site5b (NE-culvert) 10-Aug-16 6080868-01	Site5b (NE-culvert) 02-Nov-16 6110254-05	Storm Drainage 28-Mar-16 6031831-16 Normal
Background Bacteria	CFU/100 mL																			
E. coli (counts)	CFU/100 mL																			
E. coli (MPN)	MPN/100 mL	<3.0												23						
Enterococcus (MPN)	MPN/100 mL																			
Fecal coliforms (counts)	CFU/100 mL																			
Fecal coliforms (MPN)	MPN/100 mL	<3.0												23						
Total coliforms (counts)	CFU/100 mL																			
Total coliforms (MPN)	MPN/100 mL	<3.0												430						
Nutrients																				
Ammonia (total, as N)	mg/L	0.139	0.151	0.113	0.184	0.057	0.042	0.023	0.083	<0.020	0.034	0.039	<0.020	0.024	<0.020	0.067	0.041	0.090	0.536	0.049
Nitrate (as N)	mg/L	<0.010	<0.010	<0.010	<0.010	0.433	9.98	8.76	7.07	0.175	8.58	9.63	5.98	0.052	0.496	0.562	0.351	0.370	0.124	1.73
Nitrate + Nitrite (as N) (calculated)	mg/L	<0.014	<0.014	<0.014	<0.014	0.433	9.99	8.77	7.07	0.175	8.58	9.63	5.98	0.052	0.496	0.562	0.351	0.386	0.194	1.73
Nitrite (as N)	mg/L	<0.010	<0.010	<0.010	<0.010	<0.010	0.015	0.011	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.016	0.070	<0.010
Orthophosphate (dissolved, as P)	mg/L	<0.01	<0.01	<0.01	<0.01	0.09	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Phosphorus (dissolved, by ICPMS/ICPOES)	mg/L	<0.02	0.03	0.02	0.02		<0.02				0.06			<0.02	<0.02		<0.02			0.03
Phosphorus (total, by ICPMS/ICPOES)	mg/L							<0.2	0.05			<0.2				0.03		3.2	0.78	
Phosphorus (total, APHA 4500-P)	mg/L			0.036	0.029			0.023	0.038			0.753				0.060		1.07	0.874	
Phosphorus (dissolved, APHA 4500-P)	mg/L			0.029	0.028			0.020	0.035			0.027				0.037		0.046	0.128	
Potassium (dissolved)	mg/L	2.42	2.82	2.61	3.38		5.40				10.6			5.43	4.67		4.01			3.77
Potassium (total)	mg/L							6.4	7.31			14.7				6.80		16.4	7.31	
Total Metals																				
Aluminum (total)	mg/L							<0.05	0.018			0.38				0.163		*19.7*	*18.4*	
Antimony (total)	mg/L							<0.001	0.0001			<0.001				0.0003		0.003	0.0033	
Arsenic (total)	mg/L							<0.005	0.0007			<0.005				<0.0005		*0.036*	0.0044	
Barium (total)	mg/L							0.06	0.069			0.06				0.049		1.15	0.307	
Beryllium (total)	mg/L							<0.001	<0.0001			<0.001				<0.0001		<0.001	0.0006	
Bismuth (total)	mg/L							<0.001	<0.0001			<0.001				<0.0001		<0.001	0.0003	
Boron (total)	mg/L							0.08	0.050			0.17				0.011		0.13	0.008	
Cadmium (total)	mg/L							<0.0001	0.00001			<0.0001				0.00002		0.0010	0.00059	
Calcium (total)	mg/L							87.3	91.6			106				106		141	13.6	
Chromium (total)	mg/L							<0.005	0.0013			<0.005				0.0007		*0.065*	0.0481	
Cobalt (total)	mg/L							<0.0005	0.00009			<0.0005				0.00086		0.0439	0.0128	
Copper (total)	mg/L							0.003	0.0012			0.005				0.0051		0.103	0.0751	
Iron (total)	mg/L							<0.10	0.03			0.45				0.33		141	25.8	
Lead (total)	mg/L							<0.001	<0.0001			<0.001				0.0003		0.023	0.0154	
Lithium (total)	mg/L							0.011	0.0111			0.045				0.0122		0.043	0.0201	
Magnesium (total)	mg/L							35.3	42.6			71.1				40.2		50.1	9.92	
Manganese (total)	mg/L							0.006	0.0056			0.010				0.113		21.8	0.549	
Mercury (total)	mg/L							<0.00002	<0.00002			<0.00002				<0.00002		<0.00002	<0.00002	
Molybdenum (total)	mg/L							0.008	0.0103			0.009				0.0020		0.006	0.0024	
Nickel (total)	mg/L							<0.002	0.0011			0.003				0.0025		0.059	0.0362	
Selenium (total)	mg/L							0.006	0.0073			<0.005				<0.0005		<0.005	<0.0005	
Silicon (total, as Si)	mg/L							11	10.7			20				9.4		63	31.0	
Silver (total)	mg/L							<0.0005	<0.00005			<0.0005				<0.00005		<0.0005	0.00018	
Sodium (total)	mg/L							26.4	38.3			48.0				48.7		61.4	15.0	
Strontium (total)	mg/L							1.03	1.25			1.38				0.901		1.14	0.109	
Sulphur (total)	mg/L							26	20			58				61		20	<1	
Tellurium (total)	mg/L							<0.002	<0.0002			<0.002				<0.0002		<0.002	<0.0002	
Thallium (total)	mg/L							<0.0002	<0.00002			<0.0002				<0.00002		0.0003	0.00020	
Thorium (total)	mg/L							<0.001	<0.0001			<0.001				<0.0001		0.001	0.0014	
Tin (total)	mg/L							<0.002	<0.0002			<0.002				0.0003		0.003	0.0026	
Titanium (total)	mg/L							<0.05	<0.005			<0.05				0.005		0.81	0.819	
Uranium (total)	mg/L							0.0249	0.0262			0.0244				0.00826		0.0109	0.00089	
Vanadium (total)	mg/L							<0.01	0.002			<0.01				0.001		0.08	0.048	
Zinc (total)	mg/L							<0.04	0.013			<0.04				0.239		0.80	0.404	
Zirconium (total)	mg/L							<0.001	0.0001			<0.001				0.0003		0.003	0.0039	

Swan Lake

Water Quality Results

Analyte	Unit	Storm Drainage 11-Aug-16 6080942-04 Normal	Storm Drainage 02-Nov-16 6110254-02	SW Spring 31-Mar-16 6040072-02 Normal	Swan Lake 02-Apr-15 5040345-17 Normal	Swan Lake 16-Jul-15 5071187-03 Normal	Swan Lake 03-Nov-15 5110157-03 Normal	Swan Lake 29-Mar-16 6031988-07 Normal	Swan Lake 15-Aug-16 6081247-01 Normal	Swan Lake 10-Nov-16 6110974-01 Normal	Vernon Creek (Outlet) 03-Apr-15 5040345-11 Normal	Vernon Creek (Outlet) 15-Jul-15 5071046-12 Normal	Vernon Creek (Outlet) 29-Oct-15 5102146-14 Normal	Vernon Creek (Outlet) 28-Mar-16 6031831-15 Normal	Vernon Creek (Outlet) 10-Aug-16 6080942-05 Normal	Vernon Creek (Outlet) 02-Nov-16 6110254-01
Field Results																
Conductivity	µS/cm	671	349	2260	452	421	483	579	479	497	404	440	626	451	513	509
Dissolved oxygen	mg/L		10.84	11.07			10.59	12.75	9.72	10.21			8.22	12.55	9.74	9.0
Dissolved oxygen (percent)	%		98.8	96.2			91.8	114.8		90.2			70.3	102.4	112.9	81.1
Oxidation reduction potential	mV	124	96	135		-63	29	5		202	117		29	9	91	130
pH		7.7	7.8	8.0		8.5	8.2	7.5		7.9	7.95	8.2	6.6	7.9	8.1	8.1
Temperature	°C	16.1	11.16	8.9	9.4	22.6	8.9	10.7	24.15	9.8	8.3	24.8	9.3	6.4	22.3	10.0
Lab Results																
Dissolved Metals																
Aluminum (dissolved)	mg/L			<0.005			0.031	0.040		0.005			0.050	0.041		
Antimony (dissolved)	mg/L			0.0001			0.0002	0.0001		0.0002			0.0006	<0.0001		
Arsenic (dissolved)	mg/L			0.0010			0.0009	0.0007		0.0009			<0.0005	<0.0005		
Barium (dissolved)	mg/L			0.064			0.045	0.042		0.041			0.052	0.035		
Beryllium (dissolved)	mg/L			<0.0001			<0.0001	<0.0001		<0.0001			<0.0001	<0.0001		
Bismuth (dissolved)	mg/L			<0.0001			<0.0001	<0.0001		<0.0001			<0.0001	<0.0001		
Boron (dissolved)	mg/L			0.017			0.018	0.016		0.019			0.016	0.006		
Cadmium (dissolved)	mg/L			0.00015			0.00004	<0.00001		<0.00001			<0.00001	0.00001		
Calcium (dissolved)	mg/L			197			50.9	53.3		40.2			70.0	52.3		
Chromium (dissolved)	mg/L			<0.0005			<0.0005	<0.0005		<0.0005			<0.0005	<0.0005		
Cobalt (dissolved)	mg/L			0.00016			0.00009	0.00008		<0.00005			0.00015	0.00011		
Copper (dissolved)	mg/L			0.0036			0.0006	0.0015		0.0007			0.0009	0.0018		
Iron (dissolved)	mg/L			<0.010			0.049	0.044		<0.010			0.125	0.081		
Lead (dissolved)	mg/L			<0.0001			0.0002	<0.0001		0.0003			<0.0001	0.0002		
Lithium (dissolved)	mg/L			0.0225			0.0059	0.0057		0.0053			0.0045	0.0038		
Magnesium (dissolved)	mg/L			138			20.1	21.7		18.8			13.9	13.6		
Manganese (dissolved)	mg/L			0.0021			0.0057	0.0120		0.0023			0.131	0.0157		
Mercury (dissolved)	mg/L						<0.000005	<0.00002		<0.00002			<0.000005	<0.00002		
Molybdenum (dissolved)	mg/L			0.0210			0.0039	0.0035		0.0039			0.0026	0.0025		
Nickel (dissolved)	mg/L			0.0020			0.0011	0.0008		0.0007			0.0012	0.0009		
Selenium (dissolved)	mg/L			0.0099			0.0007	0.0009		0.0006			0.0009	0.0016		
Silicon (dissolved, as Si)	mg/L			6.9			6.6	6.4		7.4			7.3	7.5		
Silver (dissolved)	mg/L			<0.00005			0.00007	<0.00005		<0.00005			<0.00005	<0.00005		
Sodium (dissolved)	mg/L			115			25.9	27.2		24.1			24.0	17.4		
Strontium (dissolved)	mg/L			6.06			0.570	0.577		0.513			0.469	0.399		
Sulphur (dissolved)	mg/L			250			24	22		20			18	12		
Tellurium (dissolved)	mg/L			<0.0002			<0.0002	<0.0002		<0.0002			<0.0002	<0.0002		
Thallium (dissolved)	mg/L			<0.00002			<0.00002	<0.00002		<0.00002			<0.00002	<0.00002		
Thorium (dissolved)	mg/L			<0.0001			<0.0001	<0.0001		<0.0001			<0.0001	<0.0001		
Tin (dissolved)	mg/L			<0.0002			<0.0002	<0.0002		<0.0002			<0.0002	<0.0002		
Titanium (dissolved)	mg/L			<0.005			<0.005	<0.005		<0.005			<0.005	<0.005		
Uranium (dissolved)	mg/L			0.0370			0.00586	0.00576		0.00588			0.00206	0.00331		
Vanadium (dissolved)	mg/L			0.003			0.002	<0.001		0.002			<0.001	<0.001		
Zinc (dissolved)	mg/L			0.052			0.005	0.005		<0.004			0.007	<0.004		
Zirconium (dissolved)	mg/L			0.0002			<0.0001	<0.0001		<0.0001			0.0001	0.0003		
General																
Alkalinity (bicarbonate, as CaCO3)	mg/L	195	102		139	135	146	158	133	131	123	143	167	141	151	125
Alkalinity (carbonate, as CaCO3)	mg/L	<1	<1		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Alkalinity (hydroxide, as CaCO3)	mg/L	<1	<1		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Alkalinity (phenolphthalein, as CaCO3)	mg/L	<1	<1		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Alkalinity (total, as CaCO3)	mg/L	195	102		139	135	146	158	133	131	123	143	167	141	151	125
Bicarbonate Alkalinity (as HCO3)	mg/L	238	124					193	162	160					184	152
Carbonate Alkalinity (as CO3)	mg/L	<0.6	<0.6					<1	<0.6	<0.6					<0.6	<0.6
Hydroxide Alkalinity (as OH)	mg/L	<0.3	<0.3					<1	<0.3	<0.3					<0.3	<0.3
Bromide	mg/L	0.23	<0.10	0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.13	<0.10	<0.10	<0.10
Chloride	mg/L	54.8	26.2	112	27.5	28.7	15.8	34.9	32.7	30.9	22.6	29.3	49.5	28.2	33.2	27.3
Chlorophyll a	mg/L														0.964	
Conductivity	µS/cm	636	337	2230				540	472	484				416		403
Fluoride	mg/L	0.13	0.14	0.71	0.15	0.27	<0.10	0.32		0.17	0.12	0.29	0.13	0.14	0.14	<0.10
Hardness, total (dissolved as CaCO3)	mg/L	256	139	1060			210	222	176	178			232	186	199	169
pH		7.75	7.66	8.25	8.17			8.19	8.26	8.08	8.06			7.99	8.05	7.74
Sulphate	mg/L	55.3	21.9	898	53.9	55.2	30.4	69.1	65.5	63.5	41.4	54.3	49.6	44.9	61.6	32.5
Sulphide (total, as S)	mg/L					<0.05		<0.05				<0.05		<0.05		
Total suspended solids	mg/L															19
Turbidity	NTU														2.96	
Microbiological																

Swan Lake

Water Quality Results

Analyte	Unit	Storm Drainage 11-Aug-16 6080942-04 Normal	Storm Drainage 02-Nov-16 6110254-02	SW Spring 31-Mar-16 6040072-02 Normal	Swan Lake 02-Apr-15 5040345-17 Normal	Swan Lake 16-Jul-15 5071187-03 Normal	Swan Lake 03-Nov-15 5110157-03 Normal	Swan Lake 29-Mar-16 6031988-07 Normal	Swan Lake 15-Aug-16 6081247-01 Normal	Swan Lake 10-Nov-16 6110974-01 Normal	Vernon Creek (Outlet) 03-Apr-15 5040345-11 Normal	Vernon Creek (Outlet) 15-Jul-15 5071046-12 Normal	Vernon Creek (Outlet) 29-Oct-15 5102146-14 Normal	Vernon Creek (Outlet) 28-Mar-16 6031831-15 Normal	Vernon Creek (Outlet) 10-Aug-16 6080942-05 Normal	Vernon Creek (Outlet) 02-Nov-16 6110254-01
Background Bacteria	CFU/100 mL									>200						
E. coli (counts)	CFU/100 mL									<1						
E. coli (MPN)	MPN/100 mL						<3.0						*430*		*1100*	*460*
Enterococcus (MPN)	MPN/100 mL															*290*
Fecal coliforms (counts)	CFU/100 mL									<1						
Fecal coliforms (MPN)	MPN/100 mL						<3.0						*430*		*1100*	*460*
Total coliforms (counts)	CFU/100 mL									<1						
Total coliforms (MPN)	MPN/100 mL						73						2400			
Nutrients																
Ammonia (total, as N)	mg/L	0.034	0.147	0.050	0.053	0.035	0.043	0.070	0.114	0.053	<0.020	0.054	0.025	0.038	0.045	0.145
Nitrate (as N)	mg/L	1.14	0.529	6.46	0.271	<0.010	0.011	0.428	0.024	<0.010	0.199	0.023	0.025	0.283	0.266	0.428
Nitrate + Nitrite (as N) (calculated)	mg/L	1.14	0.551	6.46	0.271	<0.014	<0.014	0.428	0.024	<0.014	0.199	0.023	0.025	0.283	0.266	0.442
Nitrite (as N)	mg/L	<0.010	0.022	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.014
Orthophosphate (dissolved, as P)	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.06	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Phosphorus (dissolved, by ICPMS/ICPOES)	mg/L			0.05			<0.02	0.03		<0.02			<0.02	<0.02		
Phosphorus (total, by ICPMS/ICPOES)	mg/L	0.07	0.10						0.02	<0.02					0.02	0.08
Phosphorus (total, APHA 4500-P)	mg/L	0.050	0.153						0.018	0.017					0.022	0.108
Phosphorus (dissolved, APHA 4500-P)	mg/L	0.044	0.034						0.013	0.015					0.021	0.085
Potassium (dissolved)	mg/L			10.3			5.09	4.64		4.42			4.44	3.28		
Potassium (total)	mg/L	4.61	3.62						3.97	4.42					4.27	4.05
Total Metals																
Aluminum (total)	mg/L	0.110	3.00						0.010	0.016					0.045	1.97
Antimony (total)	mg/L	0.0143	0.0015						0.0002	0.0002					0.0002	0.0010
Arsenic (total)	mg/L	0.0006	0.0013						0.0009	0.0009					0.0008	0.0009
Barium (total)	mg/L	0.070	0.072						0.041	0.047					0.037	0.063
Beryllium (total)	mg/L	<0.0001	0.0001						<0.0001	<0.0001					<0.0001	<0.0001
Bismuth (total)	mg/L	<0.0001	<0.0001						<0.0001	<0.0001					<0.0001	<0.0001
Boron (total)	mg/L	0.038	0.010						0.013	0.014					0.028	0.006
Cadmium (total)	mg/L	0.00007	0.00013						<0.00001	<0.00001					0.00001	0.00007
Calcium (total)	mg/L	77.0	41.6						41.8	44.2					49.1	50.4
Chromium (total)	mg/L	0.0008	0.0081						<0.0005	<0.0005					<0.0005	0.0052
Cobalt (total)	mg/L	0.00021	0.00201						<0.00005	<0.00005					0.00011	0.00122
Copper (total)	mg/L	0.0024	0.0161						0.0010	0.0007					0.0009	0.0090
Iron (total)	mg/L	0.25	4.08						<0.01	0.01					0.28	2.75
Lead (total)	mg/L	0.0004	0.0034						<0.0001	<0.0001					0.0002	0.0020
Lithium (total)	mg/L	0.0049	0.0060						0.0054	0.0064					0.0061	0.0056
Magnesium (total)	mg/L	15.4	8.63						17.2	19.1					18.5	10.4
Manganese (total)	mg/L	0.116	0.138						0.0180	0.0236					0.0602	0.102
Mercury (total)	mg/L	<0.00002	<0.00002						<0.00002	<0.00002					<0.00002	<0.00002
Molybdenum (total)	mg/L	0.0045	0.0025						0.0040	0.0041					0.0040	0.0022
Nickel (total)	mg/L	0.0016	0.0064						0.0006	0.0008					0.0009	0.0044
Selenium (total)	mg/L	0.0057	0.0021						0.0007	0.0008					0.0015	0.0016
Silicon (total, as Si)	mg/L	10.5	9.7						6.4	7.7					6.2	8.5
Silver (total)	mg/L	<0.00005	<0.00005						<0.00005	<0.00005					<0.00005	<0.00005
Sodium (total)	mg/L	30.6	14.6						22.5	24.4					23.6	16.1
Strontium (total)	mg/L	0.565	0.268						0.487	0.534					0.523	0.339
Sulphur (total)	mg/L	17	7						19	22					19	11
Tellurium (total)	mg/L	<0.0002	<0.0002						<0.0002	<0.0002					<0.0002	<0.0002
Thallium (total)	mg/L	<0.00002	<0.00002						<0.00002	<0.00002					<0.00002	<0.00002
Thorium (total)	mg/L	<0.0001	0.0003						<0.0001	<0.0001					<0.0001	0.0002
Tin (total)	mg/L	0.0002	0.0008						<0.0002	<0.0002					<0.0002	0.0005
Titanium (total)	mg/L	0.007	0.134						<0.005	<0.005					<0.005	0.100
Uranium (total)	mg/L	0.00510	0.00218						0.00622	0.00685					0.00593	0.00183
Vanadium (total)	mg/L	0.001	0.009						0.002	0.002					0.002	0.006
Zinc (total)	mg/L	0.022	0.094						<0.004	<0.004					<0.004	0.046
Zirconium (total)	mg/L	<0.0001	0.0016						<0.0001	<0.0001					<0.0001	0.0021

Guideline Notes for Reports for RDNO Swan Lake Water Quality Assessment Water Quality Results

1. Notes for Guidelines for Canadian Drinking Water Quality - Maximum Acceptable Concentrations (GCDWQ MAC)

Note 1.1 for Arsenic (dissolved):

Every effort should be made to maintain arsenic levels in drinking water as low as reasonably achievable.

Note 1.2 for Turbidity:

Waterworks systems that use a surface water source or a groundwater source under the direct influence of surface water should filter the source water to meet health-based turbidity limits, as defined for specific treatment technologies. Where possible, filtration systems should be designed and operated to reduce turbidity levels as low as possible, with a treated water turbidity target of less than 0.1 NTU at all times. Where this is not achievable, the treated water turbidity levels from individual filters should meet the requirements described in GCDWQ.

For systems that use groundwater that is not under the direct influence of surface water, which are considered less vulnerable to faecal contamination, turbidity should generally be below 1.0 NTU.

For effective operation of the distribution system, it is good practice to ensure that water entering the distribution system has turbidity levels below 1.0 NTU.

Note 1.3 for E. coli (counts):

MAC is none detectable per 100 mL

Note 1.4 for E. coli (MPN):

MAC is none detectable per 100 mL

Note 1.5 for Fecal coliforms (counts):

The GCDWQ does not have a guideline for fecal coliforms. The GCDWQ were revised in 2006 when the guideline for fecal coliforms was deleted, and a guideline for E. coli was added. However the GCDWQ has a guideline for total coliforms that includes the following statement: “The MAC of total coliforms in water leaving a treatment plant in a public system and throughout semi-public and private supply systems is none detectable per 100 mL.” Therefore a guideline of none detectable per 100 mL was used for fecal coliforms for this report.

Note that the Drinking Water Protection Regulation (2003), under the BC Drinking Water Protection Act, has a water quality standard for potable water for fecal coliforms of “No detectable fecal coliform bacteria per 100 ml”.

Note 1.6 for Fecal coliforms (MPN):

The GCDWQ does not have a guideline for fecal coliforms. The GCDWQ were revised in 2006 when the guideline for fecal coliforms was deleted, and a guideline for E. coli was added. However the GCDWQ has a guideline for total coliforms that includes the following statement: “The MAC of total coliforms in water leaving a treatment plant in a public system and throughout semi-public and private supply systems is none detectable per 100 mL.” Therefore a guideline of none detectable per 100 mL was used for fecal coliforms for this report.

Note that the Drinking Water Protection Regulation (2003), under the BC Drinking Water Protection Act, has a water quality standard for potable water for fecal coliforms of “No detectable fecal coliform bacteria per 100 ml”.

Note 1.7 for Total coliforms (counts):

The maximum acceptable concentration (MAC) of total coliforms in water leaving a treatment plant and in non-disinfected groundwater leaving the well is none detectable per 100 mL.

Total coliforms should be monitored in the distribution system because they are used to indicate changes in water quality. Detection of total coliforms from consecutive samples from the same site or from more than 10% of the samples collected in a given sampling period should be investigated.

Note 1.8 for Total coliforms (MPN):

The maximum acceptable concentration (MAC) of total coliforms in water leaving a treatment plant and in non-disinfected groundwater leaving the well is none detectable per 100 mL.

Total coliforms should be monitored in the distribution system because they are used to indicate changes in water quality. Detection of total coliforms from consecutive samples from the same site or from more than 10% of the samples collected in a given sampling period should be investigated.

Note 1.9 for Nitrate + Nitrite (as N) (calculated):

The MAC for Nitrate (as N) is 10 mg/L

Note 1.10 for Arsenic (total):

Every effort should be made to maintain arsenic levels in drinking water as low as reasonably achievable.

2. Notes for Guidelines for Canadian Drinking Water Quality - Aesthetic Objectives (GCDWQ AO]

Note 2.1 for pH:

The operational guideline for pH is a range of 7.0 to 10.5 in finished drinking water.

Note 2.2 for Aluminum (dissolved):

This is an operational guidance value, designed to apply only to drinking water treatment plants using aluminum-based coagulants. The operational guidance value of 0.1 mg/L applies to conventional treatment plants, and 0.2 mg/L applies to other types of treatment systems.

Note 2.3 for pH:

The operational guideline for pH is a range of 7.0 to 10.5 in finished drinking water.

Note 2.4 for Sulphate:
There may be a laxative effect in some individuals when sulphate levels exceed 500 mg/L. Health authorities should be notified of drinking water sources containing above 500 mg/L.
Note 2.5 for Sulphide (total, as S):
The aesthetic objective for sulphide (as H2S) is 0.05 mg/L. This is equivalent to 0.047 mg/L sulphide (as S).
Note 2.6 for Aluminum (total):
This is an operational guidance value, designed to apply only to drinking water treatment plants using aluminum-based coagulants. The operational guidance value of 0.1 mg/L applies to conventional treatment plants, and 0.2 mg/L applies to other types of treatment systems.
3. Notes for BC Approved Water Quality Guidelines for livestock (BCAWQG L]
General Notes:
The Water Quality Guidelines (Criteria) Reports by BC Ministry of Environment were used as references for the guidelines. (Internet address: http://www.env.gov.bc.ca/wat/wq/wq_guidelines.html). Overview Reports (BC MOE) were used as the references for the guidelines unless the note for specific analyte indicates that the Technical Appendix (BC MOE) was used.
Note 3.1 for pH:
pH does not interfere with the palatability of water or the health of livestock.
Note 3.2 for Temperature:
The recommended guideline for temperature is + or - 1 degree Celsius change from natural ambient background.
Note 3.3 for Aluminum (dissolved):
The guideline maximum for total aluminum is 5 mg/L. A separate guideline for dissolved aluminum is not provided.
Note 3.4 for Arsenic (dissolved):
The interim guideline for total arsenic is 25 µg/L.
Note 3.5 for Boron (dissolved):
The guideline maximum for total boron is 5 mg/L.
Note 3.6 for Copper (dissolved):
The guideline maximum for total copper is 300 µg/L.
Note 3.7 for Lead (dissolved):
The guideline maximum for total lead is 100 µg/L.
Note 3.8 for Mercury (dissolved):
The guideline maximum for total mercury is 3.0 µg/L.
Note 3.9 for Molybdenum (dissolved):
If livestock are consuming forages not irrigated, or if no molybdenum containing fertilizers are applied to grow feed consumed by livestock, then the guideline maximum for total molybdenum is 0.08 mg/L. For all other cases, the guideline maximum for total molybdenum is 0.05 mg/L. / The most stringent guideline maximum was used in this report.
Note 3.10 for Selenium (dissolved):
The guideline for total selenium is 30.0 µg/L mean. The mean concentrations in the water column are based on at least 5 weekly samples taken over a 30-day period.
Note 3.11 for Zinc (dissolved):
The guideline maximum for total zinc is 2000 µg/L.
Note 3.12 for Chloride:
The water quality guideline for chloride for livestock watering is 600 mg/L.
Note 3.13 for Fluoride:
The total fluoride recommendation for dairy cows, breeding stock and other long-lived animals is 1.0 mg/L as a 30-day mean and 1.5 mg/L as a maximum. Total fluoride should not exceed 2.0 mg/L as a 30-day mean or 4.0 mg/L maximum in the drinking water of all other types of livestock, unless fluoride is provided in the diet by bone meal or mineral additives, in which case 1.0 mg/L as a 30-day mean and 2.0 mg/L maximum is recommended. / The most stringent guideline maximum was used in this report.
Note 3.14 for pH:
pH does not interfere with the palatability of water or the health of livestock.
Note 3.15 for Total suspended solids:
Induced suspended sediments should not exceed 10 mg/L when background suspended sediments is less than or equal to 100 mg/L, nor should induced suspended sediments be more than 10 % of background when background is greater than 100 mg/L.
Note 3.16 for Turbidity:
Induced turbidity should not exceed 5 NTU when background turbidity is less than or equal to 50 NTU, nor should induced turbidity be more than 10 % of background when background is greater than 50 NTU.
Note 3.17 for E. coli (counts):

The guideline for E. coli varies based on site specific factors including type of livestock, whether livestock are closely confined, and type of water treatment.
The guideline for free range animals is “none applicable”.
The guideline maximum for general livestock use is 200/100 mL.
The guideline maximum for closely confined, no treatment, is 0/100 mL.
The guideline maximum for closely confined, disinfection only, is less than or equal to 10/100 mL 90th percentile.
The guideline maximum for closely confined, partial treatment, is less than or equal to 100/100 mL 90th percentile.
The guideline for closely confined, complete treatment is “none applicable”. / The guideline for general livestock use was used in this report.

Note 3.18 for E. coli (MPN):
The guideline for E. coli varies based on site specific factors including type of livestock, whether livestock are closely confined, and type of water treatment.
The guideline for free range animals is “none applicable”.
The guideline maximum for general livestock use is 200/100 mL.
The guideline maximum for closely confined, no treatment, is 0/100 mL.
The guideline maximum for closely confined, disinfection only, is less than or equal to 10/100 mL 90th percentile.
The guideline maximum for closely confined, partial treatment, is less than or equal to 100/100 mL 90th percentile.
The guideline for closely confined, complete treatment is “none applicable”. / The guideline for general livestock use was used in this report.

Note 3.19 for Enterococcus (MPN):
The guideline for Enterococcus varies based on site specific factors including type of livestock, whether livestock are closely confined, and type of water treatment.
The guideline for free range animals is “none applicable”.
The guideline maximum for general livestock use is 50/100 mL.
The guideline maximum for closely confined, no treatment, is 0/100 mL.
The guideline maximum for closely confined, disinfection only, is less than or equal to 3/100 mL 90th percentile.
The guideline maximum for closely confined, partial treatment, is less than or equal to 25/100 mL 90th percentile.
The guideline for closely confined, complete treatment is “none applicable”. / The guideline for general livestock use was used in this report.

Note 3.20 for Fecal coliforms (counts):
The guideline for Fecal coliforms varies based on site specific factors including type of livestock, whether livestock are closely confined, and type of water treatment.
The guideline for free range animals is “none applicable”.
The guideline maximum for general livestock use is 200/100 mL.
The guideline maximum for closely confined, no treatment, is 0/100 mL.
The guideline maximum for closely confined, disinfection only, is less than or equal to 10/100 mL 90th percentile.
The guideline maximum for closely confined, partial treatment, is less than or equal to 100/100 mL 90th percentile.
The guideline for closely confined, complete treatment is “none applicable”. / The guideline for general livestock use was used in this report.

Note 3.21 for Fecal coliforms (MPN):
The guideline for Fecal coliforms varies based on site specific factors including type of livestock, whether livestock are closely confined, and type of water treatment.
The guideline for free range animals is “none applicable”.
The guideline maximum for general livestock use is 200/100 mL.
The guideline maximum for closely confined, no treatment, is 0/100 mL.
The guideline maximum for closely confined, disinfection only, is less than or equal to 10/100 mL 90th percentile.
The guideline maximum for closely confined, partial treatment, is less than or equal to 100/100 mL 90th percentile.
The guideline for closely confined, complete treatment is “none applicable”. / The guideline for general livestock use was used in this report.

Note 3.22 for Nitrate (as N):
Overview Report Update, September 2009.

Note 3.23 for Nitrate + Nitrite (as N) (calculated):
The guideline maximum for nitrate as nitrogen is 100 mg/l. Where nitrate and nitrite are present, the total nitrate+nitrite nitrogen should not exceed this value. Overview Report Update, September 2009.

Note 3.24 for Nitrite (as N):
Overview Report Update, September 2009.

Note 3.25 for Aluminum (total):
The guideline maximum for total aluminum is 5 mg/L. A separate guideline for dissolved aluminum is not provided.

Note 3.26 for Arsenic (total):
The interim guideline for total arsenic is 25 µg/L.

Note 3.27 for Molybdenum (total):

If livestock are consuming forages not irrigated, or if no molybdenum containing fertilizers are applied to grow feed consumed by livestock, then the guideline maximum for total molybdenum is 0.08 mg/L. For all other cases, the guideline maximum for total molybdenum is 0.05 mg/L. / The most stringent guideline maximum was used in this report.

Note 3.28 for Selenium (total):

The guideline for total selenium is 30.0 µg/L mean. The mean concentrations in the water column are based on at least 5 weekly samples taken over a 30-day period.

4. Notes for Working Water Quality Guidelines for British Columbia for livestock (BCWWQG L)

General Notes:

Reference: Working Water Quality Guidelines for British Columbia (2015). WWQG values are long-term (i.e. average) concentrations unless identified as a short-term maximum in the “Notes” for a specific analyte. Long-term WWQGs represent average substance concentrations calculated from 5 samples in 30 days. WWQG are given for total substance concentrations unless otherwise noted.

Note 4.1 for Cadmium (dissolved):

This is a Short-term maximum guideline.

Note 4.2 for Chromium (dissolved):

The guideline for Cr(VI) is 50 µg/L (total). The guideline for Cr(III) is 50 µg/L (total). The guideline of 50 µg/L for Cr(VI), and for Cr(III) was used, in this report, to identify exceedances for dissolved chromium, and total chromium as a means for determining the potential for exceeding the Cr(VI) and/or Cr(III) guidelines.

Note 4.3 for Sulphate:

The guideline is for dissolved sulphate.

Note 4.4 for Cadmium (total):

This is a Short-term maximum guideline.

Note 4.5 for Chromium (total):

The guideline for Cr(VI) is 50 µg/L (total). The guideline for Cr(III) is 50 µg/L (total). The guideline of 50 µg/L for Cr(VI), and for Cr(III) was used, in this report, to identify exceedances for dissolved chromium, and total chromium as a means for determining the potential for exceeding the Cr(VI) and/or Cr(III) guidelines.

5. Notes for BC Approved Water Quality Guidelines for irrigation (BCAWQG I)

General Notes:

The Water Quality Guidelines (Criteria) Reports by BC Ministry of Environment were used as references for the guidelines. (Internet address: http://www.env.gov.bc.ca/wat/wq/wq_guidelines.html). Overview Reports (BC MOE) were used as the references for the guidelines unless the note for specific analyte indicates that the Technical Appendix (BC MOE) was used.

Note 5.1 for pH:

The recommended criterion for irrigation waters is a pH ranging between 5.0 and 9.0. This guideline recognizes that soil acidity, alkalinity and salinity are a concern in agriculture.

Note 5.2 for Temperature:

The recommended guideline for temperature is + or - 1 degree Celsius change from natural ambient background.

Note 5.3 for Aluminum (dissolved):

The guideline maximum for total aluminum is 5 mg/L. A separate guideline for dissolved aluminum is not provided.

Note 5.4 for Arsenic (dissolved):

The interim guideline for total arsenic is 100 µg/L.

Note 5.5 for Boron (dissolved):

The guideline for total boron depends on the crop, and varies from 0.5 mg/L to 6 mg/L. The most stringent guideline maximum of 0.5 mg/L, for very sensitive and sensitive crops, was used to identify exceedances for this report.

Note 5.6 for Copper (dissolved):

The guideline maximum for total copper is 200 µg/L.

Note 5.7 for Lead (dissolved):

For neutral and alkaline fine-textured soils the total lead concentration in irrigation water should not exceed 400 µg/L at any time. The concentration of total lead in irrigation water for use on all other soils should not exceed 200 µg/L at any time. / The most stringent guideline maximum was used in this report.

Note 5.8 for Mercury (dissolved):

The guideline maximum for total mercury is 2.0 µg/L.

Note 5.9 for Molybdenum (dissolved):

The guideline maximum for total molybdenum for irrigation of forage crops is 0.05 mg/L. There is no guideline maximum for total molybdenum for irrigation of non-forage crops.

Note 5.10 for Selenium (dissolved):

The guideline for total selenium is 10 µg/L mean. The mean concentrations in the water column are based on at least 5 weekly samples taken over a 30-day period.

Note 5.11 for Zinc (dissolved):

The guideline maximum for total zinc for irrigation is as follows:

- Soil pH less than 6: 1000 µg/L.
- Soil pH equal to or greater than 6, and less than 7: 2000 µg/L.
- Soil pH greater than or equal to 7: 5000 µg/L. / The most stringent guideline maximum was used in this report.

Note 5.12 for Fluoride:
Total fluoride in irrigation water should not exceed 1.0 mg/L as a 30-day average or a maximum of 2.0 mg/L.
Note 5.13 for pH:
The recommended criterion for irrigation waters is a pH ranging between 5.0 and 9.0. This guideline recognizes that soil acidity, alkalinity and salinity are a concern in agriculture.
Note 5.14 for Total suspended solids:
Induced suspended sediments should not exceed 20 mg/L when background suspended sediments is less than or equal to 100 mg/L, nor should induced suspended sediments be more than 20 % of background when background is greater than 100 mg/L.
Note 5.15 for Turbidity:
Induced turbidity should not exceed 10 NTU when background turbidity is less than or equal to 50 NTU, nor should induced turbidity be more than 20 % of background when background is greater than 50 NTU.
Note 5.16 for E. coli (counts):
The guideline for irrigation for E. coli varies as a function of crop, public access, and livestock access.
The guideline maximum for crops eaten raw is less than or equal to 77/100 mL geometric mean.
The guideline maximum for public access and livestock access is less than or equal to 385/100 mL geometric mean.
The guideline maximum for general irrigation is less than or equal to 1000/100 mL geometric mean. / The guideline for public access and livestock access was used in this report.
Note 5.17 for E. coli (MPN):
The guideline for irrigation for E. coli varies as a function of crop, public access, and livestock access.
The guideline maximum for crops eaten raw is less than or equal to 77/100 mL geometric mean.
The guideline maximum for public access and livestock access is less than or equal to 385/100 mL geometric mean.
The guideline maximum for general irrigation is less than or equal to 1000/100 mL geometric mean. / The guideline for public access and livestock access was used in this report.
Note 5.18 for Enterococcus (MPN):
The guideline for irrigation for Enterococcus varies as a function of crop, public access, and livestock access.
The guideline maximum for crops eaten raw is less than or equal to 20/100 mL geometric mean.
The guideline maximum for public access and livestock access is less than or equal to 100/100 mL geometric mean.
The guideline maximum for general irrigation is less than or equal to 250/100 mL geometric mean. / The guideline for public access and livestock access was used in this report.
Note 5.19 for Fecal coliforms (counts):
The guideline for irrigation for Fecal coliforms depends on the crop, public access, and livestock access.
The guideline maximum for crops eaten raw is less than or equal to 200/100 mL geometric mean.
The guideline for public access and livestock access is “none applicable”.
The guideline maximum for general irrigation is less than or equal to 1000/100 mL geometric mean. / The guideline for general irrigation was used in this report.
Note 5.20 for Fecal coliforms (MPN):
The guideline for irrigation for Fecal coliforms depends on the crop, public access, and livestock access.
The guideline maximum for crops eaten raw is less than or equal to 200/100 mL geometric mean.
The guideline for public access and livestock access is “none applicable”.
The guideline maximum for general irrigation is less than or equal to 1000/100 mL geometric mean. / The guideline for general irrigation was used in this report.
Note 5.21 for Aluminum (total):
The guideline maximum for total aluminum is 5 mg/L. A separate guideline for dissolved aluminum is not provided.
Note 5.22 for Arsenic (total):
The interim guideline for total arsenic is 100 µg/L.
Note 5.23 for Boron (total):
The guideline for total boron depends on the crop, and varies from 0.5 mg/L to 6 mg/L. The most stringent guideline maximum of 0.5 mg/L, for very sensitive and sensitive crops, was used to identify exceedances for this report.
Note 5.24 for Copper (total):
The guideline maximum for total copper is 200 µg/L.
Note 5.25 for Lead (total):
For neutral and alkaline fine-textured soils the total lead concentration in irrigation water should not exceed 400 µg/L at any time. The concentration of total lead in irrigation water for use on all other soils should not exceed 200 µg/L at any time. / The most stringent guideline maximum was used in this report.
Note 5.26 for Molybdenum (total):
The guideline maximum for total molybdenum for irrigation of forage crops is 0.05 mg/L. There is no guideline maximum for total molybdenum for irrigation of non-forage crops.
Note 5.27 for Selenium (total):
The guideline for total selenium is 10 µg/L mean. The mean concentrations in the water column are based on at least 5 weekly samples taken over a 30-day period.
Note 5.28 for Zinc (total):

The guideline maximum for total zinc for irrigation is as follows:
- Soil pH less than 6: 1000 µg/L.
- Soil pH equal to or greater than 6, and less than 7: 2000 µg/L.
- Soil pH greater than or equal to 7: 5000 µg/L. / The most stringent guideline maximum was used in this report.

6. Notes for Working Water Quality Guidelines for British Columbia for irrigation (BCWWQG I)

General Notes:

Reference: Working Water Quality Guidelines for British Columbia (2015). WWQG values are long-term (i.e. average) concentrations unless identified as a short-term maximum in the "Notes" for a specific analyte. Long-term WWQGs represent average substance concentrations calculated from 5 samples in 30 days. WWQG are given for total substance concentrations unless otherwise noted.

Note 6.1 for Conductivity:

The guideline varies from 700 to 5000 µS/cm depending on the type of crop. The most stringent guideline has been used for this report.

Note 6.2 for Cadmium (dissolved):

This is a Short-term maximum guideline.

Note 6.3 for Chromium (dissolved):

The guideline for Cr(VI) is 8 µg/L (total).
The guideline for Cr(III) is 4.9 µg/L (total).
The guideline of 4.9 µg/L for Cr(III) was used, in this report, to identify exceedances for dissolved chromium, and total chromium as a means for determining the potential for exceeding the Cr(VI) and/or Cr(III) guidelines.

Note 6.4 for Cobalt (dissolved):

Continuous or intermittent use on all soils.

Note 6.5 for Lithium (dissolved):

The guideline is 2.5 mg/L for non-citrus crops (May not be protective of barley and other cereal crops; 1.0 mg/L suggested for cereal crops). The guideline is 0.75 mg/L for citrus crops. / The most stringent guideline was used in this report.

Note 6.6 for Conductivity:

The guideline varies from 700 to 5000 µS/cm depending on the type of crop. The most stringent guideline has been used for this report.

Note 6.7 for Cadmium (total):

This is a Short-term maximum guideline.

Note 6.8 for Chromium (total):

The guideline for Cr(VI) is 8 µg/L (total).
The guideline for Cr(III) is 4.9 µg/L (total).
The guideline of 4.9 µg/L for Cr(III) was used, in this report, to identify exceedances for dissolved chromium, and total chromium as a means for determining the potential for exceeding the Cr(VI) and/or Cr(III) guidelines.

Note 6.9 for Cobalt (total):

Continuous or intermittent use on all soils.

Note 6.10 for Lithium (total):

The guideline is 2.5 mg/L for non-citrus crops (May not be protective of barley and other cereal crops; 1.0 mg/L suggested for cereal crops). The guideline is 0.75 mg/L for citrus crops. / The most stringent guideline was used in this report.

7. Notes for BC Approved Water Quality Guidelines for drinking water (BCAWQG DW)

General Notes:

References: Table 1. British Columbia Ministry of Environment water quality guidelines for drinking water sources. January 2017; and Table 2. British Columbia Ministry of Environment drinking water quality guidelines for turbidity. January 2017. Overview Reports (BC MOE) and Technical Appendix (BC MOE) were also used as references for some parameters.

Note 7.1 for pH:

Designed to minimize solubilization of heavy metals and salts from water distribution pipes and the precipitation of carbonate salts in the distribution system, and maximize the effectiveness of chlorination. However, natural source water outside the guidelines may be safe to drink from a public health perspective.

Note 7.2 for pH:

Designed to minimize solubilization of heavy metals and salts from water distribution pipes and the precipitation of carbonate salts in the distribution system, and maximize the effectiveness of chlorination. However, natural source water outside the guidelines may be safe to drink from a public health perspective.

Note 7.3 for Turbidity:

For source water with exceptional clarity (natural background levels ≤ 5 NTU), the induced turbidity should not exceed 1 NTU at any time.
If natural background turbidity is > 5 and < 50 NTU then the induced turbidity should not exceed 5 NTU at any time.
If natural background turbidity is > 50 NTU then induced turbidity should not exceed 10 % of background.

Note 7.4 for E. coli (counts):

The guideline for raw drinking water depends on the type of water treatment.
The guideline maximum for raw drinking water with no treatment is 0/100 mL.
The guideline maximum for raw drinking water with disinfection only is less than or equal to 10/100 mL 90th percentile.
The guideline maximum for raw drinking water with partial treatment is less than or equal to 100/100 mL 90th percentile.
The guideline maximum for raw drinking water with complete treatment is “none applicable”. / The most stringent guideline (no water treatment) was used in this report.

Note 7.5 for E. coli (MPN):
The guideline for raw drinking water depends on the type of water treatment.
The guideline maximum for raw drinking water with no treatment is 0/100 mL.
The guideline maximum for raw drinking water with disinfection only is less than or equal to 10/100 mL 90th percentile.
The guideline maximum for raw drinking water with partial treatment is less than or equal to 100/100 mL 90th percentile.
The guideline maximum for raw drinking water with complete treatment is “none applicable”. / The most stringent guideline (no water treatment) was used in this report.

Note 7.6 for Enterococcus (MPN):
The guideline for raw drinking water depends on the type of water treatment.
The guideline maximum for raw drinking water with no treatment is 0/100 mL.
The guideline maximum for raw drinking water with disinfection only is less than or equal to 3/100 mL 90th percentile.
The guideline maximum for raw drinking water with partial treatment is less than or equal to 25/100 mL 90th percentile.
The guideline for raw drinking water with complete treatment is “none applicable”. / The most stringent guideline (no water treatment) was used in this report.

Note 7.7 for Fecal coliforms (counts):
The guideline for raw drinking water depends on the type of water treatment.
The guideline maximum for raw drinking water with no treatment is 0/100 mL.
The guideline maximum for raw drinking water with disinfection only is less than or equal to 10/100 mL 90th percentile.
The guideline maximum for raw drinking water with partial treatment is less than or equal to 100/100 mL 90th percentile.
The guideline for raw drinking water with complete treatment is “none applicable”. / The most stringent guideline (no water treatment) was used in this report.

Note 7.8 for Fecal coliforms (MPN):
The guideline for raw drinking water depends on the type of water treatment.
The guideline maximum for raw drinking water with no treatment is 0/100 mL.
The guideline maximum for raw drinking water with disinfection only is less than or equal to 10/100 mL 90th percentile.
The guideline maximum for raw drinking water with partial treatment is less than or equal to 100/100 mL 90th percentile.
The guideline for raw drinking water with complete treatment is “none applicable”. / The most stringent guideline (no water treatment) was used in this report.

Note 7.9 for Phosphorus (dissolved, by ICPMS/ICPOES):
For lakes used as a source of drinking water, the total phosphorous concentration should not exceed 10 µg/L. No guideline is recommended for streams. / The guideline for lakes was used for this report.

Note 7.10 for Phosphorus (total, by ICPMS/ICPOES):
For lakes used as a source of drinking water, the total phosphorous concentration should not exceed 10 µg/L. No guideline is recommended for streams. / The guideline for lakes was used for this report.

Note 7.11 for Phosphorus (total, APHA 4500-P):
For lakes used as a source of drinking water, the total phosphorous concentration should not exceed 10 µg/L. No guideline is recommended for streams. / The guideline for lakes was used for this report.

Note 7.12 for Phosphorus (dissolved, APHA 4500-P):
For lakes used as a source of drinking water, the total phosphorous concentration should not exceed 10 µg/L. No guideline is recommended for streams. / The guideline for lakes was used for this report.

Appendix A

Water Quality Database

Surface water results compared to the following guidelines:

- Canadian water quality guidelines for the protection of freshwater aquatic life. (CCME AL);
- BC Approved Water Quality Guidelines for freshwater aquatic life (BCAWQG AL);
- BC Approved Water Quality Guidelines for freshwater aquatic life (30-day average) (BCAWQG ALA); and
- Working Water Quality Guidelines for British Columbia for freshwater aquatic life (BCWWQG AL).

Legend for Reports for RDNO Swan Lake Water Quality Assessment Water Quality Results

<	Less than reported detection limit
>	Greater than reported upper detection limit
A	Absent
BCAWQG AL	BC Approved Water Quality Guidelines for freshwater aquatic life
BCAWQG ALA	BC Approved Water Quality Guidelines for freshwater aquatic life (30-day average)
BCWWQG AL	Working Water Quality Guidelines for British Columbia for freshwater aquatic life
Calc	Calculated guideline or standard. The guideline or standard is dependent on the value of one or more other analytes, and is calculated from a formula or table.
CCME AL	CCME. Canadian water quality guidelines for the protection of freshwater aquatic life.
L	Laboratory reading type (Lab result)
m asl	metres above sea level
N	Narrative type of guideline or standard, or Result Note.
ND	Non-detect. Result is less than lower detection limit.
NG	No Guideline
NR	No Result
NS	No Standard
NT	Not Tested
OG	Overgrown
P	Present
PR	Presumptive
TK	Test kit reading type (Field result)
TNTC	Too numerous to count
	Highlighted value has a lower detection limit that is greater than the guideline/standard maximum and/or the guideline/standard minimum, or has an upper detection limit that is less than the guideline/standard maximum and/or the guideline/standard minimum.
BCAWQG AL	Highlighted value exceeds BCAWQG AL
BCAWQG ALA	Highlighted value exceeds BCAWQG ALA
BCWWQG AL	Highlighted value exceeds BCWWQG AL
CCME AL	Highlighted value exceeds CCME AL
SL Criteria Override	Highlighted value exceeds sampling location criteria override

Swan Lake

Water Quality Results

Analyte	Unit	Guideline				Sampling Location	BX Creek	BX Creek	BX Creek	FS-43 (SW)	FS-43 (SW)	FS-43 (SW)	FS-43 (SW)	NW Spring	SE Spring	SE Spring	SE Spring	Site 3 (NE-Cowboys)
						Date Sampled	28-Mar-16	10-Aug-16	02-Nov-16	15-Jul-15	29-Oct-15	28-Mar-16	02-Nov-16	31-Mar-16	31-Mar-16	10-Aug-16	03-Nov-16	03-Apr-15
						Lab Sample ID	6031831-02	6080868-13	6110254-03	5071046-06	5102146-03	6031831-09	6110254-06	6040072-03	6040072-04	6080868-11	6110391-03	5040345-06
						Sample Type	Normal	Normal		Normal	Normal	Normal		Normal	Normal	Normal		Normal
		BCAWQG AL	BCAWQG ALA	BCWWQG AL	CCME AL													
Field Results																		
Conductivity	µS/cm	NG	NG	NG	NG		396	504	468	513	1262	306	1384		885	795		1079
Dissolved oxygen	mg/L	min 5 [1.1]	min 8 [2.1]	NG	min 5.500 [4.1]		12.3		10.76		10.09	11.64	9.68		11.04			
Dissolved oxygen (percent)	%	NG	NG	NG	NG		95.1		90.3		86.1	95.4	86		102.4			
Oxidation reduction potential	mV	NG	NG	NG	NG		216	116	20		45	4	150		117	159		168
pH		N [1.2]	N [2.2]	NG	6.5 - 9		8.4	8.3		7.6	8.8	8.2	7.9		8.0	8		8.23
Temperature	°C	19 [1.3]	19 [2.3]	NG	N [4.2]		4.0	15.8	7.8	17.1	8.2	6.7	8.3		11.1	14.8		7.9
Lab Results																		
Dissolved Metals																		
Aluminum (dissolved)	mg/L	Calc [1.4]	Calc [2.4]	NG	Calc [4.3]		0.118				0.026	0.419			0.006			
Antimony (dissolved)	mg/L	NG	NG	0.009 [3.1]	NG		0.0001				0.0005	0.0001			0.0002			
Arsenic (dissolved)	mg/L	0.005 [1.5]	0.005 [2.5]	NG	0.0050 [4.4]		<0.0005				0.0012	<0.0005			0.0006			
Barium (dissolved)	mg/L	NG	NG	1	NG		0.033				0.055	0.025			0.058			
Beryllium (dissolved)	mg/L	NG	NG	0.00013	NG		<0.0001				<0.0001	<0.0001			<0.0001			
Bismuth (dissolved)	mg/L	NG	NG	NG	NG		<0.0001				<0.0001	<0.0001			<0.0001			
Boron (dissolved)	mg/L	1.2 [1.6]	1.2 [2.6]	NG	1.5 [4.5]		0.006				0.025	<0.004			0.037			
Cadmium (dissolved)	mg/L	Calc [1.7]	Calc [2.7]	NG	Calc [4.6]		0.00002				0.00003	<0.00001			0.00002			
Calcium (dissolved)	mg/L	NG	NG	N [3.2]	NG		47.6				101	30.0			84.5			
Chromium (dissolved)	mg/L	NG	NG	0.001 [3.3]	0.0010 [4.7]		<0.0005				0.0007	0.0007			0.0009			
Cobalt (dissolved)	mg/L	0.110 [1.8]	0.004 [2.8]	NG	NG		0.00009				0.00014	0.00023			0.00008			
Copper (dissolved)	mg/L	Calc [1.9]	Calc [2.9]	NG	Calc [4.8]		0.0030				0.0025	0.0035			0.0028			
Iron (dissolved)	mg/L	0.35	0.35	NG	0.300		0.135				0.038	0.438			0.011			
Lead (dissolved)	mg/L	Calc [1.10]	Calc [2.10]	NG	Calc [4.9]		0.0001				<0.0001	0.0003			0.0001			
Lithium (dissolved)	mg/L	NG	NG	NG	NG		0.0031				0.0181	0.0058			0.0112			
Magnesium (dissolved)	mg/L	NG	NG	NG	NG		10.1				42.8	10.5			35.1			
Manganese (dissolved)	mg/L	Calc [1.11]	Calc [2.11]	NG	NG		0.0054				0.0099	0.0087			0.0154			
Mercury (dissolved)	mg/L	0.000020 [1.12]	0.000020 [2.12]	NG	0.000026 [4.10]		<0.00002				<0.000005	<0.00002						
Molybdenum (dissolved)	mg/L	2 [1.13]	1 [2.13]	NG	0.073		0.0022				0.0064	0.0011			0.0084			
Nickel (dissolved)	mg/L	NG	NG	Calc [3.4]	Calc [4.11]		0.0011				0.0029	0.0024			0.0014			
Selenium (dissolved)	mg/L	0.002 [1.14]	0.002 [2.14]	NG	0.0010		0.0022				<0.0005	<0.0005			0.0072			
Silicon (dissolved, as Si)	mg/L	NG	NG	NG	NG		8.5				9.7	11.6			9.0			
Silver (dissolved)	mg/L	Calc [1.15]	Calc [2.15]	NG	0.00025		<0.00005				0.00007	<0.00005			<0.00005			
Sodium (dissolved)	mg/L	NG	NG	NG	NG		12.8				98.5	13.7			30.6			
Strontium (dissolved)	mg/L	NG	NG	NG	NG		0.331				1.18	0.211			1.04			
Sulphur (dissolved)	mg/L	NG	NG	NG	NG		5				56	9			16			
Tellurium (dissolved)	mg/L	NG	NG	NG	NG		<0.0002				<0.0002	<0.0002			<0.0002			
Thallium (dissolved)	mg/L	NG	NG	0.0008 [3.5]	0.0008		<0.00002				<0.00002	<0.00002			<0.00002			
Thorium (dissolved)	mg/L	NG	NG	NG	NG		<0.0001				<0.0001	<0.0001			<0.0001			
Tin (dissolved)	mg/L	NG	NG	NG	NG		<0.0002				<0.0002	<0.0002			<0.0002			
Titanium (dissolved)	mg/L	NG	NG	NG	NG		<0.005				<0.005	0.019			<0.005			
Uranium (dissolved)	mg/L	NG	NG	0.0085	0.015 [4.12]		0.00221				0.0165	0.00248			0.0241			
Vanadium (dissolved)	mg/L	NG	NG	NG	NG		<0.001				0.002	0.002			0.002			
Zinc (dissolved)	mg/L	Calc [1.16]	Calc [2.16]	NG	0.030		<0.004				0.019	0.009			0.021			
Zirconium (dissolved)	mg/L	NG	NG	NG	NG		0.0004				0.0002	0.0008			0.0001			
General																		

Swan Lake

Water Quality Results

Analyte	Unit	Guideline				Sampling Location	BX Creek	BX Creek	BX Creek	FS-43 (SW)	FS-43 (SW)	FS-43 (SW)	FS-43 (SW)	NW Spring	SE Spring	SE Spring	SE Spring	Site 3 (NE-Cowboys)
						Date Sampled	28-Mar-16	10-Aug-16	02-Nov-16	15-Jul-15	29-Oct-15	28-Mar-16	02-Nov-16	31-Mar-16	31-Mar-16	10-Aug-16	03-Nov-16	03-Apr-15
						Lab Sample ID	6031831-02	6080868-13	6110254-03	5071046-06	5102146-03	6031831-09	6110254-06	6040072-03	6040072-04	6080868-11	6110391-03	5040345-06
						Sample Type	Normal	Normal		Normal	Normal	Normal		Normal	Normal	Normal		Normal
		BCAWQG AL	BCAWQG ALA	BCWWQG AL	CCME AL													
Alkalinity (bicarbonate, as CaCO3)	mg/L	NG	NG	NG	NG		124	170	155	187	303	80	326			288	318	78
Alkalinity (total, as CaCO3)	mg/L	NG	NG	N [3.7]	NG		124	170	155	187	303	80	326			288	318	78
Bicarbonate Alkalinity (as HCO3)	mg/L	NG	NG	NG	NG		151	207	190			97	398			352	388	
Carbonate Alkalinity (as CO3)	mg/L	NG	NG	NG	NG		<1	<0.6	<0.6			<1	<0.6			<0.6	<0.6	
Hydroxide Alkalinity (as OH)	mg/L	NG	NG	NG	NG		<1	<0.3	<0.3			<1	<0.3			<0.3	<0.3	
Bromide	mg/L	NG	NG	NG	NG		<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.12	<0.10	<0.10	<0.10	<0.10	<0.10
Chloride	mg/L	600 [1.17]	150 [2.17]	NG	120 [4.13]		23.7	26.8	24.3	35.8	151	15.8	161	15.7	46.2	31.0	42.6	9.29
Chlorophyll a	mg/L	N [1.18]	N [2.18]	NG	NG													
Conductivity	µS/cm	NG	NG	NG	NG		369	512	453			288	1420	913	847	778	889	
Fluoride	mg/L	Calc [1.19]	Calc [2.19]	NG	0.120 [4.14]		0.11	0.11	<0.10	0.46	0.66	0.21	0.29	0.53	0.44	0.38	0.13	0.16
Hardness, total (dissolved as CaCO3)	mg/L	NG	NG	NG	NG		160	231	198		429	118	502		355	364	404	
pH		N [1.20]	N [2.20]	NG	6.5 - 9		8.08	8.16	8.07			7.94	8.13	8.09	8.14	8.11	8.02	7.95
Sulphate	mg/L	Calc [1.21]	Calc [2.21]	NG	NG		29.2	51.4	39.2	54.0	159	40.6	181	221	64.0	60.9	58.2	31.3
Sulphide (total, as S)	mg/L	NG	NG	NG	NG		<0.05			<0.05		<0.05						
Total suspended solids	mg/L	N [1.22]	N [2.22]	NG	N [4.15]													
Turbidity	NTU	N [1.23]	N [2.23]	NG	N [4.16]													
Microbiological																		
Background Bacteria	CFU/100 mL	NG	NG	NG	NG													
E. coli (counts)	CFU/100 mL	N [1.24]	N [2.24]	NG	NG													
E. coli (MPN)	MPN/100 mL	N [1.25]	N [2.25]	NG	NG						9.1							
Enterococcus (MPN)	MPN/100 mL	N [1.26]	N [2.26]	NG	NG													
Fecal coliforms (counts)	CFU/100 mL	N [1.27]	N [2.27]	NG	NG													
Fecal coliforms (MPN)	MPN/100 mL	N [1.28]	N [2.28]	NG	NG						23							
Total coliforms (counts)	CFU/100 mL	NG	NG	NG	NG													
Total coliforms (MPN)	MPN/100 mL	NG	NG	NG	NG						1200							
Nutrients																		
Ammonia (total, as N)	mg/L	Calc [1.29]	Calc [2.29]	NG	Calc [4.17]		0.115	0.037	0.050	0.054	<0.020	<0.020	0.063	0.057	0.042	0.023	0.083	<0.020
Nitrate (as N)	mg/L	32.8 [1.30]	3.0 [2.30]	NG	3.0 [4.18]		0.419	1.74	0.702	0.018	0.039	0.197	0.550	0.433	9.98	8.76	7.07	0.175
Nitrate + Nitrite (as N) (calculated)	mg/L	32.8 [1.31]	3.0 [2.31]	NG	3.0 [4.19]		0.419	1.74	0.702	0.018	0.039	0.197	0.550	0.433	9.99	8.77	7.07	0.175
Nitrite (as N)	mg/L	Calc [1.32]	Calc [2.32]	NG	0.060		<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.015	0.011	<0.010	<0.010
Orthophosphate (dissolved, as P)	mg/L	NG	NG	NG	NG		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.09	<0.01	<0.01	<0.01	<0.01
Phosphorus (dissolved, by ICPMS/ICPC	mg/L	N [1.33]	N [2.33]	NG	N [4.20]		<0.02				0.04	0.03			<0.02			
Phosphorus (total, by ICPMS/ICPOES)	mg/L	N [1.34]	N [2.34]	NG	N [4.21]			<0.2	<0.02				<0.02			<0.2	0.05	
Phosphorus (total, APHA 4500-P)	mg/L	N [1.35]	N [2.35]	NG	N [4.22]			0.192	0.050				0.057			0.023	0.038	
Phosphorus (dissolved, APHA 4500-P)	mg/L	N [1.36]	N [2.36]	NG	N [4.23]			0.116	0.014				0.072			0.020	0.035	
Potassium (dissolved)	mg/L	NG	NG	NG	NG		2.38				9.00	3.00			5.40			
Potassium (total)	mg/L	NG	NG	NG	NG			4.3	3.70				9.60			6.4	7.31	
Total Metals																		
Aluminum (total)	mg/L	NG	NG	NG	Calc [4.24]			0.07	0.150				0.113			<0.05	0.018	
Antimony (total)	mg/L	NG	NG	0.009 [3.8]	NG			<0.001	<0.0001				0.0003			<0.001	0.0001	
Arsenic (total)	mg/L	0.005	0.005	NG	0.0050 [4.25]			<0.005	<0.0005				0.0012			<0.005	0.0007	
Barium (total)	mg/L	NG	NG	1	NG			0.06	0.046				0.068			0.06	0.069	
Beryllium (total)	mg/L	NG	NG	0.00013	NG			<0.001	<0.0001				<0.0001			<0.001	<0.0001	
Bismuth (total)	mg/L	NG	NG	NG	NG			<0.001	<0.0001				<0.0001			<0.001	<0.0001	

Swan Lake

Water Quality Results

Analyte	Unit	Guideline				Sampling Location	BX Creek	BX Creek	BX Creek	FS-43 (SW)	FS-43 (SW)	FS-43 (SW)	FS-43 (SW)	NW Spring	SE Spring	SE Spring	SE Spring	Site 3 (NE-Cowboys)
						Date Sampled	28-Mar-16	10-Aug-16	02-Nov-16	15-Jul-15	29-Oct-15	28-Mar-16	02-Nov-16	31-Mar-16	31-Mar-16	10-Aug-16	03-Nov-16	03-Apr-15
						Lab Sample ID	6031831-02	6080868-13	6110254-03	5071046-06	5102146-03	6031831-09	6110254-06	6040072-03	6040072-04	6080868-11	6110391-03	5040345-06
						Sample Type	Normal	Normal		Normal	Normal	Normal		Normal	Normal	Normal		Normal
		BCAWQG AL	BCAWQG ALA	BCWWQG AL	CCME AL													
Boron (total)	mg/L	1.2	1.2	NG	1.5 [4.26]		0.06	<0.004					0.013			0.08	0.050	
Cadmium (total)	mg/L	NG	NG	NG	Calc [4.27]		<0.0001	0.00003					0.00002			<0.0001	0.00001	
Calcium (total)	mg/L	NG	NG	NG	NG		66.3	58.6					116			87.3	91.6	
Chromium (total)	mg/L	NG	NG	0.001 [3.9]	0.0010 [4.28]		<0.005	0.0009					0.0008			<0.005	0.0013	
Cobalt (total)	mg/L	0.110 [1.37]	0.004 [2.37]	NG	NG		<0.0005	0.00013					0.00017			<0.0005	0.00009	
Copper (total)	mg/L	Calc [1.38]	Calc [2.38]	NG	Calc [4.29]		0.002	0.0014					0.0031			0.003	0.0012	
Iron (total)	mg/L	1.0	1.0	NG	0.300		0.12	0.25					0.15			<0.10	0.03	
Lead (total)	mg/L	Calc [1.39]	Calc [2.39]	NG	Calc [4.30]		<0.001	0.0002					0.0001			<0.001	<0.0001	
Lithium (total)	mg/L	NG	NG	NG	NG		0.006	0.0037					0.0187			0.011	0.0111	
Magnesium (total)	mg/L	NG	NG	NG	NG		16.0	12.5					51.4			35.3	42.6	
Manganese (total)	mg/L	Calc [1.40]	Calc [2.40]	NG	NG		0.013	0.0187					0.0136			0.006	0.0056	
Mercury (total)	mg/L	0.000020 [1.41]	0.000020 [2.41]	NG	0.000026 [4.31]		<0.00002	<0.00002					<0.00002			<0.00002	<0.00002	
Molybdenum (total)	mg/L	2 [1.42]	1 [2.42]	NG	0.073		0.004	0.0024					0.0069			0.008	0.0103	
Nickel (total)	mg/L	NG	NG	Calc [3.10]	Calc [4.32]		<0.002	0.0008					0.0033			<0.002	0.0011	
Selenium (total)	mg/L	0.002 [1.43]	0.002 [2.43]	NG	0.0010		<0.005	0.0022					<0.0005			0.006	0.0073	
Silicon (total, as Si)	mg/L	NG	NG	NG	NG		9	7.1					10.0			11	10.7	
Silver (total)	mg/L	Calc [1.44]	Calc [2.44]	NG	0.00025		<0.0005	<0.00005					<0.00005			<0.0005	<0.00005	
Sodium (total)	mg/L	NG	NG	NG	NG		18.1	15.6					119			26.4	38.3	
Strontium (total)	mg/L	NG	NG	NG	NG		0.55	0.439					1.47			1.03	1.25	
Sulphur (total)	mg/L	NG	NG	NG	NG		19	13					63			26	20	
Tellurium (total)	mg/L	NG	NG	NG	NG		<0.002	<0.0002					<0.0002			<0.002	<0.0002	
Thallium (total)	mg/L	NG	NG	0.0008 [3.11]	0.0008		<0.0002	<0.00002					<0.00002			<0.0002	<0.00002	
Thorium (total)	mg/L	NG	NG	NG	NG		<0.001	<0.0001					<0.0001			<0.001	<0.0001	
Tin (total)	mg/L	NG	NG	NG	NG		<0.002	<0.0002					0.0003			<0.002	<0.0002	
Titanium (total)	mg/L	NG	NG	NG	NG		<0.05	0.007					<0.005			<0.05	<0.005	
Uranium (total)	mg/L	NG	NG	0.0085	0.015 [4.33]		0.0051	0.00314					0.0183			0.0249	0.0262	
Vanadium (total)	mg/L	NG	NG	NG	NG		<0.01	<0.001					0.002			<0.01	0.002	
Zinc (total)	mg/L	Calc [1.45]	Calc [2.45]	NG	0.030		<0.04	0.006					0.025			<0.04	0.013	
Zirconium (total)	mg/L	NG	NG	NG	NG		<0.001	0.0001					0.0003			<0.001	0.0001	

Swan Lake

Water Quality Results

Analyte	Unit	Site 3 (NE-Cowboys) 28-Mar-16 6031831-04 Normal	Site 3 (NE-Cowboys) 10-Aug-16 6080868-02	Site 5 (NE-Culvert) 03-Apr-15 5040345-05 Normal	Site 5 (NE-Culvert) 29-Oct-15 5102146-08 Normal	Site 5 (NE-Culvert) 29-Mar-16 6031988-02 Normal	Site 5 (NE-Culvert) 02-Nov-16 6110254-04	Site5b (NE-culvert) 28-Mar-16 6031831-11 Normal	Site5b (NE-culvert) 10-Aug-16 6080868-01	Site5b (NE-culvert) 02-Nov-16 6110254-05	Storm Drainage 28-Mar-16 6031831-16 Normal	Storm Drainage 11-Aug-16 6080942-04 Normal	Storm Drainage 02-Nov-16 6110254-02	SW Spring 31-Mar-16 6040072-02 Normal	Swan Lake 02-Apr-15 5040345-17 Normal	Swan Lake 16-Jul-15 5071187-03 Normal	Swan Lake 03-Nov-15 5110157-03 Normal
Field Results																	
Conductivity	µS/cm	1228	1150	1273	804	579	865	460	1020	124	747	671	349	2260	452	421	483
Dissolved oxygen	mg/L	11.15			9.29	11.19	8.2	11.3			10.48		10.84	11.07			10.59
Dissolved oxygen (percent)	%	93.5			80.4	95.4	74.6	93.8			94.4		98.8	96.2			91.8
Oxidation reduction potential	mV	154	160		79	171	143	33	103	122	29	124	96	135		-63	29
pH		8.5	8.2	9.1	8.8	7.8	8.0	8.3	7.6	8.4	8.3	7.7	7.8	8.0		8.5	8.2
Temperature	°C	7.6	20.5	7.87	8.8	5.6	10.5	7.0	19.1	8.2	10.2	16.1	11.16	8.9	9.4	22.6	8.9
Lab Results																	
Dissolved Metals																	
Aluminum (dissolved)	mg/L	0.023			0.053	0.019		0.017			0.040			<0.005			0.031
Antimony (dissolved)	mg/L	0.0002			0.0002	0.0001		0.0001			0.0016			0.0001			0.0002
Arsenic (dissolved)	mg/L	0.0009			<0.0005	<0.0005		<0.0005			0.0006			0.0010			0.0009
Barium (dissolved)	mg/L	0.055			0.038	0.028		0.022			0.069			0.064			0.045
Beryllium (dissolved)	mg/L	<0.0001			<0.0001	<0.0001		<0.0001			<0.0001			<0.0001			<0.0001
Bismuth (dissolved)	mg/L	<0.0001			<0.0001	<0.0001		<0.0001			<0.0001			<0.0001			<0.0001
Boron (dissolved)	mg/L	0.061			0.012	0.010		<0.004			0.015			0.017			0.018
Cadmium (dissolved)	mg/L	<0.00001			0.00001	0.00001		<0.00001			0.00010			0.00015			0.00004
Calcium (dissolved)	mg/L	136			73.1	66.0		57.6			92.3			197			50.9
Chromium (dissolved)	mg/L	<0.0005			<0.0005	<0.0005		<0.0005			<0.0005			<0.0005			<0.0005
Cobalt (dissolved)	mg/L	0.00018			0.00042	0.00011		0.00011			0.00020			0.00016			0.00009
Copper (dissolved)	mg/L	0.0035			0.0014	0.0030		0.0031			0.0017			0.0036			0.0006
Iron (dissolved)	mg/L	0.030			0.108	0.039		0.041			0.119			<0.010			0.049
Lead (dissolved)	mg/L	<0.0001			0.0001	<0.0001		<0.0001			<0.0001			<0.0001			0.0002
Lithium (dissolved)	mg/L	0.0263			0.0120	0.0086		0.0081			0.0044			0.0225			0.0059
Magnesium (dissolved)	mg/L	54.5			25.0	18.2		14.5			17.8			138			20.1
Manganese (dissolved)	mg/L	0.0017			0.0757	0.0088		0.0064			0.153			0.0021			0.0057
Mercury (dissolved)	mg/L	<0.00002			<0.000005	<0.00002		<0.00002			<0.00002						<0.000005
Molybdenum (dissolved)	mg/L	0.0057			0.0016	0.0016		0.0015			0.0033			0.0210			0.0039
Nickel (dissolved)	mg/L	0.0016			0.0017	0.0013		0.0015			0.0013			0.0020			0.0011
Selenium (dissolved)	mg/L	0.0014			<0.0005	0.0007		0.0008			0.0086			0.0099			0.0007
Silicon (dissolved, as Si)	mg/L	12.5			8.5	16.2		14.6			8.2			6.9			6.6
Silver (dissolved)	mg/L	<0.00005			<0.00005	<0.00005		<0.00005			<0.00005			<0.00005			0.00007
Sodium (dissolved)	mg/L	45.7			38.1	20.3		12.7			33.9			115			25.9
Strontium (dissolved)	mg/L	1.10			0.547	0.429		0.352			0.590			6.06			0.570
Sulphur (dissolved)	mg/L	51			25	22		15			17			250			24
Tellurium (dissolved)	mg/L	<0.0002			<0.0002	<0.0002		<0.0002			<0.0002			<0.0002			<0.0002
Thallium (dissolved)	mg/L	<0.00002			<0.00002	<0.00002		<0.00002			<0.00002			<0.00002			<0.00002
Thorium (dissolved)	mg/L	<0.0001			<0.0001	<0.0001		<0.0001			<0.0001			<0.0001			<0.0001
Tin (dissolved)	mg/L	<0.0002			<0.0002	<0.0002		<0.0002			<0.0002			<0.0002			<0.0002
Titanium (dissolved)	mg/L	<0.005			<0.005	<0.005		<0.005			<0.005			<0.005			<0.005
Uranium (dissolved)	mg/L	0.0174			0.00393	0.00271		0.00180			0.00607			0.0370			0.00586
Vanadium (dissolved)	mg/L	0.002			<0.001	<0.001		<0.001			<0.001			0.003			0.002
Zinc (dissolved)	mg/L	0.005			0.018	0.013		0.006			0.015			0.052			0.005
Zirconium (dissolved)	mg/L	0.0001			0.0001	0.0001		0.0001			<0.0001			0.0002			<0.0001
General																	

Swan Lake

Water Quality Results

Analyte	Unit	Site 3 (NE-Cowboys) 28-Mar-16 6031831-04 Normal	Site 3 (NE-Cowboys) 10-Aug-16 6080868-02	Site 5 (NE-Culvert) 03-Apr-15 5040345-05 Normal	Site 5 (NE-Culvert) 29-Oct-15 5102146-08 Normal	Site 5 (NE-Culvert) 29-Mar-16 6031988-02 Normal	Site 5 (NE-Culvert) 02-Nov-16 6110254-04	Site5b (NE-culvert) 28-Mar-16 6031831-11 Normal	Site5b (NE-culvert) 10-Aug-16 6080868-01	Site5b (NE-culvert) 02-Nov-16 6110254-05	Storm Drainage 28-Mar-16 6031831-16 Normal	Storm Drainage 11-Aug-16 6080942-04 Normal	Storm Drainage 02-Nov-16 6110254-02	SW Spring 31-Mar-16 6040072-02 Normal	Swan Lake 02-Apr-15 5040345-17 Normal	Swan Lake 16-Jul-15 5071187-03 Normal	Swan Lake 03-Nov-15 5110157-03 Normal
Alkalinity (bicarbonate, as CaCO3)	mg/L	311	322	315	241	162	247	148	347	40	200	195	102		139	135	146
Alkalinity (total, as CaCO3)	mg/L	311	323	315	241	162	247	148	347	40	200	195	102		139	135	146
Bicarbonate Alkalinity (as HCO3)	mg/L	379	393			198	301	181	423	49		238	124				
Carbonate Alkalinity (as CO3)	mg/L	<1	<0.6			<1	<0.6	<1	<1	<0.6		<0.6	<0.6				
Hydroxide Alkalinity (as OH)	mg/L	<1	<0.3			<1	<0.3	<1	<0.7	<0.3		<0.3	<0.3				
Bromide	mg/L	0.15	0.29	<0.10	<0.10	<0.10	<0.10	<0.10	0.13	<0.10	0.23	0.23	<0.10	0.10	<0.10	<0.10	<0.10
Chloride	mg/L	102	96.3	118	79.5	33.0	66.2	19.2	123	9.43	76.7	54.8	26.2	112	27.5	28.7	15.8
Chlorophyll a	mg/L																
Conductivity	µS/cm	1180	1170			531	989	442	1030	118	708	636	337	2230			
Fluoride	mg/L	0.82	0.97	0.77	0.32	0.32	0.17	0.33	0.50	0.11	0.12	0.13	0.14	0.71	0.15	0.27	<0.10
Hardness, total (dissolved as CaCO3)	mg/L	564	559		285	240	430	203	559	74.8	304	256	139	1060			210
pH		8.23	8.30	8.10		8.08	8.04	8.11	7.45	6.41	7.83	7.75	7.66	8.25	8.17		
Sulphate	mg/L	161	149	122	73.2	67.3	168	54.0	41.3	1.7	59.9	55.3	21.9	898	53.9	55.2	30.4
Sulphide (total, as S)	mg/L	<0.05				<0.05		<0.05			<0.05					<0.05	
Total suspended solids	mg/L																
Turbidity	NTU																
Microbiological																	
Background Bacteria	CFU/100 mL																
E. coli (counts)	CFU/100 mL																
E. coli (MPN)	MPN/100 mL				23												<3.0
Enterococcus (MPN)	MPN/100 mL																
Fecal coliforms (counts)	CFU/100 mL																
Fecal coliforms (MPN)	MPN/100 mL				23												<3.0
Total coliforms (counts)	CFU/100 mL																
Total coliforms (MPN)	MPN/100 mL				430												73
Nutrients																	
Ammonia (total, as N)	mg/L	0.034	0.039	<0.020	0.024	<0.020	0.067	0.041	0.090	0.536	0.049	0.034	0.147	0.050	0.053	0.035	0.043
Nitrate (as N)	mg/L	8.58	9.63	5.98	0.052	0.496	0.562	0.351	0.370	0.124	1.73	1.14	0.529	6.46	0.271	<0.010	0.011
Nitrate + Nitrite (as N) (calculated)	mg/L	8.58	9.63	5.98	0.052	0.496	0.562	0.351	0.386	0.194	1.73	1.14	0.551	6.46	0.271	<0.014	<0.014
Nitrite (as N)	mg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.016	0.070	<0.010	<0.010	0.022	<0.010	<0.010	<0.010	<0.010
Orthophosphate (dissolved, as P)	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Phosphorus (dissolved, by ICPMS/ICPC	mg/L	0.06			<0.02	<0.02		<0.02			0.03			0.05			<0.02
Phosphorus (total, by ICPMS/ICPOES)	mg/L		<0.2				0.03		3.2	0.78		0.07	0.10				
Phosphorus (total, APHA 4500-P)	mg/L		0.753				0.060		1.07	0.874		0.050	0.153				
Phosphorus (dissolved, APHA 4500-P)	mg/L		0.027				0.037		0.046	0.128		0.044	0.034				
Potassium (dissolved)	mg/L	10.6			5.43	4.67		4.01			3.77			10.3			5.09
Potassium (total)	mg/L		14.7				6.80		16.4	7.31		4.61	3.62				
Total Metals																	
Aluminum (total)	mg/L		0.38				0.163		19.7	18.4		0.110	3.00				
Antimony (total)	mg/L		<0.001				0.0003		0.003	0.0033		0.0143	0.0015				
Arsenic (total)	mg/L		<0.005				<0.0005		0.036	0.0044		0.0006	0.0013				
Barium (total)	mg/L		0.06				0.049		1.15	0.307		0.070	0.072				
Beryllium (total)	mg/L		<0.001				<0.0001		<0.001	0.0006		<0.0001	0.0001				
Bismuth (total)	mg/L		<0.001				<0.0001		<0.001	0.0003		<0.0001	<0.0001				

Swan Lake

Water Quality Results

Analyte	Unit	Site 3 (NE-Cowboys) 28-Mar-16 6031831-04 Normal	Site 3 (NE-Cowboys) 10-Aug-16 6080868-02	Site 5 (NE-Culvert) 03-Apr-15 5040345-05 Normal	Site 5 (NE-Culvert) 29-Oct-15 5102146-08 Normal	Site 5 (NE-Culvert) 29-Mar-16 6031988-02 Normal	Site 5 (NE-Culvert) 02-Nov-16 6110254-04	Site5b (NE-culvert) 28-Mar-16 6031831-11 Normal	Site5b (NE-culvert) 10-Aug-16 6080868-01	Site5b (NE-culvert) 02-Nov-16 6110254-05	Storm Drainage 28-Mar-16 6031831-16 Normal	Storm Drainage 11-Aug-16 6080942-04 Normal	Storm Drainage 02-Nov-16 6110254-02	SW Spring 31-Mar-16 6040072-02 Normal	Swan Lake 02-Apr-15 5040345-17 Normal	Swan Lake 16-Jul-15 5071187-03 Normal	Swan Lake 03-Nov-15 5110157-03 Normal
Boron (total)	mg/L		0.17				0.011		0.13	0.008		0.038	0.010				
Cadmium (total)	mg/L		<0.0001				0.00002		0.0010	0.00059		0.00007	0.00013				
Calcium (total)	mg/L		106				106		141	13.6		77.0	41.6				
Chromium (total)	mg/L		<0.005				0.0007		0.065	0.0481		0.0008	0.0081				
Cobalt (total)	mg/L		<0.0005				0.00086		0.0439	0.0128		0.00021	0.00201				
Copper (total)	mg/L		0.005				0.0051		0.103	0.0751		0.0024	0.0161				
Iron (total)	mg/L		0.45				0.33		141	25.8		0.25	4.08				
Lead (total)	mg/L		<0.001				0.0003		0.023	0.0154		0.0004	0.0034				
Lithium (total)	mg/L		0.045				0.0122		0.043	0.0201		0.0049	0.0060				
Magnesium (total)	mg/L		71.1				40.2		50.1	9.92		15.4	8.63				
Manganese (total)	mg/L		0.010				0.113		21.8	0.549		0.116	0.138				
Mercury (total)	mg/L		<0.00002				<0.00002		<0.00002	<0.00002		<0.00002	<0.00002				
Molybdenum (total)	mg/L		0.009				0.0020		0.006	0.0024		0.0045	0.0025				
Nickel (total)	mg/L		0.003				0.0025		0.059	0.0362		0.0016	0.0064				
Selenium (total)	mg/L		<0.005				<0.0005		<0.005	<0.0005		0.0057	0.0021				
Silicon (total, as Si)	mg/L		20				9.4		63	31.0		10.5	9.7				
Silver (total)	mg/L		<0.0005				<0.00005		<0.0005	0.00018		<0.00005	<0.00005				
Sodium (total)	mg/L		48.0				48.7		61.4	15.0		30.6	14.6				
Strontium (total)	mg/L		1.38				0.901		1.14	0.109		0.565	0.268				
Sulphur (total)	mg/L		58				61		20	<1		17	7				
Tellurium (total)	mg/L		<0.002				<0.0002		<0.002	<0.0002		<0.0002	<0.0002				
Thallium (total)	mg/L		<0.0002				<0.00002		0.0003	0.00020		<0.00002	<0.00002				
Thorium (total)	mg/L		<0.001				<0.0001		0.001	0.0014		<0.0001	0.0003				
Tin (total)	mg/L		<0.002				0.0003		0.003	0.0026		0.0002	0.0008				
Titanium (total)	mg/L		<0.05				0.005		0.81	0.819		0.007	0.134				
Uranium (total)	mg/L		0.0244				0.00826		0.0109	0.00089		0.00510	0.00218				
Vanadium (total)	mg/L		<0.01				0.001		0.08	0.048		0.001	0.009				
Zinc (total)	mg/L		<0.04				0.239		0.80	0.404		0.022	0.094				
Zirconium (total)	mg/L		<0.001				0.0003		0.003	0.0039		<0.0001	0.0016				

Swan Lake

Water Quality Results

Analyte	Unit	Swan Lake 29-Mar-16 6031988-07 Normal	Swan Lake 15-Aug-16 6081247-01 Normal	Swan Lake 10-Nov-16 6110974-01 Normal	Vernon Creek (Outlet) 03-Apr-15 5040345-11 Normal	Vernon Creek (Outlet) 15-Jul-15 5071046-12 Normal	Vernon Creek (Outlet) 29-Oct-15 5102146-14 Normal	Vernon Creek (Outlet) 28-Mar-16 6031831-15 Normal	Vernon Creek (Outlet) 10-Aug-16 6080942-05 Normal	Vernon Creek (Outlet) 02-Nov-16 6110254-01
Field Results										
Conductivity	µS/cm	579	479	497	404	440	626	451	513	509
Dissolved oxygen	mg/L	12.75	9.72	10.21			8.22	12.55	9.74	9.0
Dissolved oxygen (percent)	%	114.8		90.2			70.3	102.4	112.9	81.1
Oxidation reduction potential	mV	5		202	117		29	9	91	130
pH		7.5		7.9	7.95	8.2	6.6	7.9	8.1	8.1
Temperature	°C	10.7	24.15	9.8	8.3	24.8	9.3	6.4	22.3	10.0
Lab Results										
Dissolved Metals										
Aluminum (dissolved)	mg/L	0.040		0.005			0.050	0.041		
Antimony (dissolved)	mg/L	0.0001		0.0002			0.0006	<0.0001		
Arsenic (dissolved)	mg/L	0.0007		0.0009			<0.0005	<0.0005		
Barium (dissolved)	mg/L	0.042		0.041			0.052	0.035		
Beryllium (dissolved)	mg/L	<0.0001		<0.0001			<0.0001	<0.0001		
Bismuth (dissolved)	mg/L	<0.0001		<0.0001			<0.0001	<0.0001		
Boron (dissolved)	mg/L	0.016		0.019			0.016	0.006		
Cadmium (dissolved)	mg/L	<0.00001		<0.00001			<0.00001	0.00001		
Calcium (dissolved)	mg/L	53.3		40.2			70.0	52.3		
Chromium (dissolved)	mg/L	<0.0005		<0.0005			<0.0005	<0.0005		
Cobalt (dissolved)	mg/L	0.00008		<0.00005			0.00015	0.00011		
Copper (dissolved)	mg/L	0.0015		0.0007			0.0009	0.0018		
Iron (dissolved)	mg/L	0.044		<0.010			0.125	0.081		
Lead (dissolved)	mg/L	<0.0001		0.0003			<0.0001	0.0002		
Lithium (dissolved)	mg/L	0.0057		0.0053			0.0045	0.0038		
Magnesium (dissolved)	mg/L	21.7		18.8			13.9	13.6		
Manganese (dissolved)	mg/L	0.0120		0.0023			0.131	0.0157		
Mercury (dissolved)	mg/L	<0.00002		<0.00002			<0.000005	<0.00002		
Molybdenum (dissolved)	mg/L	0.0035		0.0039			0.0026	0.0025		
Nickel (dissolved)	mg/L	0.0008		0.0007			0.0012	0.0009		
Selenium (dissolved)	mg/L	0.0009		0.0006			0.0009	0.0016		
Silicon (dissolved, as Si)	mg/L	6.4		7.4			7.3	7.5		
Silver (dissolved)	mg/L	<0.00005		<0.00005			<0.00005	<0.00005		
Sodium (dissolved)	mg/L	27.2		24.1			24.0	17.4		
Strontium (dissolved)	mg/L	0.577		0.513			0.469	0.399		
Sulphur (dissolved)	mg/L	22		20			18	12		
Tellurium (dissolved)	mg/L	<0.0002		<0.0002			<0.0002	<0.0002		
Thallium (dissolved)	mg/L	<0.00002		<0.00002			<0.00002	<0.00002		
Thorium (dissolved)	mg/L	<0.0001		<0.0001			<0.0001	<0.0001		
Tin (dissolved)	mg/L	<0.0002		<0.0002			<0.0002	<0.0002		
Titanium (dissolved)	mg/L	<0.005		<0.005			<0.005	<0.005		
Uranium (dissolved)	mg/L	0.00576		0.00588			0.00206	0.00331		
Vanadium (dissolved)	mg/L	<0.001		0.002			<0.001	<0.001		
Zinc (dissolved)	mg/L	0.005		<0.004			0.007	<0.004		
Zirconium (dissolved)	mg/L	<0.0001		<0.0001			0.0001	0.0003		
General										

Swan Lake

Water Quality Results

Analyte	Unit	Swan Lake 29-Mar-16 6031988-07 Normal	Swan Lake 15-Aug-16 6081247-01 Normal	Swan Lake 10-Nov-16 6110974-01 Normal	Vernon Creek (Outlet) 03-Apr-15 5040345-11 Normal	Vernon Creek (Outlet) 15-Jul-15 5071046-12 Normal	Vernon Creek (Outlet) 29-Oct-15 5102146-14 Normal	Vernon Creek (Outlet) 28-Mar-16 6031831-15 Normal	Vernon Creek (Outlet) 10-Aug-16 6080942-05 Normal	Vernon Creek (Outlet) 02-Nov-16 6110254-01
Alkalinity (bicarbonate, as CaCO3)	mg/L	158	133	131	123	143	167	141	151	125
Alkalinity (total, as CaCO3)	mg/L	158	133	131	123	143	167	141	151	125
Bicarbonate Alkalinity (as HCO3)	mg/L	193	162	160					184	152
Carbonate Alkalinity (as CO3)	mg/L	<1	<0.6	<0.6					<0.6	<0.6
Hydroxide Alkalinity (as OH)	mg/L	<1	<0.3	<0.3					<0.3	<0.3
Bromide	mg/L	<0.10	<0.10	<0.10	<0.10	<0.10	0.13	<0.10	<0.10	<0.10
Chloride	mg/L	34.9	32.7	30.9	22.6	29.3	49.5	28.2	33.2	27.3
Chlorophyll a	mg/L								0.964	
Conductivity	µS/cm	540	472	484				416		403
Fluoride	mg/L	0.32		0.17	0.12	0.29	0.13	0.14	0.14	<0.10
Hardness, total (dissolved as CaCO3)	mg/L	222	176	178			232	186	199	169
pH		8.19	8.26	8.08	8.06			7.99	8.05	7.74
Sulphate	mg/L	69.1	65.5	63.5	41.4	54.3	49.6	44.9	61.6	32.5
Sulphide (total, as S)	mg/L	<0.05				<0.05		<0.05		
Total suspended solids	mg/L									19
Turbidity	NTU								2.96	
Microbiological										
Background Bacteria	CFU/100 mL			>200						
E. coli (counts)	CFU/100 mL			<1						
E. coli (MPN)	MPN/100 mL						430		1100	460
Enterococcus (MPN)	MPN/100 mL									290
Fecal coliforms (counts)	CFU/100 mL			<1						
Fecal coliforms (MPN)	MPN/100 mL						430		1100	460
Total coliforms (counts)	CFU/100 mL			<1						
Total coliforms (MPN)	MPN/100 mL						2400			
Nutrients										
Ammonia (total, as N)	mg/L	0.070	0.114	0.053	<0.020	0.054	0.025	0.038	0.045	0.145
Nitrate (as N)	mg/L	0.428	0.024	<0.010	0.199	0.023	0.025	0.283	0.266	0.428
Nitrate + Nitrite (as N) (calculated)	mg/L	0.428	0.024	<0.014	0.199	0.023	0.025	0.283	0.266	0.442
Nitrite (as N)	mg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.014
Orthophosphate (dissolved, as P)	mg/L	0.06	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Phosphorus (dissolved, by ICPMS/ICPO	mg/L	0.03		<0.02			<0.02	<0.02		
Phosphorus (total, by ICPMS/ICPOES)	mg/L		0.02	<0.02					0.02	0.08
Phosphorus (total, APHA 4500-P)	mg/L		0.018	0.017					0.022	0.108
Phosphorus (dissolved, APHA 4500-P)	mg/L		0.013	0.015					0.021	0.085
Potassium (dissolved)	mg/L	4.64		4.42			4.44	3.28		
Potassium (total)	mg/L		3.97	4.42					4.27	4.05
Total Metals										
Aluminum (total)	mg/L		0.010	0.016					0.045	1.97
Antimony (total)	mg/L		0.0002	0.0002					0.0002	0.0010
Arsenic (total)	mg/L		0.0009	0.0009					0.0008	0.0009
Barium (total)	mg/L		0.041	0.047					0.037	0.063
Beryllium (total)	mg/L		<0.0001	<0.0001					<0.0001	<0.0001
Bismuth (total)	mg/L		<0.0001	<0.0001					<0.0001	<0.0001

Swan Lake

Water Quality Results

Analyte	Unit		Swan Lake 29-Mar-16 6031988-07 Normal	Swan Lake 15-Aug-16 6081247-01 Normal	Swan Lake 10-Nov-16 6110974-01 Normal	Vernon Creek (Outlet) 03-Apr-15 5040345-11 Normal	Vernon Creek (Outlet) 15-Jul-15 5071046-12 Normal	Vernon Creek (Outlet) 29-Oct-15 5102146-14 Normal	Vernon Creek (Outlet) 28-Mar-16 6031831-15 Normal	Vernon Creek (Outlet) 10-Aug-16 6080942-05 Normal	Vernon Creek (Outlet) 02-Nov-16 6110254-01
Boron (total)	mg/L			0.013	0.014					0.028	0.006
Cadmium (total)	mg/L			<0.00001	<0.00001					0.00001	0.00007
Calcium (total)	mg/L			41.8	44.2					49.1	50.4
Chromium (total)	mg/L			<0.0005	<0.0005					<0.0005	0.0052
Cobalt (total)	mg/L			<0.00005	<0.00005					0.00011	0.00122
Copper (total)	mg/L			0.0010	0.0007					0.0009	0.0090
Iron (total)	mg/L			<0.01	0.01					0.28	2.75
Lead (total)	mg/L			<0.0001	<0.0001					0.0002	0.0020
Lithium (total)	mg/L			0.0054	0.0064					0.0061	0.0056
Magnesium (total)	mg/L			17.2	19.1					18.5	10.4
Manganese (total)	mg/L			0.0180	0.0236					0.0602	0.102
Mercury (total)	mg/L			<0.00002	<0.00002					<0.00002	<0.00002
Molybdenum (total)	mg/L			0.0040	0.0041					0.0040	0.0022
Nickel (total)	mg/L			0.0006	0.0008					0.0009	0.0044
Selenium (total)	mg/L			0.0007	0.0008					0.0015	0.0016
Silicon (total, as Si)	mg/L			6.4	7.7					6.2	8.5
Silver (total)	mg/L			<0.00005	<0.00005					<0.00005	<0.00005
Sodium (total)	mg/L			22.5	24.4					23.6	16.1
Strontium (total)	mg/L			0.487	0.534					0.523	0.339
Sulphur (total)	mg/L			19	22					19	11
Tellurium (total)	mg/L			<0.0002	<0.0002					<0.0002	<0.0002
Thallium (total)	mg/L			<0.00002	<0.00002					<0.00002	<0.00002
Thorium (total)	mg/L			<0.0001	<0.0001					<0.0001	0.0002
Tin (total)	mg/L			<0.0002	<0.0002					<0.0002	0.0005
Titanium (total)	mg/L			<0.005	<0.005					<0.005	0.100
Uranium (total)	mg/L			0.00622	0.00685					0.00593	0.00183
Vanadium (total)	mg/L			0.002	0.002					0.002	0.006
Zinc (total)	mg/L			<0.004	<0.004					<0.004	0.046
Zirconium (total)	mg/L			<0.0001	<0.0001					<0.0001	0.0021

Guideline Notes for Reports for RDNO Swan Lake Water Quality Assessment Water Quality Results

1. Notes for BC Approved Water Quality Guidelines for freshwater aquatic life (BCAWQG AL)

General Notes:

The Water Quality Guidelines (Criteria) Reports by BC Ministry of Environment were used as references for the guidelines. (Internet address: http://www.env.gov.bc.ca/wat/wq/wq_guidelines.html). Overview Reports (BC MOE) were used as the references for the guidelines unless the note for specific analyte indicates that the Technical Appendix (BC MOE) was used. / For some parameters, guidelines are specified as two values: the maximum value or the acute criterion, and the 30-day average value or the chronic criterion. The maximum value was used in this report for parameters that have both guideline values.

Note 1.1 for Dissolved oxygen:

The instantaneous minimum guideline for dissolved oxygen is 5 mg/L for all life stages other than buried embryo/alevin. The instantaneous minimum guideline for dissolved oxygen in the water column is 9 mg/L for buried embryo/alevin. The instantaneous minimum guideline for dissolved oxygen in interstitial water is 6 mg/L for buried embryo/alevin.

The 30-day mean guideline (minimum) for dissolved oxygen is 8 mg/L for all life stages other than buried embryo/alevin. The 30-day mean guideline (minimum) for dissolved oxygen in the water column is 11 mg/L for buried embryo/alevin. The 30-day mean guideline (minimum) for dissolved oxygen in interstitial water is 8 mg/L for buried embryo/alevin.

Note 1.2 for pH:

pH less than 6.5: No statistically significant decrease in pH from background.
pH from 6.5 to 9.0: Unrestricted change permitted within this range.
pH over 9.0: No statistically significant increase in pH from background.
See BC MOE Overview Report for additional details.

Note 1.3 for Temperature:

The maximum daily temperature of 19 degrees Celsius is for streams with unknown fish distribution. See BC MOE Overview Report for additional details for streams with unknown fish distribution, and specific guidelines for streams with known fish distribution, and guideline for lakes and impoundments.

Note 1.4 for Aluminum (dissolved):

The maximum concentration of dissolved aluminum at any time should not exceed:
1. 0.10 mg/L when the pH is greater than or equal to 6.5
2. The value (in mg/L) determined by the following relationship if pH less than 6.5
Dissolved Aluminum = e (1.209-2.426 (pH) + 0.286 (pH)^2)

The 30-day average concentration of dissolved aluminum (based on a minimum of 5 approximately weekly samples) should not exceed:
1. 0.05 mg/L when the median pH over 30 days is greater than or equal to 6.5
2. the value determined by the following relationship at median pH less than 6.5
Dissolved Aluminum = e (1.6-3.327 (median pH) + 0.402 (median pH)^2)

Note 1.5 for Arsenic (dissolved):

The recommended guideline is for total arsenic.

Note 1.6 for Boron (dissolved):

The recommended guideline is for total boron.

Note 1.7 for Cadmium (dissolved):

The guideline for cadmium is determined on a site-specific basis according to the local water hardness. The guideline for cadmium (dissolved) in µg/L is determined by the following equations for short term exposure:
1. If hardness (as CaCO3) is less than 7 mg/L then maximum is 0.0380 µg/L
2. If hardness (as CaCO3) is from 7 to 45 mg/L then maximum is based on equation:
e to the power of {1.03[ln(hardness)] - 5.274}
3. If hardness (as CaCO3) is greater than 455 mg/L then maximum is 2.8 µg/L.

When water hardness is greater than the upper bound (i.e., highest water hardness tested), a site-specific assessment may be required.

Note 1.8 for Cobalt (dissolved):

The interim maximum concentration for total cobalt is 110 µg/L to protect aquatic life in the freshwater environment from acute effects of cobalt.

The interim 30-day average concentration for total cobalt (based on five weekly samples) is 4 µg/L to protect aquatic life from chronic effects of cobalt.

Note 1.9 for Copper (dissolved):

The maximum concentration of total copper should not exceed at any time the numerical value (in µg/L) given by the formula "0.094(hardness)+2", where water hardness is reported as mg/L CaCO3.

The 30-day average concentration of total copper (based on a minimum of 5 approximately weekly samples) should not exceed 2 µg/L when average water hardness over the same period (expressed as mg/L CaCO3) is less than 50 mg/L. When average water hardness is greater than 50 mg/L the 30-day average concentration should not exceed the numerical value (in µg/L) given by the formula "0.04(average hardness)", where water hardness is reported as mg/L CaCO3.

Note 1.10 for Lead (dissolved):
The maximum guideline for total lead in water, at a water hardness less than or equal to 8 mg/L as CaCO3 is set at 3.0 µg/L. When water hardness exceeds 8.0 mg/L CaCO3 the maximum guideline for lead at any time is given by the following equation:
Maximum Criteria (µg/L) = exp (1.273 ln(hardness) - 1.460).
The 30-day average guideline for total lead in water, when water hardness exceeds 8 mg/L as CaCO3, is as follows:
30-Day Average (µg/L) is less than or equal to 3.31 + exp (1.273 ln (mean hardness) - 4.704).
For hardness less than or equal to 8.0 mg/L there is no 30-day average guideline; hence the maximum concentration of 3.0 µg/L is used.
Note 1.11 for Manganese (dissolved):
The maximum concentration of total manganese in mg/L at any time should not exceed the value as determined by the following relationship:
0.01102 hardness + 0.54
where water hardness is reported as mg/L of CaCO3.
The 30-day mean concentration of total manganese in mg/L should be less than or equal to the value as determined by the following relationship:
0.0044 hardness + 0.605
where water hardness is reported as mg/L of CaCO3.
Note 1.12 for Mercury (dissolved):
The average concentration of total mercury in water as measured over a 30-day period (based on five weekly samples) should not exceed 0.02 µg/L when the methyl mercury (MeHg) constitutes less than or equal to 0.5% of the total mercury concentration. When the proportion of MeHg is greater than 0.5%, the guideline should be adjusted as indicated in the Table 1 and Table 4 of the BC MOE Overview Report - First Update, February 2001.
There is no guideline maximum for total mercury in water, for freshwater aquatic life.
Note 1.13 for Molybdenum (dissolved):
The maximum concentration for total molybdenum is 2 mg/L.
The 30-day average concentration for total molybdenum (based on at least five weekly samples in a period of 30 days) is less than or equal to 1 mg/L.
Note 1.14 for Selenium (dissolved):
The 30-day average water quality guideline for protection of aquatic life is 2 µg/L determined as the mean concentration of 5 evenly spaced samples collected over 30 days, and measured as total selenium.
The 30-day average alert concentration for the protection of aquatic life in sensitive ecosystems is 1 µg/L determined as the mean concentration of 5 evenly spaced samples collected over 30 days, and measured as total selenium.
Note 1.15 for Silver (dissolved):
The guideline maximum for total silver is:
0.1 µg/L maximum if hardness less than or equal to 100 mg/L
3.0 µg/L maximum if hardness greater than 100 mg/L.
The guideline 30-day average for total silver is:
0.05 µg/L as 30-day mean if hardness less than or equal to 100 mg/L
1.5 µg/L as 30-day mean if hardness greater than 100 mg/L.
Note 1.16 for Zinc (dissolved):
The maximum concentration of total zinc (µg/L) at any time should not exceed 33 µg/L when water hardness is less than or equal to 90 mg/L as CaCO3.
When water hardness exceeds 90 mg/L CaCO3, the guideline maximum in µg/L for total zinc is the value determined by the following relationship:
33 + 0.75 * (hardness - 90)
where water hardness is reported as mg/L of CaCO3.
The 30-day average concentration of total zinc (µg/L) at any time should not exceed 7.5 µg/L when water hardness is less than or equal to 90 mg/L as CaCO3.
When water hardness exceeds 90 mg/L CaCO3, the guideline maximum in µg/L for total zinc is the value determined by the following relationship:
7.5 + 0.75 * (hardness - 90)
where water hardness is reported as mg/L of CaCO3.
Note 1.17 for Chloride:
To protect freshwater aquatic life from acute and lethal effects, the maximum concentration of chloride (mg/L as NaCl) at any time should not exceed 600 mg/L.
To protect freshwater aquatic life from chronic effects, the average (arithmetic mean computed from five weekly samples collected over a 30-day period) concentration of chloride (mg/L as NaCl) should not exceed 150 mg/L.
Note 1.18 for Chlorophyll a:
For protection of aquatic life in streams, a maximum biomass of 100 mg/m2 chlorophyll a is suggested. This guideline applies to naturally growing periphytic algae. There is no guideline for chlorophyll a for lakes.
Note 1.19 for Fluoride:

Correction by BC MOE Sept. 2011: The criteria for Fluoride (total) in mg/L is 0.4 as a maximum where the water hardness (as CaCO3) is less than or equal to 10 mg/L. Otherwise use the equation:
LC50 fluoride = -51.73 + 92.57 log10 (Hardness) and multiply by 0.01.
Hardness is as CaCO3 in units mg/L.

Note 1.20 for pH:

pH less than 6.5: No statistically significant decrease in pH from background.
pH from 6.5 to 9.0: Unrestricted change permitted within this range.
pH over 9.0: No statistically significant increase in pH from background.
See BC MOE Overview Report for additional details.

Note 1.21 for Sulphate:

The approved 30-day average (minimum of 5 evenly-spaced samples collected in 30 days) water quality guidelines to protect aquatic life in BC for sulphate are:
128 mg/L at hardness of 0 to 30 mg/L as CaCO3
218 mg/L at hardness of 31 to 75 mg/L as CaCO3
309 mg/L at hardness of 76 to 180mg/L as CaCO3
429 mg/L at hardness 181 to 250 mg/L as CaCO3
Need to determine guideline based on site water for hardness greater than 250 mg/L as CaCO3.
For screening purposes in this report, exceedance were flagged for sulphate greater than 429 mg/L at hardness greater than 250 mg/L as CaCO3.

Note 1.22 for Total suspended solids:

Maximum Induced Suspended Sediments - mg/L or % of background:
- 25 mg/L in 24 hours when background is less than or equal to 25;
- Mean of 5 mg/L in 30 days when background is less than or equal to 25;
- 25 mg/L when background is between 25 and 250;
- 10% when background is greater than or equal to 250.

Note 1.23 for Turbidity:

When background is less than or equal to 8 NTU:
- Maximum Induced Turbidity of 8 NTU in 24 hours.
- For sediment inputs that last between 24 hours and 30 days (daily sampling preferred) the mean turbidity should not exceed background by more than 2 NTU.

Maximum Induced Turbidity of 5 NTU when background is between 8 and 50 NTU.
Maximum Induced Turbidity of 10% when background is greater than 50 NTU.

Note 1.24 for E. coli (counts):

The escherichia coli density in fresh and marine waters used for the growing and harvesting of shellfish for human consumption should not exceed a median MPN of 14/100 mL over 30 days, and at least 90% of the samples in a 30-day period should not exceed 43/100 mL.

Note 1.25 for E. coli (MPN):

The escherichia coli density in fresh and marine waters used for the growing and harvesting of shellfish for human consumption should not exceed a median MPN of 14/100 mL over 30 days, and at least 90% of the samples in a 30-day period should not exceed 43/100 mL.

Note 1.26 for Enterococcus (MPN):

The enterococci density in fresh and marine waters used for the growing and harvesting of shellfish for human consumption should not exceed a median MPN of 4/100 mL, and at least 90% of the samples in a 30-day period should not exceed 11/100 mL.

Note 1.27 for Fecal coliforms (counts):

The guideline for fecal coliforms is as follows: “The fecal coliform density in fresh and marine waters used for the growing and harvesting of shellfish for human consumption should not exceed a median MPN of 14/100 mL over 30 days, and at least 90% of the samples in a 30-day period should not exceed 43/100 mL.”

Note 1.28 for Fecal coliforms (MPN):

The guideline for fecal coliforms is as follows: “The fecal coliform density in fresh and marine waters used for the growing and harvesting of shellfish for human consumption should not exceed a median MPN of 14/100 mL over 30 days, and at least 90% of the samples in a 30-day period should not exceed 43/100 mL.”

Note 1.29 for Ammonia (total, as N):

The maximum guideline for ammonia varies as a function of pH and temperature. See Table 3 in Overview Report Update September 2009.
The 30-day average guideline for ammonia varies as a function of pH and temperature. See Table 4 in Overview Report Update September 2009. / The lab pH and field temperature results were used for determining the maximum ammonia for this report. If a lab pH result was not available then the field pH result was used.

Note 1.30 for Nitrate (as N):

The guideline maximum for nitrate (as N) is 32.8 mg/l.
The 30-day average guideline for nitrate (as N) is 3.0 mg /L. The 30-day average (chronic) concentration is based on 5 weekly samples collected within a 30-day period.
Where nitrate and nitrite are present, the total nitrate+nitrite nitrogen should not exceed these values.

Note 1.31 for Nitrate + Nitrite (as N) (calculated):
The guideline maximum for nitrate (as N) is 32.8 mg/l.
The 30-day average guideline for nitrate (as N) is 3.0 mg /L. The 30-day average (chronic) concentration is based on 5 weekly samples collected within a 30-day period.
Where nitrate and nitrite are present, the total nitrate+nitrite nitrogen should not exceed these values.
Note 1.32 for Nitrite (as N):
The guideline maximum for nitrite as N is:
0.06 mg/L if chloride less than 2 mg/L
0.12 mg/L if chloride is 2 to 4 mg/L
0.18 mg/L if chloride is 4 to 6 mg/L
0.24 mg/L if chloride is 6 to 8 mg/L
0.30 mg/L if chloride is 8 to 10 mg/L
0.60 mg/L if chloride is greater than 10 mg/L.
The guideline 30-day average for nitrite as N is:
0.02 mg/L if chloride less than 2 mg/L
0.04 mg/L if chloride is 2 to 4 mg/L
0.06 mg/L if chloride is 4 to 6 mg/L
0.08 mg/L if chloride is 6 to 8 mg/L
0.10 mg/L if chloride is 8 to 10 mg/L
0.20 mg/L if chloride is greater than 10 mg/L.
Note 1.33 for Phosphorus (dissolved, by ICPMS/ICPOES):
Streams: None proposed for streams.
Lakes: It is not possible to specify a single phosphorous concentration to achieve protection of aquatic life in lakes. A range of total phosphorous concentrations (5-15 µg/L) is suggested as the criterion which can be used as the basis for site specific water quality objectives.
Note 1.34 for Phosphorus (total, by ICPMS/ICPOES):
Streams: None proposed for streams.
Lakes: It is not possible to specify a single phosphorous concentration to achieve protection of aquatic life in lakes. A range of total phosphorous concentrations (5-15 µg/L) is suggested as the criterion which can be used as the basis for site specific water quality objectives.
Note 1.35 for Phosphorus (total, APHA 4500-P):
Streams: None proposed for streams.
Lakes: It is not possible to specify a single phosphorous concentration to achieve protection of aquatic life in lakes. A range of total phosphorous concentrations (5-15 µg/L) is suggested as the criterion which can be used as the basis for site specific water quality objectives.
Note 1.36 for Phosphorus (dissolved, APHA 4500-P):
Streams: None proposed for streams.
Lakes: It is not possible to specify a single phosphorous concentration to achieve protection of aquatic life in lakes. A range of total phosphorous concentrations (5-15 µg/L) is suggested as the criterion which can be used as the basis for site specific water quality objectives.
Note 1.37 for Cobalt (total):
The interim maximum concentration for total cobalt is 110 µg/L to protect aquatic life in the freshwater environment from acute effects of cobalt.
The interim 30-day average concentration for total cobalt (based on five weekly samples) is 4 µg/L to protect aquatic life from chronic effects of cobalt.
Note 1.38 for Copper (total):
The maximum concentration of total copper should not exceed at any time the numerical value (in µg/L) given by the formula "0.094(hardness)+2", where water hardness is reported as mg/L CaCO3.
The 30-day average concentration of total copper (based on a minimum of 5 approximately weekly samples) should not exceed 2 µg/L when average water hardness over the same period (expressed as mg/L CaCO3) is less than 50 mg/L.
When average water hardness is greater than 50 mg/L the 30-day average concentration should not exceed the numerical value (in µg/L) given by the formula "0.04(average hardness)", where water hardness is reported as mg/L CaCO3.
Note 1.39 for Lead (total):
The maximum guideline for total lead in water, at a water hardness less than or equal to 8 mg/L as CaCO3 is set at 3.0 µg/L. When water hardness exceeds 8.0 mg/L CaCO3 the maximum guideline for lead at any time is given by the following equation:
Maximum Criteria (µg/L) = exp (1.273 ln(hardness) - 1.460).
The 30-day average guideline for total lead in water, when water hardness exceeds 8 mg/L as CaCO3, is as follows:
30-Day Average (µg/L) is less than or equal to 3.31 + exp (1.273 ln (mean hardness) - 4.704).
For hardness less than or equal to 8.0 mg/L there is no 30-day average guideline; hence the maximum concentration of 3.0 µg/L is used.
Note 1.40 for Manganese (total):

The maximum concentration of total manganese in mg/L at any time should not exceed the value as determined by the following relationship:
0.01102 hardness + 0.54
where water hardness is reported as mg/L of CaCO3.
The 30-day mean concentration of total manganese in mg/L should be less than or equal to the value as determined by the following relationship:
0.0044 hardness + 0.605
where water hardness is reported as mg/L of CaCO3.

Note 1.41 for Mercury (total):
The average concentration of total mercury in water as measured over a 30-day period (based on five weekly samples) should not exceed 0.02 µg/L when the methyl mercury (MeHg) constitutes less than or equal to 0.5% of the total mercury concentration. When the proportion of MeHg is greater than 0.5%, the guideline should be adjusted as indicated in the Table 1 and Table 4 of the BC MOE Overview Report - First Update, February 2001.
There is no guideline maximum for total mercury in water, for freshwater aquatic life.

Note 1.42 for Molybdenum (total):
The maximum concentration for total molybdenum is 2 mg/L.
The 30-day average concentration for total molybdenum (based on at least five weekly samples in a period of 30 days) is less than or equal to 1 mg/L.

Note 1.43 for Selenium (total):
The 30-day average water quality guideline for protection of aquatic life is 2 µg/L determined as the mean concentration of 5 evenly spaced samples collected over 30 days, and measured as total selenium.
The 30-day average alert concentration for the protection of aquatic life in sensitive ecosystems is 1 µg/L determined as the mean concentration of 5 evenly spaced samples collected over 30 days, and measured as total selenium.

Note 1.44 for Silver (total):
The guideline maximum for total silver is:
0.1 µg/L maximum if hardness less than or equal to 100 mg/L
3.0 µg/L maximum if hardness greater than 100 mg/L.
The guideline 30-day average for total silver is:
0.05 µg/L as 30-day mean if hardness less than or equal to 100 mg/L
1.5 µg/L as 30-day mean if hardness greater than 100 mg/L.

Note 1.45 for Zinc (total):
The maximum concentration of total zinc (µg/L) at any time should not exceed 33 µg/L when water hardness is less than or equal to 90 mg/L as CaCO3.
When water hardness exceeds 90 mg/L CaCO3, the guideline maximum in µg/L for total zinc is the value determined by the following relationship:
33 + 0.75 * (hardness - 90)
where water hardness is reported as mg/L of CaCO3.
The 30-day average concentration of total zinc (µg/L) at any time should not exceed 7.5 µg/L when water hardness is less than or equal to 90 mg/L as CaCO3.
When water hardness exceeds 90 mg/L CaCO3, the guideline maximum in µg/L for total zinc is the value determined by the following relationship:
7.5 + 0.75 * (hardness - 90)
where water hardness is reported as mg/L of CaCO3.

2. Notes for BC Approved Water Quality Guidelines for freshwater aquatic life (30-day average) (BCAWQG ALA)
General Notes:
The Water Quality Guidelines (Criteria) Reports by BC Ministry of Environment were used as references for the guidelines. (Internet address: http://www.env.gov.bc.ca/wat/wq/wq_guidelines.html). Overview Reports (BC MOE) were used as the references for the guidelines unless the note for specific analyte indicates that the Technical Appendix (BC MOE) was used. / For some parameters, guidelines are specified as two values: the maximum value or the acute criterion, and the 30-day average value or the chronic criterion. The 30-day average value was used in this report for parameters that have both guideline values.

Note 2.1 for Dissolved oxygen:
The instantaneous minimum guideline for dissolved oxygen is 5 mg/L for all life stages other than buried embryo/alevin. The instantaneous minimum guideline for dissolved oxygen in the water column is 9 mg/L for buried embryo/alevin. The instantaneous minimum guideline for dissolved oxygen in interstitial water is 6 mg/L for buried embryo/alevin.
The 30-day mean guideline (minimum) for dissolved oxygen is 8 mg/L for all life stages other than buried embryo/alevin. The 30-day mean guideline (minimum) for dissolved oxygen in the water column is 11 mg/L for buried embryo/alevin. The 30-day mean guideline (minimum) for dissolved oxygen in interstitial water is 8 mg/L for buried embryo/alevin.

Note 2.2 for pH:

pH less than 6.5: No statistically significant decrease in pH from background.
pH from 6.5 to 9.0: Unrestricted change permitted within this range.
pH over 9.0: No statistically significant increase in pH from background.
See BC MOE Overview Report for additional details.

Note 2.3 for Temperature:

The maximum daily temperature of 19 degrees Celsius is for streams with unknown fish distribution. See BC MOE Overview Report for additional details for streams with unknown fish distribution, and specific guidelines for streams with known fish distribution, and guideline for lakes and impoundments.

Note 2.4 for Aluminum (dissolved):

The maximum concentration of dissolved aluminum at any time should not exceed:
1. 0.10 mg/L when the pH is greater than or equal to 6.5
2. The value (in mg/L) determined by the following relationship if pH less than 6.5
Dissolved Aluminum = e (1.209-2.426 (pH) + 0.286 (pH)^2)
The 30-day average concentration of dissolved aluminum (based on a minimum of 5 approximately weekly samples) should not exceed:
1. 0.05 mg/L when the median pH over 30 days is greater than or equal to 6.5
2. the value determined by the following relationship at median pH less than 6.5
Dissolved Aluminum = e (1.6-3.327 (median pH) + 0.402 (median pH)^2) / The lab pH results were used for determining the maximum aluminum (dissolved) concentration for this report. If a lab pH result was not available then the field pH result was used.

Note 2.5 for Arsenic (dissolved):

The recommended guideline is for total arsenic.

Note 2.6 for Boron (dissolved):

The recommended guideline is for total boron.

Note 2.7 for Cadmium (dissolved):

The guideline for cadmium is determined on a site-specific basis according to the local water hardness. The guideline for cadmium (dissolved) in µg/L is determined by the following equations for long term exposure:
1. If hardness (as CaCO3) is less than 3.4 mg/L then maximum is 0.0176 µg/L
2. If hardness (as CaCO3) is from 3.4 to 285 mg/L then maximum is based on equation:
e raised to the power of {0.736[ln(hardness)] - 4.943}
3. If hardness (as CaCO3) is greater than 285 mg/L then maximum is 0.457 µg/L.
When water hardness is greater than the upper bound (i.e., highest water hardness tested), a site-specific assessment may be required.

Note 2.8 for Cobalt (dissolved):

The interim maximum concentration for total cobalt is 110 µg/L to protect aquatic life in the freshwater environment from acute effects of cobalt.
The interim 30-day average concentration for total cobalt (based on five weekly samples) is 4 µg/L to protect aquatic life from chronic effects of cobalt.

Note 2.9 for Copper (dissolved):

The maximum concentration of total copper should not exceed at any time the numerical value (in µg/L) given by the formula "0.094(hardness)+2", where water hardness is reported as mg/L CaCO3.
The 30-day average concentration of total copper (based on a minimum of 5 approximately weekly samples) should not exceed 2 µg/L when average water hardness over the same period (expressed as mg/L CaCO3) is less than 50 mg/L.
When average water hardness is greater than 50 mg/L the 30-day average concentration should not exceed the numerical value (in µg/L) given by the formula "0.04(average hardness)", where water hardness is reported as mg/L CaCO3.

Note 2.10 for Lead (dissolved):

The maximum guideline for total lead in water, at a water hardness less than or equal to 8 mg/L as CaCO3 is set at 3.0 µg/L. When water hardness exceeds 8.0 mg/L CaCO3 the maximum guideline for lead at any time is given by the following equation:
Maximum Criteria (µg/L) = exp (1.273 ln(hardness) - 1.460).
The 30-day average guideline for total lead in water, when water hardness exceeds 8 mg/L as CaCO3, is as follows:
30-Day Average (µg/L) is less than or equal to 3.31 + exp (1.273 ln (mean hardness) - 4.704).
For hardness less than or equal to 8.0 mg/L there is no 30-day average guideline; hence the maximum concentration of 3.0 µg/L is used.

Note 2.11 for Manganese (dissolved):

The maximum concentration of total manganese in mg/L at any time should not exceed the value as determined by the following relationship:
0.01102 hardness + 0.54
where water hardness is reported as mg/L of CaCO3.
The 30-day mean concentration of total manganese in mg/L should be less than or equal to the value as determined by the following relationship:
0.0044 hardness + 0.605
where water hardness is reported as mg/L of CaCO3.

Note 2.12 for Mercury (dissolved):
The average concentration of total mercury in water as measured over a 30-day period (based on five weekly samples) should not exceed 0.02 µg/L when the methyl mercury (MeHg) constitutes less than or equal to 0.5% of the total mercury concentration. When the proportion of MeHg is greater than 0.5%, the guideline should be adjusted as indicated in the Table 1 and Table 4 of the BC MOE Overview Report - First Update, February 2001.
There is no guideline maximum for total mercury in water, for freshwater aquatic life.
Note 2.13 for Molybdenum (dissolved):
The maximum concentration for total molybdenum is 2 mg/L.
The 30-day average concentration for total molybdenum (based on at least five weekly samples in a period of 30 days) is less than or equal to 1 mg/L.
Note 2.14 for Selenium (dissolved):
The 30-day average water quality guideline for protection of aquatic life is 2 µg/L determined as the mean concentration of 5 evenly spaced samples collected over 30 days, and measured as total selenium.
The 30-day average alert concentration for the protection of aquatic life in sensitive ecosystems is 1 µg/L determined as the mean concentration of 5 evenly spaced samples collected over 30 days, and measured as total selenium.
Note 2.15 for Silver (dissolved):
The guideline maximum for total silver is:
0.1 µg/L maximum if hardness less than or equal to 100 mg/L
3.0 µg/L maximum if hardness greater than 100 mg/L.
The guideline 30-day average for total silver is:
0.05 µg/L as 30-day mean if hardness less than or equal to 100 mg/L
1.5 µg/L as 30-day mean if hardness greater than 100 mg/L.
Note 2.16 for Zinc (dissolved):
The maximum concentration of total zinc (µg/L) at any time should not exceed 33 µg/L when water hardness is less than or equal to 90 mg/L as CaCO3.
When water hardness exceeds 90 mg/L CaCO3, the guideline maximum in µg/L for total zinc is the value determined by the following relationship:
33 + 0.75 * (hardness - 90)
where water hardness is reported as mg/L of CaCO3.
The 30-day average concentration of total zinc (µg/L) at any time should not exceed 7.5 µg/L when water hardness is less than or equal to 90 mg/L as CaCO3.
When water hardness exceeds 90 mg/L CaCO3, the guideline maximum in µg/L for total zinc is the value determined by the following relationship:
7.5 + 0.75 * (hardness - 90)
where water hardness is reported as mg/L of CaCO3.
Note 2.17 for Chloride:
To protect freshwater aquatic life from acute and lethal effects, the maximum concentration of chloride (mg/L as NaCl) at any time should not exceed 600 mg/L.
To protect freshwater aquatic life from chronic effects, the average (arithmetic mean computed from five weekly samples collected over a 30-day period) concentration of chloride (mg/L as NaCl) should not exceed 150 mg/L.
Note 2.18 for Chlorophyll a:
For protection of aquatic life in streams, a maximum biomass of 100 mg/m2 chlorophyll a is suggested. This guideline applies to naturally growing periphytic algae. There is no guideline for chlorophyll a for lakes.
Note 2.19 for Fluoride:
Correction by BC MOE Sept. 2011: The criteria for Fluoride (total) in mg/L is 0.4 as a maximum where the water hardness (as CaCO3) is less than or equal to 10 mg/L. Otherwise use the equation:
LC50 fluoride = -51.73 + 92.57 log10 (Hardness) and multiply by 0.01.
Hardness is as CaCO3 in units mg/L.
Note 2.20 for pH:
pH less than 6.5: No statistically significant decrease in pH from background.
pH from 6.5 to 9.0: Unrestricted change permitted within this range.
pH over 9.0: No statistically significant increase in pH from background.
See BC MOE Overview Report for additional details.
Note 2.21 for Sulphate:
The approved 30-day average (minimum of 5 evenly-spaced samples collected in 30 days) water quality guidelines to protect aquatic life in BC for sulphate are:
128 mg/L at hardness of 0 to 30 mg/L as CaCO3
218 mg/L at hardness of 31 to 75 mg/L as CaCO3
309 mg/L at hardness of 76 to 180mg/L as CaCO3
429 mg/L at hardness 181 to 250 mg/L as CaCO3
Need to determine guideline based on site water for hardness greater than 250 mg/L as CaCO3.
For screening purposes in this report, exceedance were flagged for sulphate greater than 429 mg/L at hardness greater than 250 mg/L as CaCO3.

Note 2.22 for Total suspended solids:
Maximum Induced Suspended Sediments - mg/L or % of background:
- 25 mg/L in 24 hours when background is less than or equal to 25;
- Mean of 5 mg/L in 30 days when background is less than or equal to 25;
- 25 mg/L when background is between 25 and 250;
- 10% when background is greater than or equal to 250.

Note 2.23 for Turbidity:
When background is less than or equal to 8 NTU:
- Maximum Induced Turbidity of 8 NTU in 24 hours.
- For sediment inputs that last between 24 hours and 30 days (daily sampling preferred) the mean turbidity should not exceed background by more than 2 NTU.

Maximum Induced Turbidity of 5 NTU when background is between 8 and 50 NTU.
Maximum Induced Turbidity of 10% when background is greater than 50 NTU.

Note 2.24 for E. coli (counts):
The escherichia coli density in fresh and marine waters used for the growing and harvesting of shellfish for human consumption should not exceed a median MPN of 14/100 mL over 30 days, and at least 90% of the samples in a 30-day period should not exceed 43/100 mL.

Note 2.25 for E. coli (MPN):
The escherichia coli density in fresh and marine waters used for the growing and harvesting of shellfish for human consumption should not exceed a median MPN of 14/100 mL over 30 days, and at least 90% of the samples in a 30-day period should not exceed 43/100 mL.

Note 2.26 for Enterococcus (MPN):
The enterococci density in fresh and marine waters used for the growing and harvesting of shellfish for human consumption should not exceed a median MPN of 4/100 mL, and at least 90% of the samples in a 30-day period should not exceed 11/100 mL.

Note 2.27 for Fecal coliforms (counts):
The guideline for fecal coliforms is as follows: “The fecal coliform density in fresh and marine waters used for the growing and harvesting of shellfish for human consumption should not exceed a median MPN of 14/100 mL over 30 days, and at least 90% of the samples in a 30-day period should not exceed 43/100 mL.”

Note 2.28 for Fecal coliforms (MPN):
The guideline for fecal coliforms is as follows: “The fecal coliform density in fresh and marine waters used for the growing and harvesting of shellfish for human consumption should not exceed a median MPN of 14/100 mL over 30 days, and at least 90% of the samples in a 30-day period should not exceed 43/100 mL.”

Note 2.29 for Ammonia (total, as N):
The maximum guideline for ammonia varies as a function of pH and temperature. See Table 3 in Overview Report Update September 2009.
The 30-day average guideline for ammonia varies as a function of pH and temperature. See Table 4 in Overview Report Update September 2009. / The lab pH and field temperature results were used for determining the maximum ammonia concentration for this report. If a lab pH result was not available then the field pH result was used.

Note 2.30 for Nitrate (as N):
The guideline maximum for nitrate (as N) is 32.8 mg/l.
The 30-day average guideline for nitrate (as N) is 3.0 mg /L. The 30-day average (chronic) concentration is based on 5 weekly samples collected within a 30-day period.
Where nitrate and nitrite are present, the total nitrate+nitrite nitrogen should not exceed these values.

Note 2.31 for Nitrate + Nitrite (as N) (calculated):
The guideline maximum for nitrate (as N) is 32.8 mg/l.
The 30-day average guideline for nitrate (as N) is 3.0 mg /L. The 30-day average (chronic) concentration is based on 5 weekly samples collected within a 30-day period.
Where nitrate and nitrite are present, the total nitrate+nitrite nitrogen should not exceed these values.

Note 2.32 for Nitrite (as N):

The guideline maximum for nitrite as N is:
0.06 mg/L if chloride less than 2 mg/L
0.12 mg/L if chloride is 2 to 4 mg/L
0.18 mg/L if chloride is 4 to 6 mg/L
0.24 mg/L if chloride is 6 to 8 mg/L
0.30 mg/L if chloride is 8 to 10 mg/L
0.60 mg/L if chloride is greater than 10 mg/L.
The guideline 30-day average for nitrite as N is:
0.02 mg/L if chloride less than 2 mg/L
0.04 mg/L if chloride is 2 to 4 mg/L
0.06 mg/L if chloride is 4 to 6 mg/L
0.08 mg/L if chloride is 6 to 8 mg/L
0.10 mg/L if chloride is 8 to 10 mg/L
0.20 mg/L if chloride is greater than 10 mg/L.

Note 2.33 for Phosphorus (dissolved, by ICPMS/ICPOES):
Streams: None proposed for streams.
Lakes: It is not possible to specify a single phosphorous concentration to achieve protection of aquatic life in lakes. A range of total phosphorous concentrations (5-15 µg/L) is suggested as the criterion which can be used as the basis for site specific water quality objectives.

Note 2.34 for Phosphorus (total, by ICPMS/ICPOES):
Streams: None proposed for streams.
Lakes: It is not possible to specify a single phosphorous concentration to achieve protection of aquatic life in lakes. A range of total phosphorous concentrations (5-15 µg/L) is suggested as the criterion which can be used as the basis for site specific water quality objectives.

Note 2.35 for Phosphorus (total, APHA 4500-P):
Streams: None proposed for streams.
Lakes: It is not possible to specify a single phosphorous concentration to achieve protection of aquatic life in lakes. A range of total phosphorous concentrations (5-15 µg/L) is suggested as the criterion which can be used as the basis for site specific water quality objectives.

Note 2.36 for Phosphorus (dissolved, APHA 4500-P):
Streams: None proposed for streams.
Lakes: It is not possible to specify a single phosphorous concentration to achieve protection of aquatic life in lakes. A range of total phosphorous concentrations (5-15 µg/L) is suggested as the criterion which can be used as the basis for site specific water quality objectives.

Note 2.37 for Cobalt (total):
The interim maximum concentration for total cobalt is 110 µg/L to protect aquatic life in the freshwater environment from acute effects of cobalt.
The interim 30-day average concentration for total cobalt (based on five weekly samples) is 4 µg/L to protect aquatic life from chronic effects of cobalt.

Note 2.38 for Copper (total):
The maximum concentration of total copper should not exceed at any time the numerical value (in µg/L) given by the formula "0.094(hardness)+2", where water hardness is reported as mg/L CaCO3.
The 30-day average concentration of total copper (based on a minimum of 5 approximately weekly samples) should not exceed 2 µg/L when average water hardness over the same period (expressed as mg/L CaCO3) is less than 50 mg/L.
When average water hardness is greater than 50 mg/L the 30-day average concentration should not exceed the numerical value (in µg/L) given by the formula "0.04(average hardness)", where water hardness is reported as mg/L CaCO3.

Note 2.39 for Lead (total):
The maximum guideline for total lead in water, at a water hardness less than or equal to 8 mg/L as CaCO3 is set at 3.0 µg/L. When water hardness exceeds 8.0 mg/L CaCO3 the maximum guideline for lead at any time is given by the following equation:
Maximum Criteria (µg/L) = exp (1.273 ln(hardness) - 1.460).
The 30-day average guideline for total lead in water, when water hardness exceeds 8 mg/L as CaCO3, is as follows:
30-Day Average (µg/L) is less than or equal to 3.31 + exp (1.273 ln (mean hardness) - 4.704).
For hardness less than or equal to 8.0 mg/L there is no 30-day average guideline; hence the maximum concentration of 3.0 µg/L is used.

Note 2.40 for Manganese (total):

The maximum concentration of total manganese in mg/L at any time should not exceed the value as determined by the following relationship:
0.01102 hardness + 0.54
where water hardness is reported as mg/L of CaCO3.
The 30-day mean concentration of total manganese in mg/L should be less than or equal to the value as determined by the following relationship:
0.0044 hardness + 0.605
where water hardness is reported as mg/L of CaCO3.

Note 2.41 for Mercury (total):
The average concentration of total mercury in water as measured over a 30-day period (based on five weekly samples) should not exceed 0.02 µg/L when the methyl mercury (MeHg) constitutes less than or equal to 0.5% of the total mercury concentration. When the proportion of MeHg is greater than 0.5%, the guideline should be adjusted as indicated in the Table 1 and Table 4 of the BC MOE Overview Report - First Update, February 2001.
There is no guideline maximum for total mercury in water, for freshwater aquatic life.

Note 2.42 for Molybdenum (total):
The maximum concentration for total molybdenum is 2 mg/L.
The 30-day average concentration for total molybdenum (based on at least five weekly samples in a period of 30 days) is less than or equal to 1 mg/L.

Note 2.43 for Selenium (total):
The 30-day average water quality guideline for protection of aquatic life is 2 µg/L determined as the mean concentration of 5 evenly spaced samples collected over 30 days, and measured as total selenium.
The 30-day average alert concentration for the protection of aquatic life in sensitive ecosystems is 1 µg/L determined as the mean concentration of 5 evenly spaced samples collected over 30 days, and measured as total selenium.

Note 2.44 for Silver (total):
The guideline maximum for total silver is:
0.1 µg/L maximum if hardness less than or equal to 100 mg/L
3.0 µg/L maximum if hardness greater than 100 mg/L.
The guideline 30-day average for total silver is:
0.05 µg/L as 30-day mean if hardness less than or equal to 100 mg/L
1.5 µg/L as 30-day mean if hardness greater than 100 mg/L.

Note 2.45 for Zinc (total):
The maximum concentration of total zinc (µg/L) at any time should not exceed 33 µg/L when water hardness is less than or equal to 90 mg/L as CaCO3.
When water hardness exceeds 90 mg/L CaCO3, the guideline maximum in µg/L for total zinc is the value determined by the following relationship:
33 + 0.75 * (hardness - 90)
where water hardness is reported as mg/L of CaCO3.
The 30-day average concentration of total zinc (µg/L) at any time should not exceed 7.5 µg/L when water hardness is less than or equal to 90 mg/L as CaCO3.
When water hardness exceeds 90 mg/L CaCO3, the guideline maximum in µg/L for total zinc is the value determined by the following relationship:
7.5 + 0.75 * (hardness - 90)
where water hardness is reported as mg/L of CaCO3.

3. Notes for Working Water Quality Guidelines for British Columbia for freshwater aquatic life (BCWWQG AL)

General Notes:
Reference: Working Water Quality Guidelines for British Columbia (2015). WWQG values are long-term (i.e. average) concentrations unless identified as a short-term maximum in the “Notes” for a specific analyte. Long-term WWQGs represent average substance concentrations calculated from 5 samples in 30 days. WWQG are given for total substance concentrations unless otherwise noted.

Note 3.1 for Antimony (dissolved):
The guideline is for antimony (III).

Note 3.2 for Calcium (dissolved):
The guideline for dissolved calcium in mg/L is as follows:
- Less than 4, highly sensitive to acid inputs
- 4 to 8, moderately sensitive
- Greater than 8, low sensitivity.

Note 3.3 for Chromium (dissolved):
The guideline for Cr(VI) is 1 µg/L (total). The guideline for Cr(III) is 8.9 µg/L (total). The guideline of 1 µg/L for Cr(VI) was used, in this report, to identify exceedances for dissolved chromium, and total chromium as a means for determining the potential for exceeding the Cr(VI) and/or Cr(III) guidelines.

Note 3.4 for Nickel (dissolved):

The guideline for nickel in µg/L is determined as follows:
When the water hardness is 0 to ≤ 60 mg/L, the maximum is 25 µg/L
At hardness > 60 to ≤ 180 mg/L the maximum is calculated using the equation:
e raised to the power of {0.76[ln(hardness)] + 1.06}
At hardness >180 mg/L, the maximum is 150 µg/L
Where water hardness is reported as mg/L CaCO3.
If the water hardness is unknown, the maximum is 25 µg/L.

Note 3.5 for Thallium (dissolved):
30-day average, site-specific objective for the lower Columbia River, BC

Note 3.6 for Alkalinity (phenolphthalein, as CaCO3):
The guideline for alkalinity (total as CaCO3) is as follows:
- Less than 10 mg/L, highly sensitive to acid inputs
- 10 to 20 mg/L, moderately sensitive to acid inputs
- Greater than 20 mg/L, low sensitivity to acid inputs.

Note 3.7 for Alkalinity (total, as CaCO3):
The guideline for alkalinity (total as CaCO3) is as follows:
- Less than 10 mg/L, highly sensitive to acid inputs
- 10 to 20 mg/L, moderately sensitive to acid inputs
- Greater than 20 mg/L, low sensitivity to acid inputs.

Note 3.8 for Antimony (total):
The guideline is for antimony (III).

Note 3.9 for Chromium (total):
The guideline for Cr(VI) is 1 µg/L (total). The guideline for Cr(III) is 8.9 µg/L (total). The guideline of 1 µg/L for Cr(VI) was used, in this report, to identify exceedances for dissolved chromium, and total chromium as a means for determining the potential for exceeding the Cr(VI) and/or Cr(III) guidelines.

Note 3.10 for Nickel (total):
The guideline for nickel in µg/L is determined as follows:
When the water hardness is 0 to ≤ 60 mg/L, the maximum is 25 µg/L
At hardness > 60 to ≤ 180 mg/L the maximum is calculated using the equation:
e raised to the power of {0.76[ln(hardness)] + 1.06}
At hardness >180 mg/L, the maximum is 150 µg/L
Where water hardness is reported as mg/L CaCO3.
If the water hardness is unknown, the maximum is 25 µg/L.

Note 3.11 for Thallium (total):
30-day average, site-specific objective for the lower Columbia River, BC

4. Notes for CCME. Canadian water quality guidelines for the protection of freshwater aquatic life. (CCME AL)

General Notes:
The CCME Canadian water quality guidelines for the protection of freshwater aquatic life provide both a Long-Term Exposure guideline, and Short-Term Exposure guideline for some analytes. The Long-Term Exposure guidelines were used in this report.

Note 4.1 for Dissolved oxygen:
Dissolved oxygen guideline minimum:
For warm-water biota: early life stages = 6000 µg/L
For warm-water biota: other life stages = 5500 µg/L
For cold-water biota: early life stages = 9500 µg/L
For cold-water biota: other life stages = 6500 µg/L

Note 4.2 for Temperature:
Thermal Stratification: Thermal additions to receiving waters should be such that thermal stratification and subsequent turnover dates are not altered from those existing prior to the addition of heat from artificial origins.
Maximum Weekly Average Temperature: Thermal additions to receiving waters should be such that the maximum weekly average temperature is not exceeded.
Short-term Exposure to Extreme Temperature: Thermal additions to receiving waters should be such that the short-term exposures to maximum temperatures are not exceeded. Exposures should not be so lengthy or frequent as to adversely affect the important species.

Note 4.3 for Aluminum (dissolved):
The guideline for aluminum is:
5 µg/L when pH is less than 6.5
100 µg/L when pH is greater than or equal to 6.5

Note 4.4 for Arsenic (dissolved):
Guideline is for total arsenic.

Note 4.5 for Boron (dissolved):
The Short-Term Exposure Guideline is 29 mg/L. The Long-Term Exposure Guideline is 1.5 mg/L.

Note 4.6 for Cadmium (dissolved):

The long-term guideline for cadmium is determined on a site-specific basis according to the local water hardness. The guideline for total cadmium in µg/L is determined as follows for long-term exposure:
1. If hardness (as CaCO3) is less than 17 mg/L then maximum is 0.04 µg/L
2. If hardness (as CaCO3) is from 17 to 280 mg/L then maximum is based on equation:
10 raised to the power of {0.83[log(hardness)] - 2.46}
3. If hardness (as CaCO3) is greater than 280 mg/L then maximum is 0.37 µg/L.
The short-term benchmark for cadmium is determined on a site-specific basis according to the local water hardness. The benchmark for total cadmium in µg/L is determined as follows for short-term exposure:
1. If hardness (as CaCO3) is less than 5.3 mg/L then maximum is 0.11 µg/L
2. If hardness (as CaCO3) is from 5.3 to 360 mg/L then maximum is based on equation:
10 raised to the power of {1.016[log(hardness)] - 1.71}
3. If hardness (as CaCO3) is greater than 360 mg/L then maximum is 7.7 µg/L.

Note 4.7 for Chromium (dissolved):
CCME guideline for freshwater aquatic life is 0.0010 mg/L for chromium VI. CCME interim guideline for freshwater aquatic life is 0.0089 mg/L for chromium III. The guideline of 0.0010 mg/L was used, in this report, to identify exceedances for dissolved chromium, and total chromium as a means for determining the potential for exceeding the chromium VI and/or chromium III guidelines.

Note 4.8 for Copper (dissolved):
The guideline for copper in µg/L is determined as follows:
When the water hardness is 0 to < 82 mg/L, the CWQG is 2 µg/L
At hardness ≥82 to ≤180 mg/L the CWQG is calculated using the equation:
e raised to the power of {0.8545[ln(hardness)]-1.465} * 0.2 µg/L
At hardness >180 mg/L, the CWQG is 4 µg/L
Where water hardness is reported as mg/L CaCO3.
If the water hardness is unknown, the CWQG is 2 µg/L

Note 4.9 for Lead (dissolved):
The guideline for lead in µg/L is determined as follows:
When the hardness is 0 to ≤ 60 mg/L, the CWQG is 1 µg/L
At hardness > 60 to ≤ 180 mg/L the CWQG is calculated using the equation:
e raised to the power of {1.273[ln(hardness)] - 4.705}
At hardness >180 mg/L, the CWQG is 7 µg/L
Where water hardness is reported as mg/L CaCO3.
If the water hardness is unknown, the CWQG is 1 µg/L

Note 4.10 for Mercury (dissolved):
May not prevent accumulation of methylmercury in aquatic life, therefore, may not protect wildlife that consume aquatic life; see fact sheet for details.
Consult also the appropriate Canadian Tissue Residue Guideline for the Protection of Wildlife Consumers of Aquatic Biota.

Note 4.11 for Nickel (dissolved):
The guideline for nickel in µg/L is determined as follows:
When the water hardness is 0 to ≤ 60 mg/L, the CWQG is 25 µg/L
At hardness > 60 to ≤ 180 mg/L the CWQG is calculated using the equation:
e raised to the power of {0.76[ln(hardness)] + 1.06}
At hardness >180 mg/L, the CWQG is 150 µg/L
Where water hardness is reported as mg/L CaCO3.
If the water hardness is unknown, the CWQG is 25 µg/L

Note 4.12 for Uranium (dissolved):
The Short-Term Exposure Guideline is 33 µg/L. The Long-Term Exposure Guideline is 15 µg/L. The guidelines are for total recoverable, unfiltered analyses.

Note 4.13 for Chloride:
The Short-Term Exposure Guideline is 640 mg/L. The Long-Term Exposure Guideline is 120 mg/L.

Note 4.14 for Fluoride:
The interim guideline for the protection of freshwater aquatic life for total inorganic fluorides is 0.12 mg/L

Note 4.15 for Total suspended solids:
Water quality guideline for suspended sediments is as follows.
Clear flow:
Maximum increase of 25 mg/L from background levels for any short-term exposure (e.g., 24-h period). Maximum average increase of 5 mg/L from background levels for longer term exposures (e.g., inputs lasting between 24 h and 30 d).
High flow:
Maximum increase of 25 mg/L from background levels at any time when background levels are between 25 and 250 mg/L. Should not increase more than 10% of background levels when background is >250 mg/L.

Note 4.16 for Turbidity:

Water quality guideline for turbidity is as follows.
Clear flow:
Maximum increase of 8 NTUs from background levels for a short-term exposure (e.g., 24-h period). Maximum average increase of 2 NTUs from background levels for a longer term exposure (e.g., 30-d period).
High flow or turbid waters:
Maximum increase of 8 NTUs from background levels at any one time when background levels are between 8 and 80 NTUs. Should not increase more than 10% of background levels when background is >80 NTUs.

Note 4.17 for Ammonia (total, as N):
The guideline for ammonia varies as a function of pH and temperature.

Note 4.18 for Nitrate (as N):
The Short-Term Exposure Guideline is 124 mg/L. The Long-Term Exposure Guideline is 3.0 mg/L. The guidelines for nitrate are for protection from direct toxic effects; the guidelines do not consider indirect effects due to eutrophication.
The Long Term guideline is derived from toxicity tests utilizing $NaNO_3$. The Long Term guideline is derived with mostly no- and some low-effect data and are intended to protect against negative effects to aquatic ecosystem structure and function during indefinite exposures (e.g. abide by the guiding principle as per CCME 2007).

Note 4.19 for Nitrate + Nitrite (as N) (calculated):
Long-Term Exposure Guideline for Nitrate (as N) is 3.0 mg/L

Note 4.20 for Phosphorus (dissolved, by ICPMS/ICPOES):
Canadian Guidance Framework for Phosphorus is for developing phosphorus guidelines (does not provide guidance on other freshwater nutrients). It provides Trigger Ranges for Total Phosphorus (see Guidance Framework for Phosphorus factsheet):
ultra-oligotrophic <4 µg/L;
oligotrophic 4-10 µg/L;
mesotrophic 10-20 µg/L;
meso-eutrophic 20-35 µg/L;
eutrophic 35-100 µg/L;
hyper-eutrophic >100 µg/L

Note 4.21 for Phosphorus (total, by ICPMS/ICPOES):
Canadian Guidance Framework for Phosphorus is for developing phosphorus guidelines (does not provide guidance on other freshwater nutrients). It provides Trigger Ranges for Total Phosphorus (see Guidance Framework for Phosphorus factsheet):
ultra-oligotrophic <4 µg/L;
oligotrophic 4-10 µg/L;
mesotrophic 10-20 µg/L;
meso-eutrophic 20-35 µg/L;
eutrophic 35-100 µg/L;
hyper-eutrophic >100 µg/L

Note 4.22 for Phosphorus (total, APHA 4500-P):
Canadian Guidance Framework for Phosphorus is for developing phosphorus guidelines (does not provide guidance on other freshwater nutrients). It provides Trigger Ranges for Total Phosphorus (see Guidance Framework for Phosphorus factsheet):
ultra-oligotrophic <4 µg/L;
oligotrophic 4-10 µg/L;
mesotrophic 10-20 µg/L;
meso-eutrophic 20-35 µg/L;
eutrophic 35-100 µg/L;
hyper-eutrophic >100 µg/L

Note 4.23 for Phosphorus (dissolved, APHA 4500-P):
Canadian Guidance Framework for Phosphorus is for developing phosphorus guidelines (does not provide guidance on other freshwater nutrients). It provides Trigger Ranges for Total Phosphorus (see Guidance Framework for Phosphorus factsheet):
ultra-oligotrophic <4 µg/L;
oligotrophic 4-10 µg/L;
mesotrophic 10-20 µg/L;
meso-eutrophic 20-35 µg/L;
eutrophic 35-100 µg/L;
hyper-eutrophic >100 µg/L

Note 4.24 for Aluminum (total):
The guideline for aluminum is:
5 µg/L when pH is less than 6.5
100 µg/L when pH is greater than or equal to 6.5

Note 4.25 for Arsenic (total):
Guideline is for total arsenic.

Note 4.26 for Boron (total):
The Short-Term Exposure Guideline is 29 mg/L. The Long-Term Exposure Guideline is 1.5 mg/L.
Note 4.27 for Cadmium (total):
The long-term guideline for cadmium is determined on a site-specific basis according to the local water hardness. The guideline for total cadmium in µg/L is determined as follows for long-term exposure:
1. If hardness (as CaCO3) is less than 17 mg/L then maximum is 0.04 µg/L
2. If hardness (as CaCO3) is from 17 to 280 mg/L then maximum is based on equation:
10 raised to the power of {0.83[log(hardness)] - 2.46}
3. If hardness (as CaCO3) is greater than 280 mg/L then maximum is 0.37 µg/L.
The short-term benchmark for cadmium is determined on a site-specific basis according to the local water hardness. The benchmark for total cadmium in µg/L is determined as follows for short-term exposure:
1. If hardness (as CaCO3) is less than 5.3 mg/L then maximum is 0.11 µg/L
2. If hardness (as CaCO3) is from 5.3 to 360 mg/L then maximum is based on equation:
10 raised to the power of {1.016[log(hardness)] - 1.71}
3. If hardness (as CaCO3) is greater than 360 mg/L then maximum is 7.7 µg/L.
Note 4.28 for Chromium (total):
CCME guideline for freshwater aquatic life is 0.0010 mg/L for chromium VI. CCME interim guideline for freshwater aquatic life is 0.0089 mg/L for chromium III. The guideline of 0.0010 mg/L was used, in this report, to identify exceedances for dissolved chromium, and total chromium as a means for determining the potential for exceeding the chromium VI and/or chromium III guidelines.
Note 4.29 for Copper (total):
The guideline for copper in µg/L is determined as follows:
When the water hardness is 0 to < 82 mg/L, the CWQG is 2 µg/L
At hardness ≥82 to ≤180 mg/L the CWQG is calculated using the equation:
e raised to the power of {0.8545[ln(hardness)]-1.465} * 0.2 µg/L
At hardness >180 mg/L, the CWQG is 4 µg/L
Where water hardness is reported as mg/L CaCO3.
If the water hardness is unknown, the CWQG is 2 µg/L
Note 4.30 for Lead (total):
The guideline for lead in µg/L is determined as follows:
When the hardness is 0 to ≤ 60 mg/L, the CWQG is 1 µg/L
At hardness > 60 to ≤ 180 mg/L the CWQG is calculated using the equation:
e raised to the power of {1.273[ln(hardness)] - 4.705}
At hardness >180 mg/L, the CWQG is 7 µg/L
Where water hardness is reported as mg/L CaCO3.
If the water hardness is unknown, the CWQG is 1 µg/L
Note 4.31 for Mercury (total):
May not prevent accumulation of methylmercury in aquatic life, therefore, may not protect wildlife that consume aquatic life; see fact sheet for details.
Consult also the appropriate Canadian Tissue Residue Guideline for the Protection of Wildlife Consumers of Aquatic Biota.
Note 4.32 for Nickel (total):
The guideline for nickel in µg/L is determined as follows:
When the water hardness is 0 to ≤ 60 mg/L, the CWQG is 25 µg/L
At hardness > 60 to ≤ 180 mg/L the CWQG is calculated using the equation:
e raised to the power of {0.76[ln(hardness)] + 1.06}
At hardness >180 mg/L, the CWQG is 150 µg/L
Where water hardness is reported as mg/L CaCO3.
If the water hardness is unknown, the CWQG is 25 µg/L
Note 4.33 for Uranium (total):
The Short-Term Exposure Guideline is 33 µg/L. The Long-Term Exposure Guideline is 15 µg/L. The guidelines are for total recoverable, unfiltered analyses.